MAGAZIJN 44 AS THE ENERGY HUB IN GENTBRUGGE

FLY OVER - NATURAL VILLAGE - ENERGY

Climate Design &
Sustainability

KULeuven - Departement Architecture
2021
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MAGAZIJN

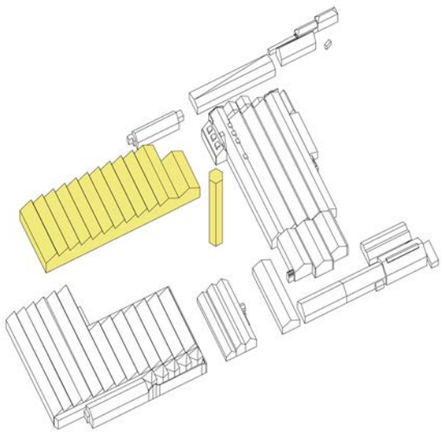
TEAM & CONTENT

1. TEAM & RESPONSIBILITIES

Cedric Coopman	team communication
Estelle Degeyter	output deliveries
Astrid De Mazière	general management
Mélanie Demoulin	urban counselor
Maxim Loncke	progress report & time management







2. FUNCTION

Appartments
Co-Housing
Retail spaces
Offices
Bike parking

Green areas:
- sportsfield
- playground
- recreational garden for flowers and vegetables
- partly paved area for terraces and market

Heat storage: buffer tanks
Energy storage: tower

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  - dynamo
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  - apartments
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OUR PROJECT GOALS

CITY SCALE CONNECTION
heat network

GREEN ENERGY PRODUCTION
geothermal fields
solar panels
biogas plant
hydro-electricity
regenerative breaking

LANDMARK
Energy Tower

MIXED USE
retail spaces for green startups
offices
multigenerational housing
co-housing
gathering spaces

PASSIVE BUILDING
natural daylight
natural ventilation
natural cooling
natural shading system
efficient insulation
airtight

BASIC DATA

function of the building:
housing, offices
retail saces
green recreational spaces
sports facilities

how many users:
76 residents
118 office workers
= total of 264 people

total m2 (footprint): 10 248 m2

total livable m2: 4822 m2

total m3: 13 876 m3

CONTEXT

Ghentbrugge
Arsenaalsite
Brusselse Steenweg 602, 9050 Gentbrugge

Existing situation: old NMBS warehouse

WATER

A lot of the site's surface is converted to green space. In this way we prevent dehydration of the soil. The heat network uses water to store the heat. The water is heated by geothermal energy.

ENERGY

natural cooling, heating, ventilation
energy production = 7,5 MWhyr

MOBILITY

The site is accesible by train and bike. In the building is a bike storage place. The elevators is large enough for wheelchairs. All the buildings are accesible for disabled people.

MATERIALS

Lightweight building blocks and concrete for the structure which provides flexibility and makes it easy to make the building airtight.

Re-used concrete panels and brickwork.
Recuperated from deconstructed buildings on site.

No transport is needed.

NATURE

Green space is used to create a more controlled environment around the buildings.

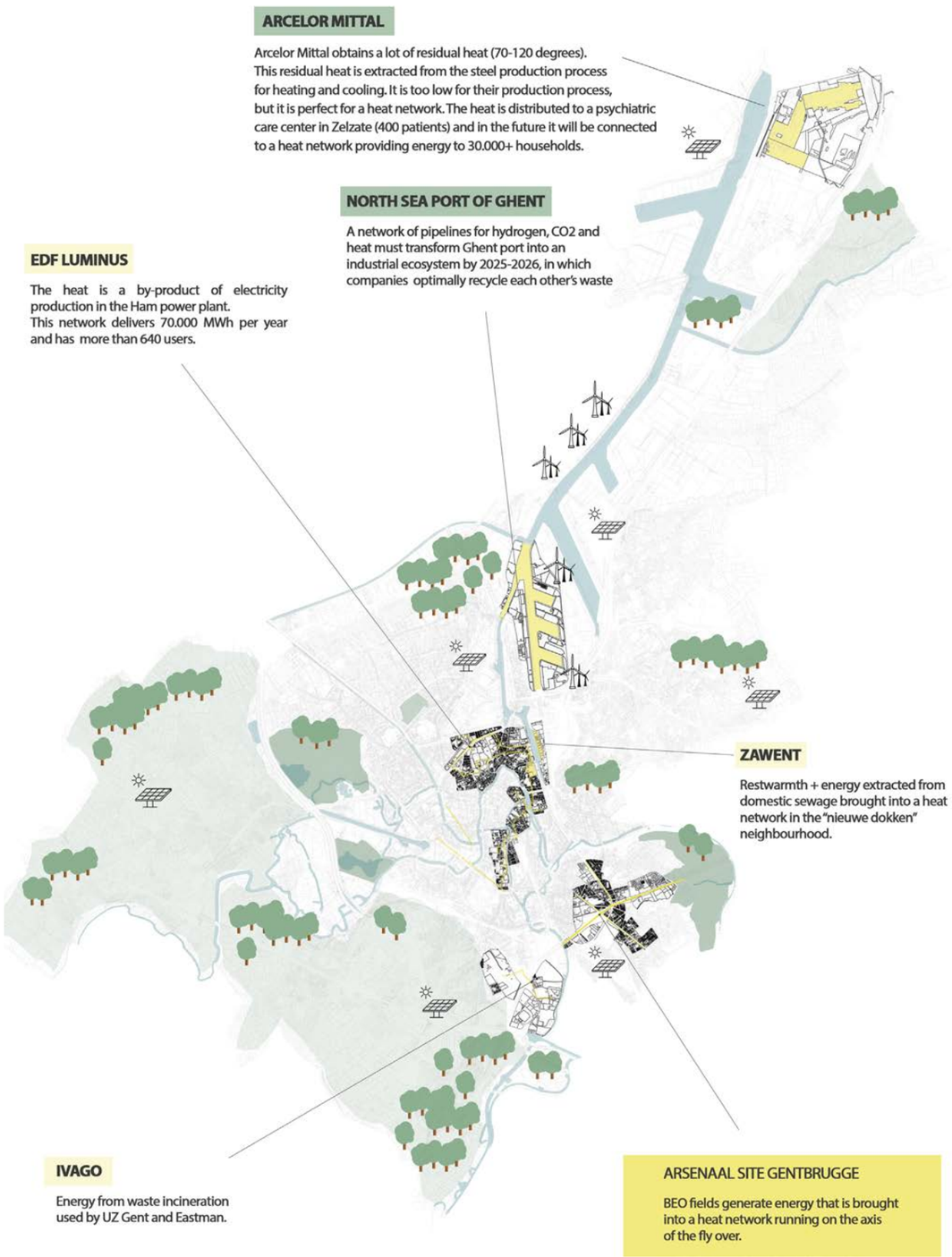
number of existing and new trees: +- 125 trees

economy number of new jobs: 188 new jobs

GENERAL OVERVIEW

As the energy team of the natural village our primary focus was to create an Energy Hub by providing and maintaining networks that gives the village and neighborhoods renewable energy. We focused on providing heat and electricity and also a place to store it. The building is located on the Arsenaalsite in Ghentbrugge where we use an existing building to implement our program of housing, commercial spaces and energy production. By implementing nature the Arsenaalsite will be a center place for the community.

GREEN ENERGY SOURCES GHENT



VISION 2050 GHENT

The vision for 2050 is the maximum reduction in energy consumption by producing energy sources locally. The city of Ghent uses various renewable energy resources and innovations to its highest potential. Ghent has the goal of becoming climate neutral by 2050.

This vision eliminates the import of fuel sources from other countries, this makes fossil fuels extra polluting. The city of Gent should be independent in producing and consuming energy. Most important it makes sure that we produce and consume renewable energy.

De Nieuwe Dokken uses the innovative energy concept ZAWENT. The new residential area in Ghent is heated with waste water, kitchen waste and industrial residual heat. The local water purification system is linked to the heat network. All homes will be built energy-efficiently and the use of sustainable energy sources will make the district energy neutral.

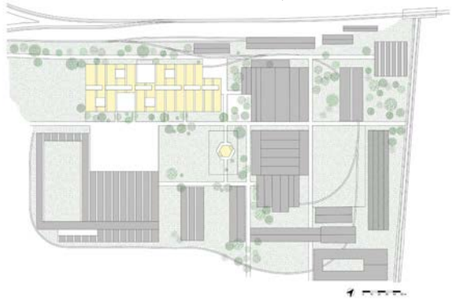
IVAGO uses the Waste-to-Energy, the processing of combustible waste. The heat that is released is usefully used for the production of steam and electricity. The electricity is for own use and supply to the public electricity network. In addition, steam is used for heating of their own buildings and installations. IVAGO also supplies about 60% of the energy needs of the Ghent University Hospital 1,500 m away by underground pipes. In addition, IVAGO also supplies steam to a neighbor company.

EDF LUMINUS in Gent Ham provides heath to hospitals, social housing complexes, university buildings and shopping centers via an underground network. The buildings are connected to the main hot water pipe. Their installations are heated via a heat exchanger, after which the cooled water flows back to the power station. They are supplied with local, clean and green energy.

In 2025 Arcelor Mittal wants to achieve the goal to use a network of pipelines through the port of Ghent to transport hydrogen as an alternative energy source for steel production. The pipelines connect ArcelorMittal to a Dutch network that transports hydrogen to a chemical factory in Terneuzen. Right now Arcelor Mittal obtains a lot of residual heat (70-120 degrees) from the steel production process for heating and cooling. They can't use this heat but it is perfect for a heat network. The heat is distributed to a psychiatric care center in Zelzate (400 patients) and in the future will be connected to a heat network providing energy to 30.000+ househoulds.

The port of Ghent is also expanding their energy networks in the future to transform the port into an industrial ecosystem by 2025.

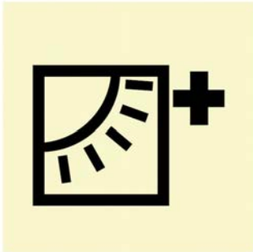
Magazijn 44 and the Energy Tower will be achieved on the Arsenaalsite in Ghentbrugge to create an Energy Hub. With the Energy Tower we provide an energy storage. Inside our building Magazijn 44 we provide a heat buffer to store the heat of our geothermal fields on the site. The energy will be produced by solar panels on the roofs of the existing buildings in the site.



The village is located in Gentbrugge and more precisely along the current Fly-Over E17. This is a 15 metre high viaduct that creates a clear physical barrier between the north and south of the city of Ghent. The landscape is dominated by this massive infrastructure rather than by people. Moreover, the residual space underneath has no functional urban use since parts of the motorway collapsed. The Viaduct and the space underneath are becoming dangerous and the question of its future arises.

The main hypothesis of the village is to partially demolish the Fly Over and transfer the highway outside the city. Taking advantage of the linearity of the residual space, the objective is to develop a green corridor linking existing green patches, creating new connections and allowing the movement and development of biodiversity. Part of the structure will be retained as an ecoduct to cross some important existing roads. The village consists of different innovative buildings, each focusing on a theme such as water, materials, mobility, adaptability, food and energy. Together, we are designing a self-sufficient and natural village.

The Arsenaal site where we are located will develop into an energy centre with energy production and storage. The energy tower will be a landmark in the village, as will the materials crane and the water tower. The village will be known as the 3 Towers of Ghentbrugge, in reference to the 3 towers in the historic centre of Ghent.



SMART PROJECT - passive building

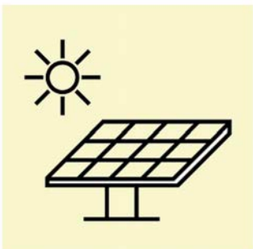
The rules of a passive building must be applied to keep the heating demand low. This means that the building must use high insulation and be airtight. In addition, the materials chosen must have a low environmental impact and/or be sustainable. Finally, buildings should have efficient sun shading.

LOW/NO TECH- use of natural processes

The building should be able to take advantage of natural processes. Natural light should be used to reduce the amount of artificial light during the day. In addition, natural cooling and heating should be encouraged. Finally, natural ventilation will also reduce energy consumption.

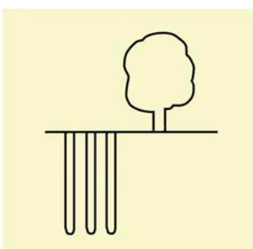
POSITIVE IMPACT - green energy production

Each building must produce green energy to offset its energy consumption. Green energy includes renewable energy, water treatment, solar panels, etc.



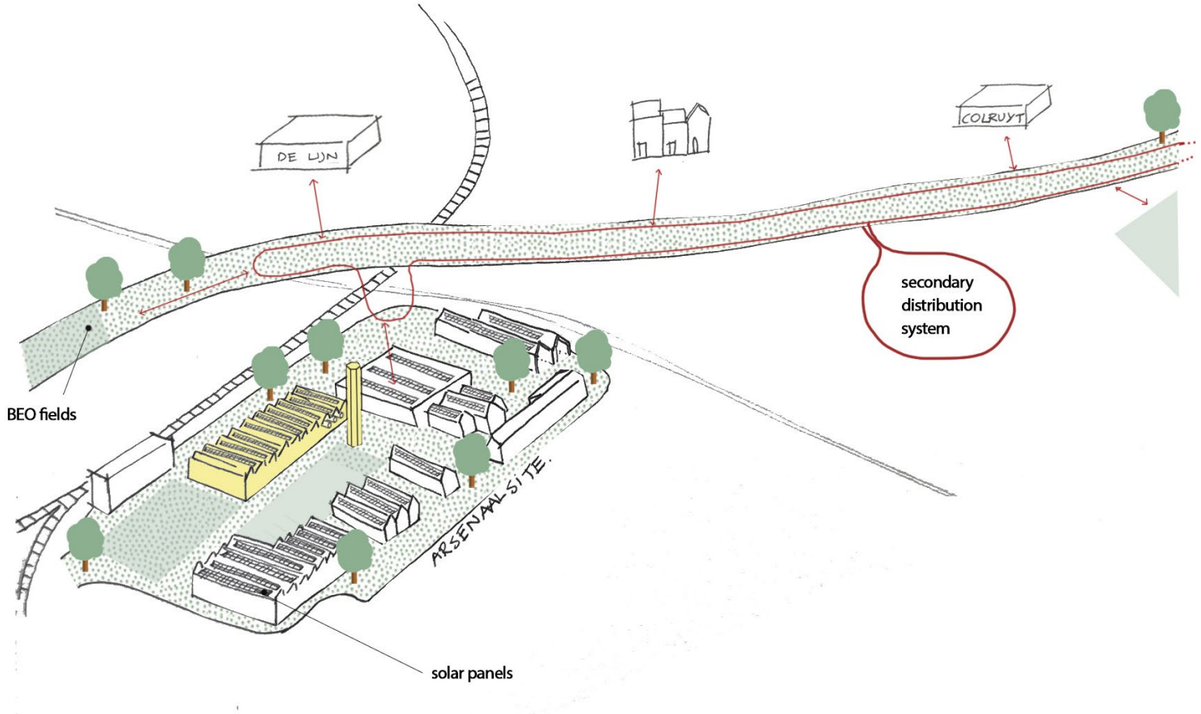
SOLAR PANELS

Unused roof surfaces should have solar panels to produce electricity.



GEOTHERMAL FIELD

Large mineral ground surfaces that wil be unpaved and changed into a green area should implement geothermal pipes.

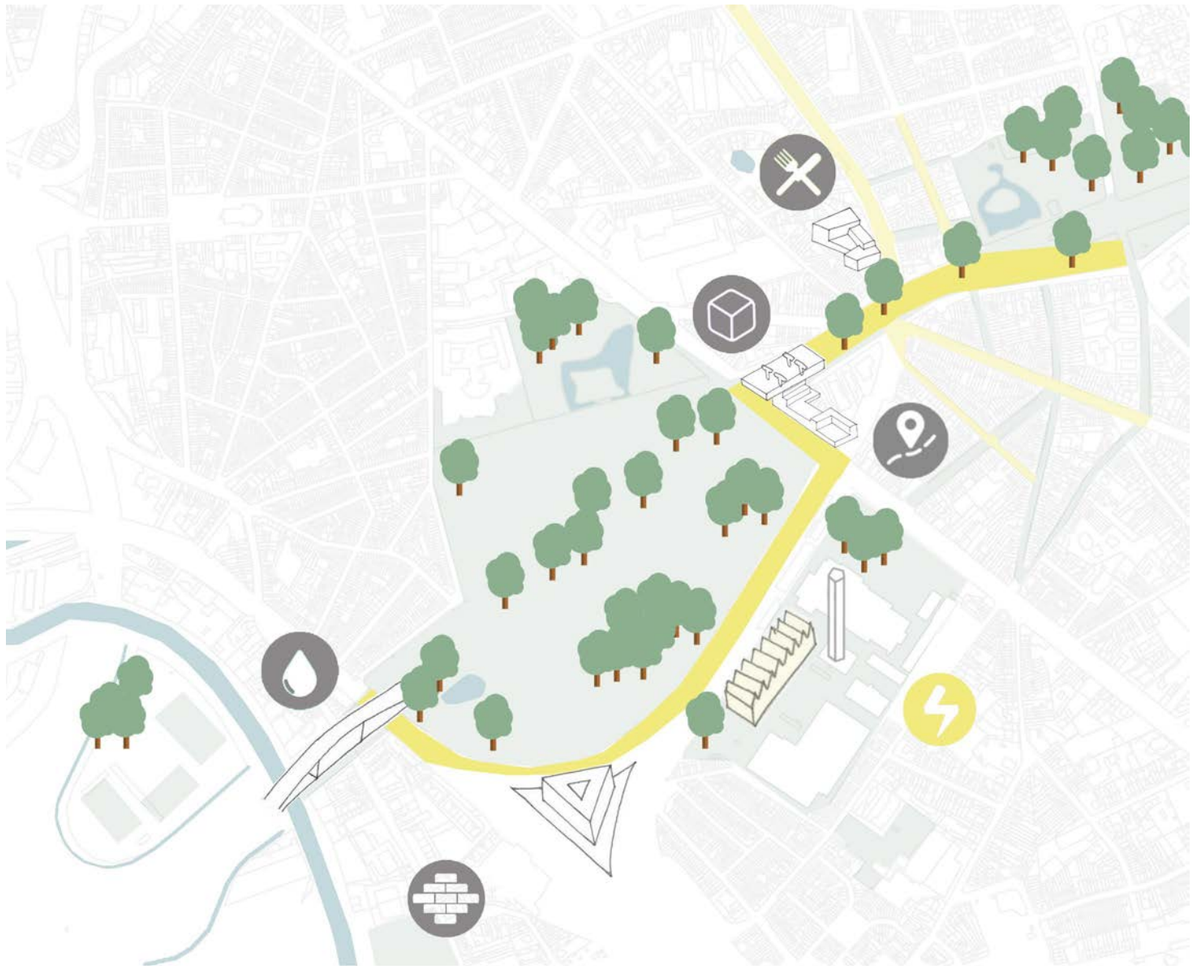


As an energy team we are focusing on techniques to reduce our energy consumption within our building but also to promote renewable energy production using solar panels and geothermal fields.

Henceforth, the energy production will be collected in a heat/cooling network that will be distributed in the village. This is a closed loop to which new buildings in the village, existing houses and shops will be connected. Their heating system will now be based on renewable energy. The smaller secondary distribution systems can be connected to the primary loop to extend the network and reach more houses.

The BEO fields are located on the Arsenaal site but can be spread in the future in the park on the other side of the railway.

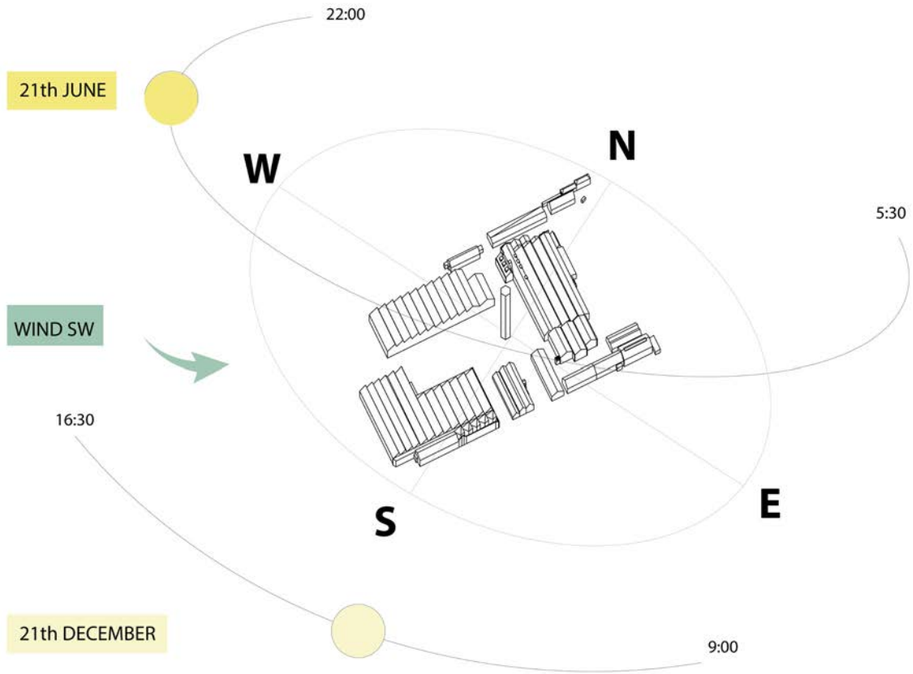
LOCATION OF THE HEAT NETWORK



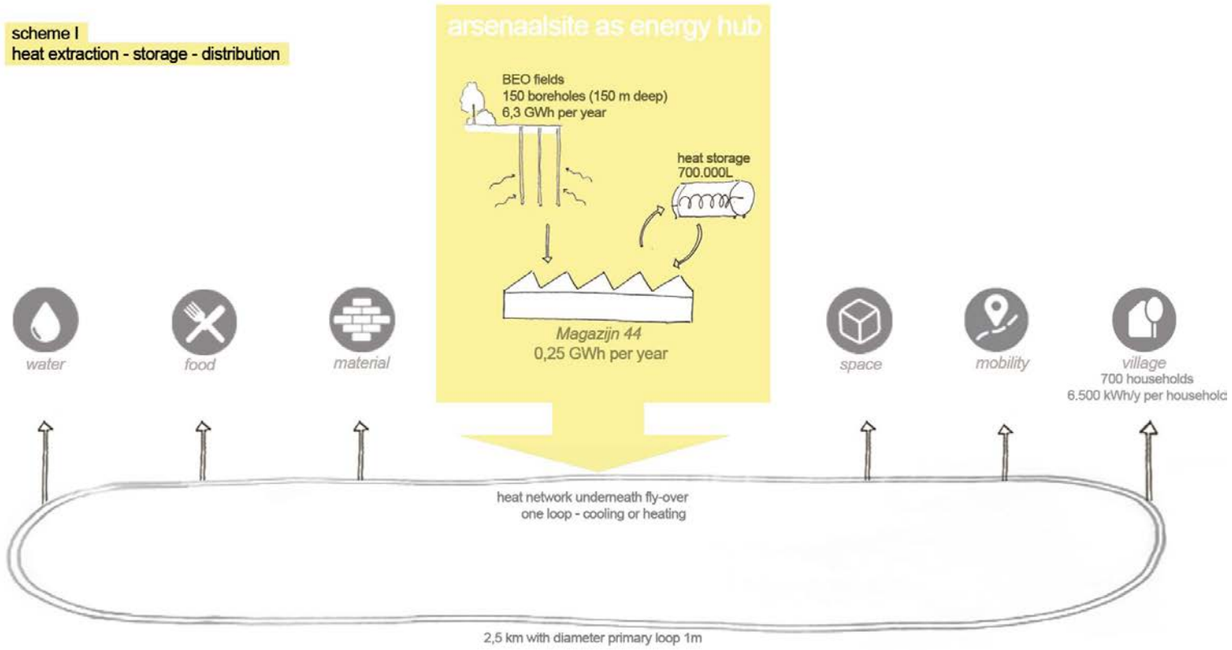
The primary loop will start from the main energy production point, the Arsenaal site. It will first follow the railway line to reach the water and materials team. On the other side, it will lead to the former Fly Over, which is now being transformed into an ecological corridor. With these changes, it will facilitate the installation of the underground heat network. This will reach the mobility, adaptability and food team as well as other houses to provide heating and cooling.

Following the urban team's planning for the street restructuring, the heat network will develop secondary loops. When the mineral pavement of the streets will be transformed into greener streets, it will be easier to install this network. The network is, therefore, reaching every team.

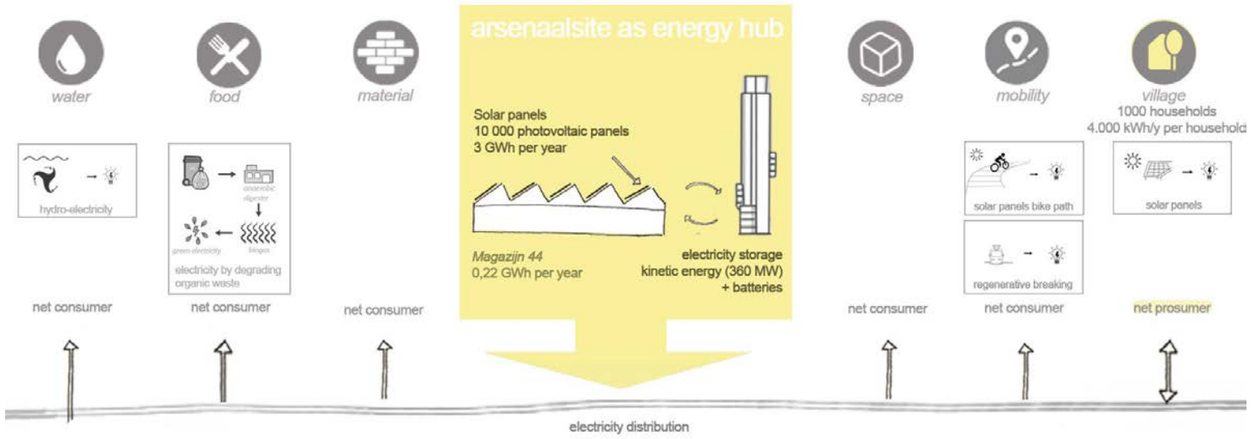
SUN ANALYSIS



As a major energy production centre, it was important for us to have good sun orientation and to have a lot of free and unused roof space. The Arsenaal site meets this need with its various sheds. The roof pitch and orientation are suitable for the installation of solar panels. The south-western orientation of the roofs is perfect for maxim sunlight.

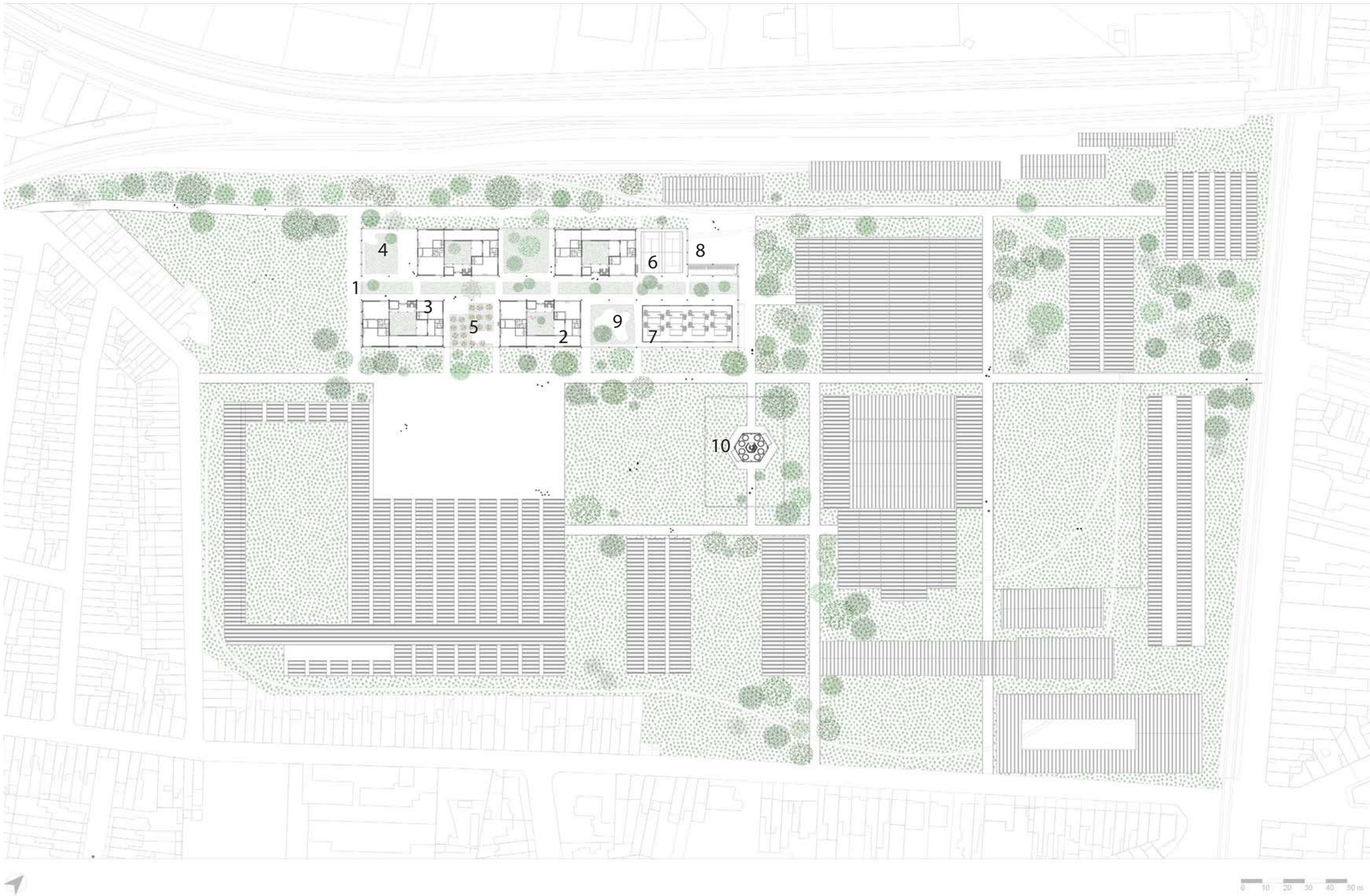


Most of the heat will be produced by geothermal fields on the Arsenal site and stored in a 450,000 L tank in our building. The heat will be distributed to every team through the main loop to provide them heating in winter and cooling in summer.



Electricity production through solar panels will be stored into the tower and batteries. It can be shared to the other teams through an electricity network. Some of the teams such as material, mobility and the food team got their own solar panels and then provide to their own needs but the network will support them in case the energy they produce doesn't respond to their demands. Also, some innovative way to produce green energy link to their own theme will be set up. For example, the water team install water turbines to generate hydroelectricity with slow moving water in the blue network. The food team can produce biogas with the food waste of their production but also waste from the inhabitants. Finally, the mobility team implement several electricity production in the slow mobility network such as regenerative breaking for tram, solar panels bike path and energy generative pedestrian tiles. All this innovation contributes to respond on the electricity demands of each building.

View on the Energy Tower and Magazijn 44 from the open square.



Ghent developed a plan for the Arsenaalsite in 'Ruimte voor Gent'. The city wants to give the existing high-potential site a new mixed interpretation with respect for the architectural heritage. The Arsenaal site is defined in the plan as a future urban hub. An urban hub is a place with a highly developed mobility network and urban facilities supplemented by housing.

By implementing this vision into our project we want to further develop this hub to the Energy Hub of Ghent. The program of our project consists of a recreational building on the ground floor with green spaces and commercial spaces (offices and retail spaces for green start-ups). The green areas are filled in with a sportsfield, a playgarden, a flower and vegetable garden and some recreational terraces. On the first floor, there is place for a residential program with private apartments and co-housing units.

Heat is provided by the use of geothermal fields. The geothermal heat is subtracted from the earth through geothermal pipes which we place on the Arsenaal site and around our building Magazijn 44. We can store this heat with a buffer on site.

Electricity will be produced on site by using solar panels. They are placed on the roofs of the three largest buildings of the Arsenaal site. The electricity can be stored in the Energy Tower.

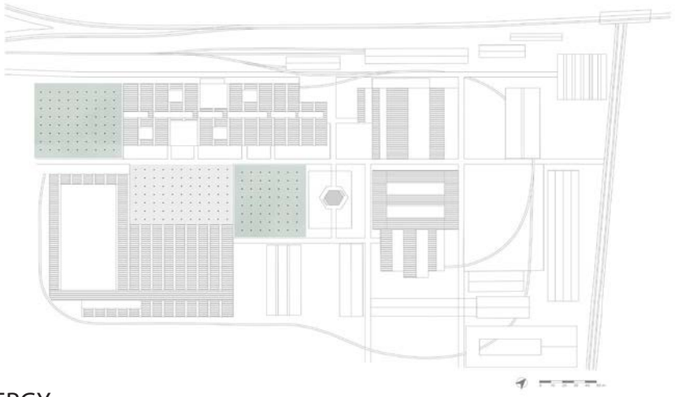
1. green axis
2. offices
3. retail spaces
4. recreational garden
5. vegetable/flower garden
6. sportsfield
7. heat buffer storage
8. bicylcle parking
9. playground
10. Energy Tower

NATURE

The majority of the open space is unpaved so nature can fill in the site. The green areas are also used as a barrier for the Arsenaal site. The areas can also be used as recreational gardens to create a living and dynamic environment for the neighborhood.

MOBILITY

The mobility plan of the site is based on a central axis in the middle of the site. The site is accesible by bike as it is a car free zone. The old railways are used as the outlines for a pathway. The railway station is next to the site for an easy connection with the city Ghent.



ENERGY

The heat is achieved by the use of geothermal fields. The electricity is provided by solar panels on the roofs of three buildings on the Arsenaalsite. The Energy Tower works as a storage for the electricity.

SOLAR PANELS (electricity)

25 000 m2 for 10 000 solar panels
-> 3000 MWh/year
-> equivalent of +- 1000 households

GEOTHERMAL FIELD (heat)

150 bore holes
-> 6 570MWh/year
-> equivalent of +- 1000 households

BUILDING SCALE : TOWER

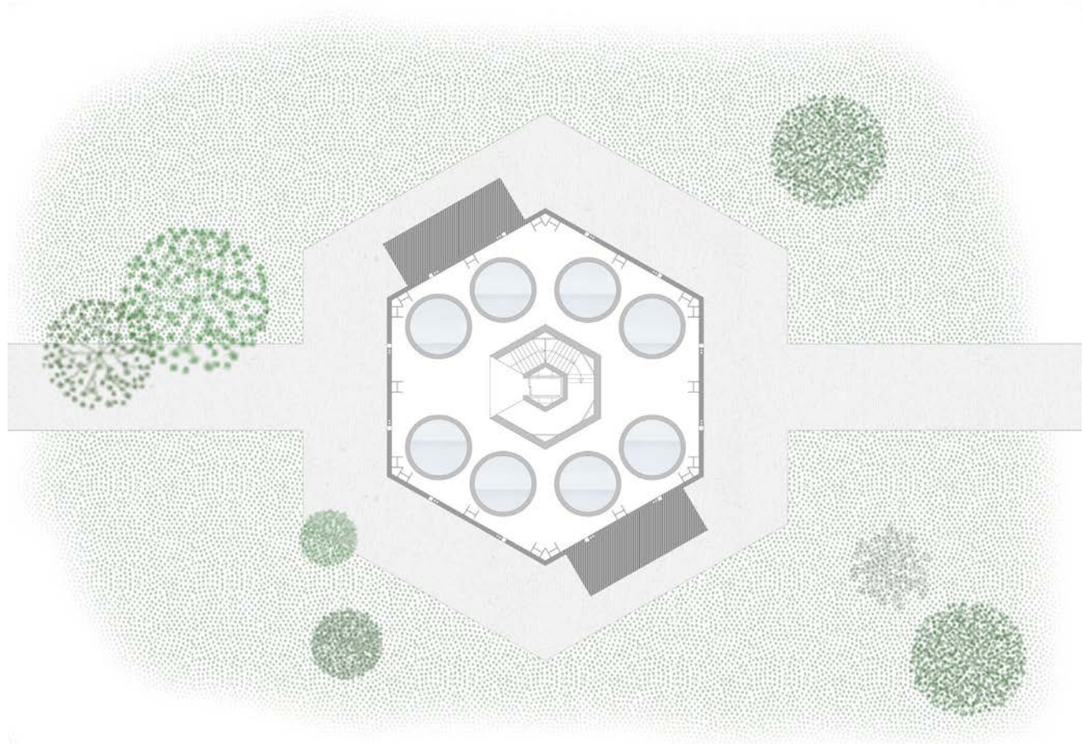
The Energy Tower is placed central in the Arsenaalsite. For the storage of electricity we have created an energy storage tower. This tower can store energy temporarily trough gravitational force and kinetic energy. This way of storing energy means that the tower is always in motion. As the tower measures 60m in height this movement is visible all over the village and neighborhoods.

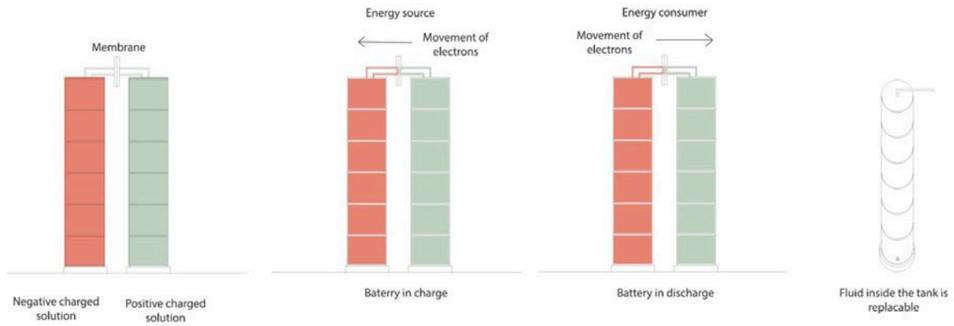
The tower is a landmark for our energy site. The function of the tower is to store energy on a day-to-day basis. That is why there are four redox flow batteries placed inside the tower. They can provide enough power to cover a shortage for around 2100 families for a period of 24u. These redox flow batteries have a longer life span than ordinary batteries and do not need to be completely replaced, their liquid just must be changed. This way we can ensure that the tower can keep being the center of energy storage for a long time. That is why we have chosen for these types of batteries and not the conventional kind. We want to keep the focus on the "natural" part of our village. And research behind these types of batteries show that there is a possibility to use water as a liquid inside the batteries. Making them completely circular. The technical rooms for the installations are integrated into the tower.

The tower also has a recreational program. Inside the tower there is place for vertical agriculture, but also green areas with vegetation. The program also contains a restaurant with a large view on Ghentbrugge. This way we have gardens and productive gardens that are on a height of 30-50m. These green spaces will be visible around the whole village. The restaurant in the tower uses the vegetables from the vertical garden and the food team.

SECTION

PLAN





Flow batteries

Vanadium- redox- flow batteries -> 15-25Wh/l capacity

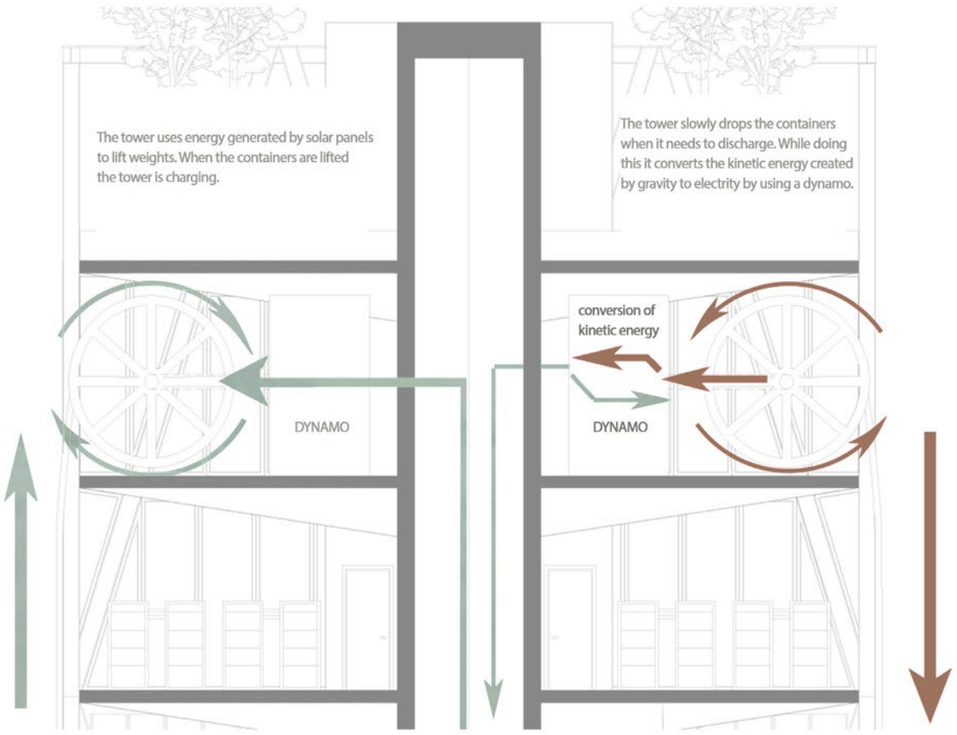
Tanks on site are Ø 3m and 15m high= Capacity of 106m³

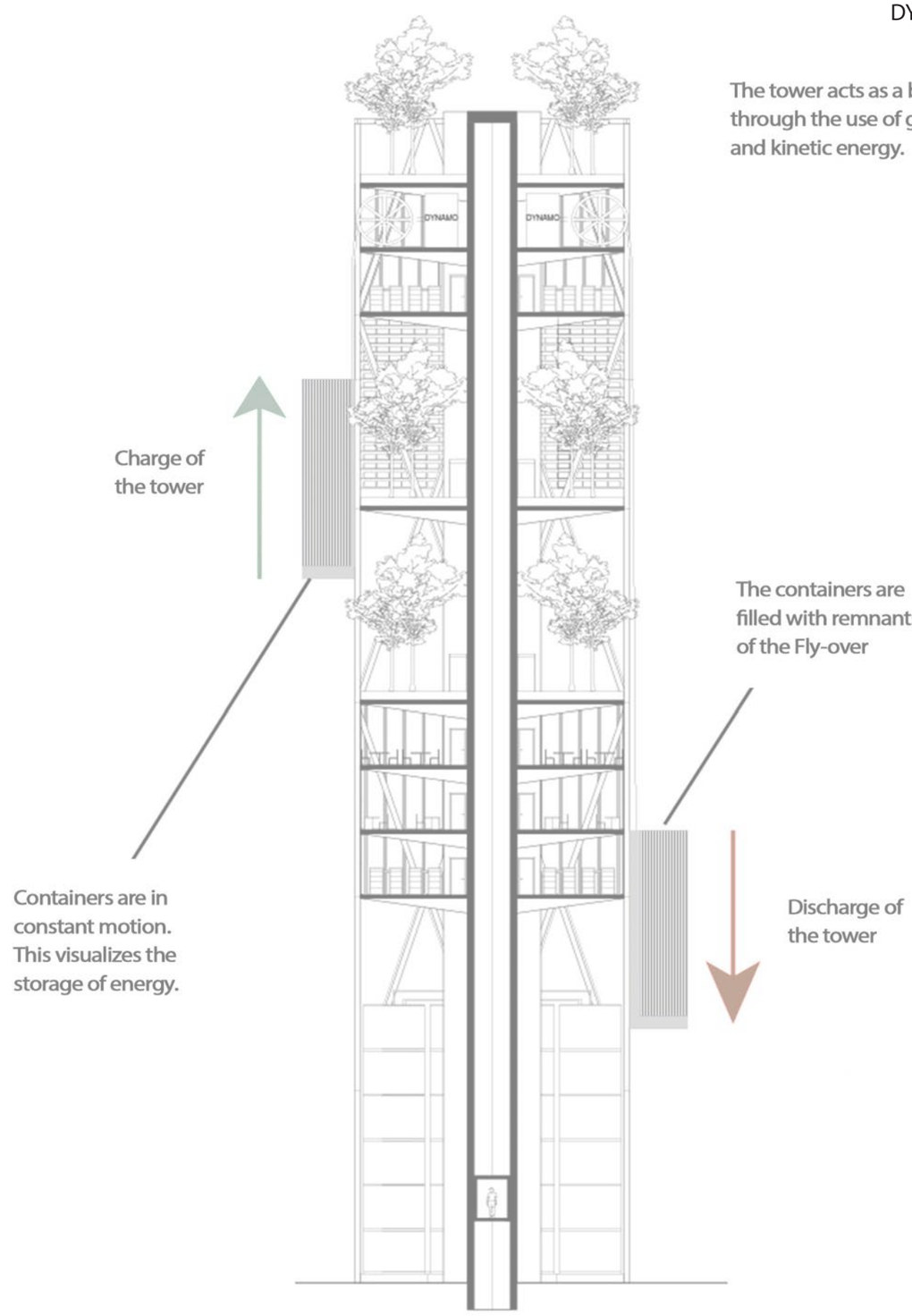
With 8 tanks on site = Capacity of 848m³

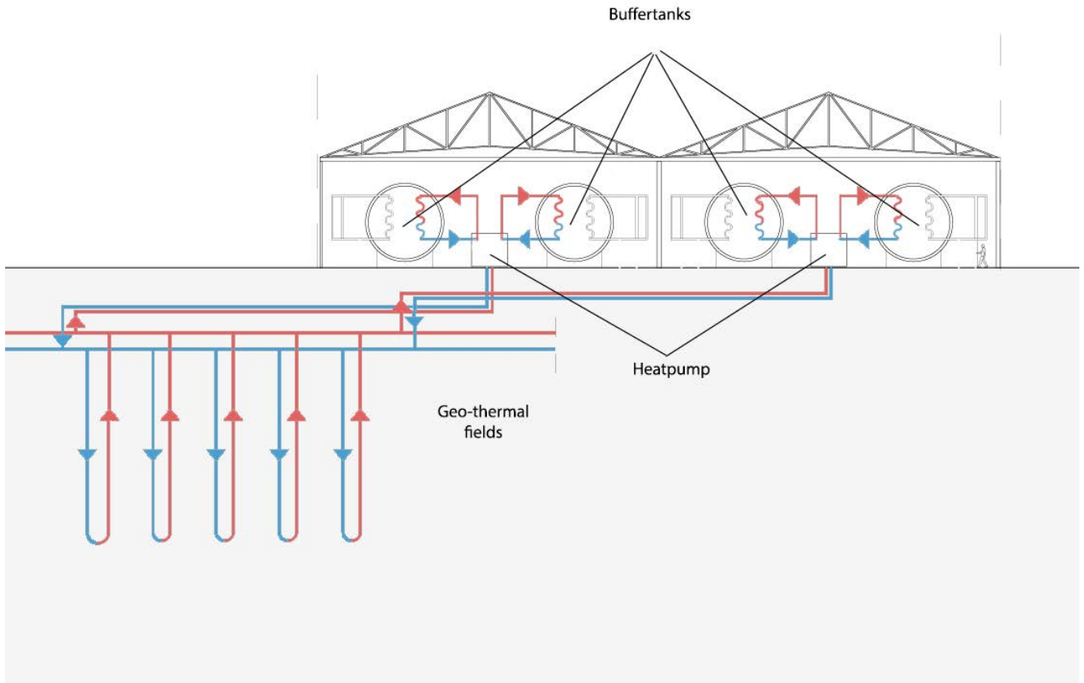
So we have $848000l \times \frac{25Wh}{l} = 21\ 200\ 000Wh$ = 21 200 kWh= 0,021MWh

Moderate family of 4 consumes ± 3500 kWh/year => ± 10kWh/ day

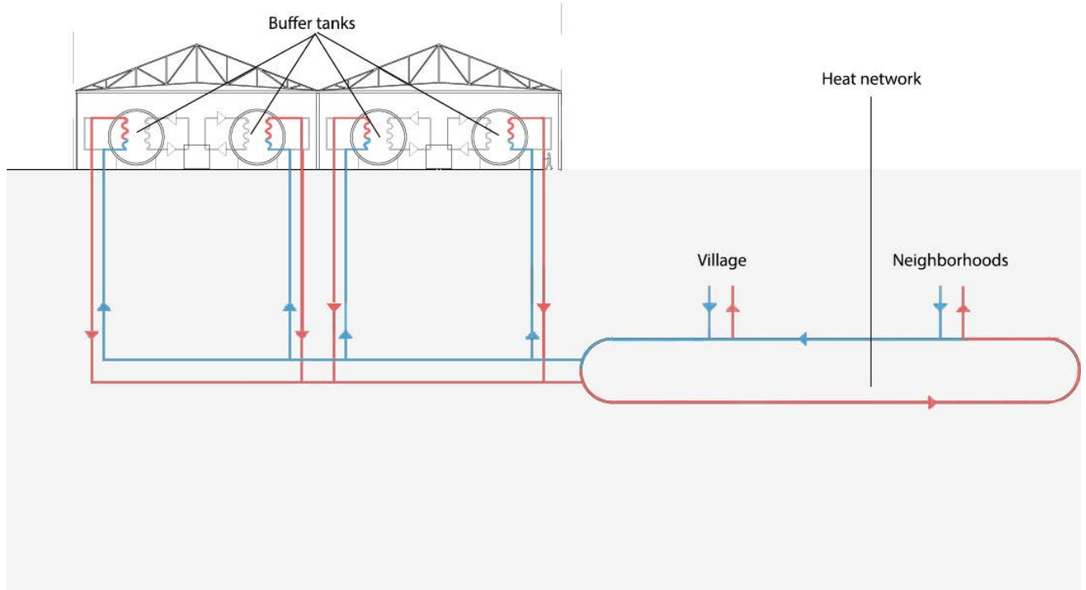
This makes sure we can supply 2120 families of clean energy for a day. With this buffer.


The tower uses energy generated by solar panels to lift weights. When the containers are lifted the tower is charging.
The tower slowly drops the containers when it needs to discharge. While doing this it converts the kinetic energy created by gravity to electrity by using a dynamo.
conversion of kinetic energy
DYNAMO
DYNAMO


The tower acts as a battery, through the use of gravity and kinetic energy.
DYNAMO
DYNAMO
Charge of the tower
The containers are filled with remnants of the Fly-over
Containers are in constant motion. This visualizes the storage of energy.
Discharge of the tower



The heat demand is answered by geothermal energy, there is a sort of failsafe in the system. When the groud is not delivering enough heat, we can add this by using an extra storage. The heat storage takes place inside Magazijn 44 and consists of 4 tanks with a capacity of 175m3. Inside the tanks there is water kept on a fixed temperature. The geothermal fields deliver the heat to a heat pump connected to the tanks. The heat pump will convert the heat to the tanks and it makes sure that the temperature stays the same.



The heat network takes heat from the tanks and delivers it to the connected buildings in the neighborhood. It is also possible that some buildings have residual heat. That residual heat can be put back into the heat network so that it will not be wasted. This residual heat can then go back to the buffer tanks. In this way the whole system is a closed loop with the focus on keeping the waste of energy to a minimum.

Buffer tanks heat storage.

*ref Energy Bunker Hamburg

Capacity for 3000 households - > 2 000 000l

Arsenaal site

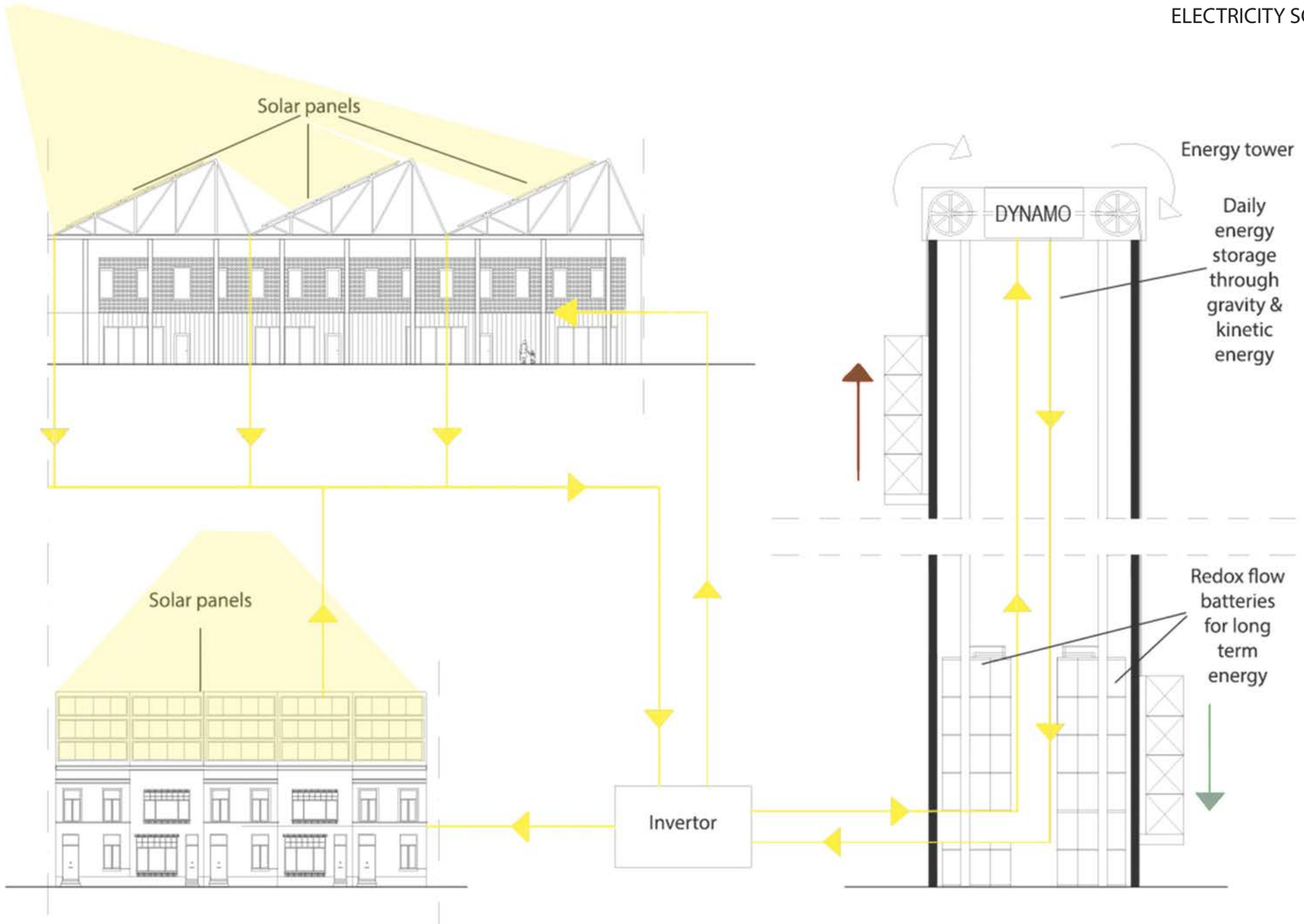
Capacity for 1000 households-> 700 000l

700 000l= 700m -> four tanks -> 1 tank = 175m³ (length 12m & Ø 4,5m)

Our main way of electricity production inside of the village is through solar energy. The total production is around 7,5 MWh/year. This is more then enough to provide for the village and the surrounding neighborhoods.

Firstly, the energy is being consumed directly by the users, so the natural village and the surrounding neighborhoods. To make sure that the network is completely independent we have placed 2 ways of storing energy on site. For a day-to-day basis we use the energy tower, and we use vanadium redox flow batteries to have an extra buffer of electricity in case of a shortage.

This system ensures that the electricity network is totally independent of fossil fuels. And also ensures that the natural village is independent in it's energy needs.

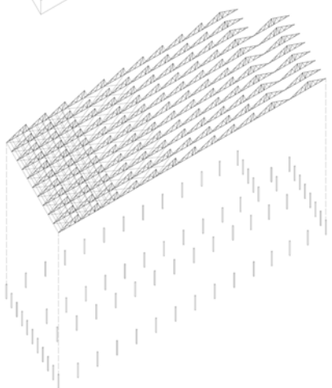


Calculation Solar panels
3 big buildings on site with ideal oriented roofs. (SW)
Total roof surface= 43 280 m²
Total surface x 1,5 (placement correction) = 28 853 photovoltaic panels
➔ 25 853 panels oriented south-west at ± 30- 45° (correction coefficient of 90%)
This gives us an output of 7 500 000 kWh/year= 7,5 MWh/year

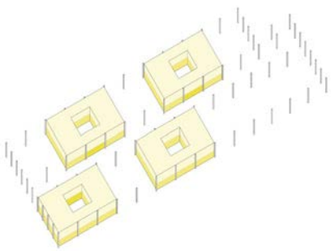
The view from the green inner street looking to the Energy Tower and the heat storage and the commercial/housing building.

OUTLINE

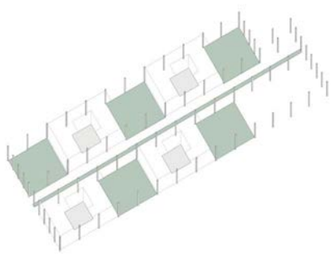
The outline of the existing building is preserverd. The typical shed roof



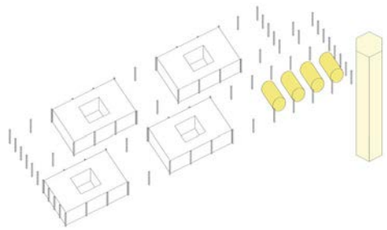
THE EXISTING STRUCTURE
The existing structure is retained. The grid provides flexibility and allows the project to evolve in the future. The prefab walls are removed and reused for the new volumes.



NEW BUILDINGS
In the existing building, new rectangular volumes are set up completely independent from the existing structure. Offices and retail spaces for green startups and gathering spaces activate the ground floor. The first floor accomodates the private part for housing and co-housing.

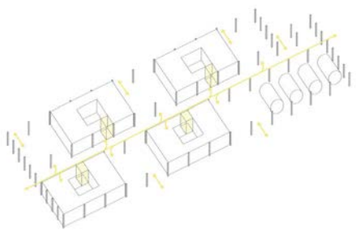


GREEN INTEGRATION
The public courtyard are gathering sapces with different uses depending on their location such as a productive garden, a playground for children, green terraces for bars and restaurants and a sportsfield. The private courtyard provides a more private outdoor space for the residents of the apartments or co-housing units.

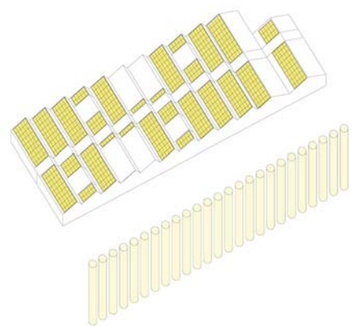


ENERGY PRODUCTION

-> the heat storage
-> the electricity storage



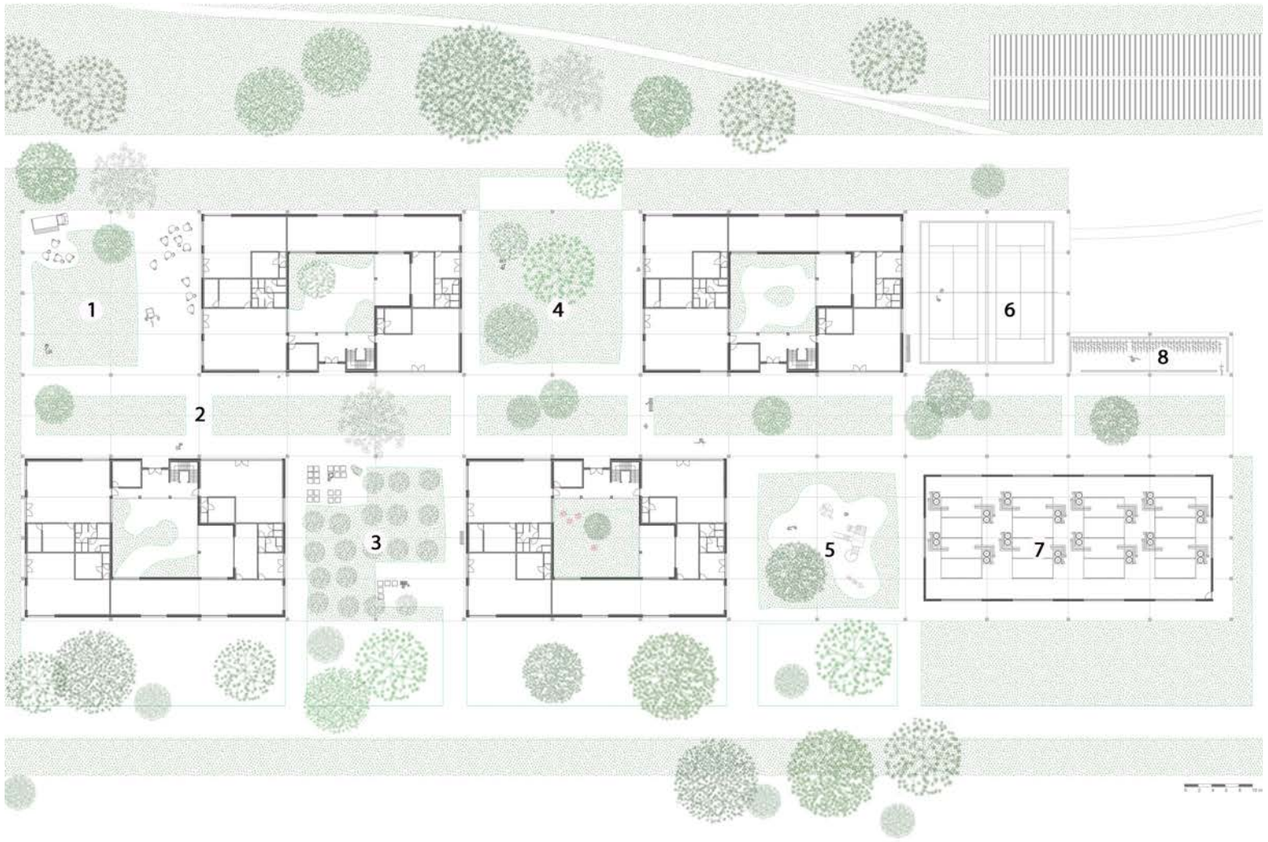
CIRCULATION
The building is accessible by an inner center street (green axis) that distributes the public courtyards, the retail spaces and the private entrances. It is also possible to enter through the public courtyards. The housing units are accessible by stairs and elevators in each volume. The vertical circulation is connected to the inner street.



ENERGY PRODUCTION
SOLAR PANELS
Some parts of the roof are removed to achieve the feeling of an open building. Where the shed roof is kept, solar panels are implemented facing South.

BEO FIELD
Geothermal pipes are installed in empty surfaces on the Arsenaalsite.

GROUND FLOOR



OFFICES / RETAIL SPACES

On the groundfloor we used a central green street as our circulation. The place will be a dynamic street that connects to the entrances of the offices and retail spaces.

On the first floor we offered two housing typologies in our building, 2-3 bedroom apartemens and co-housing. This way we hope to include as many social groups into the Arsenaalsite.

The offices and retail spaces are different in size, they offer working spaces to green startups. The commercial spaces will bring life into the site. The spaces are accessible by the green inner street.

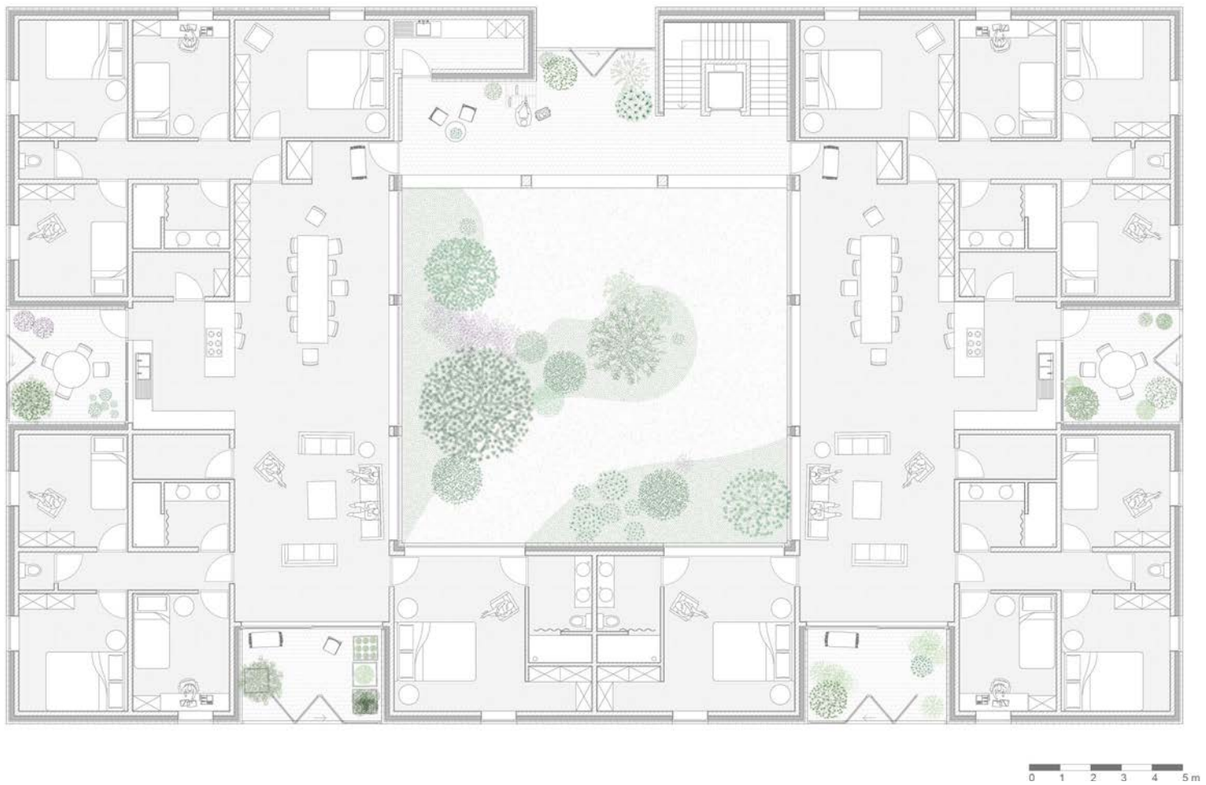
1 terraces and cafes
2 central green axis with bike path
3 vegetable garden and orchard
4 green square
5 play ground
6 sport fields
7 heat storage tanks
8 bike park

MAGAZIJN

APARTMENTS

The apartments have a difference in size, there is option between 2-bedroom and 3-bedroom apartments. Each apartment has a pr winter garden. The terrace can be closed of in winter scenario.

CO-HOUSING



The co-housing is made for 12 inhabitants per unit. Each unit has two winter gardens to bring the nature into the living spaces. The terrace can be closed of by a window in winter scenario. The living areas are orientated towards the patio.

MAGAZIJN

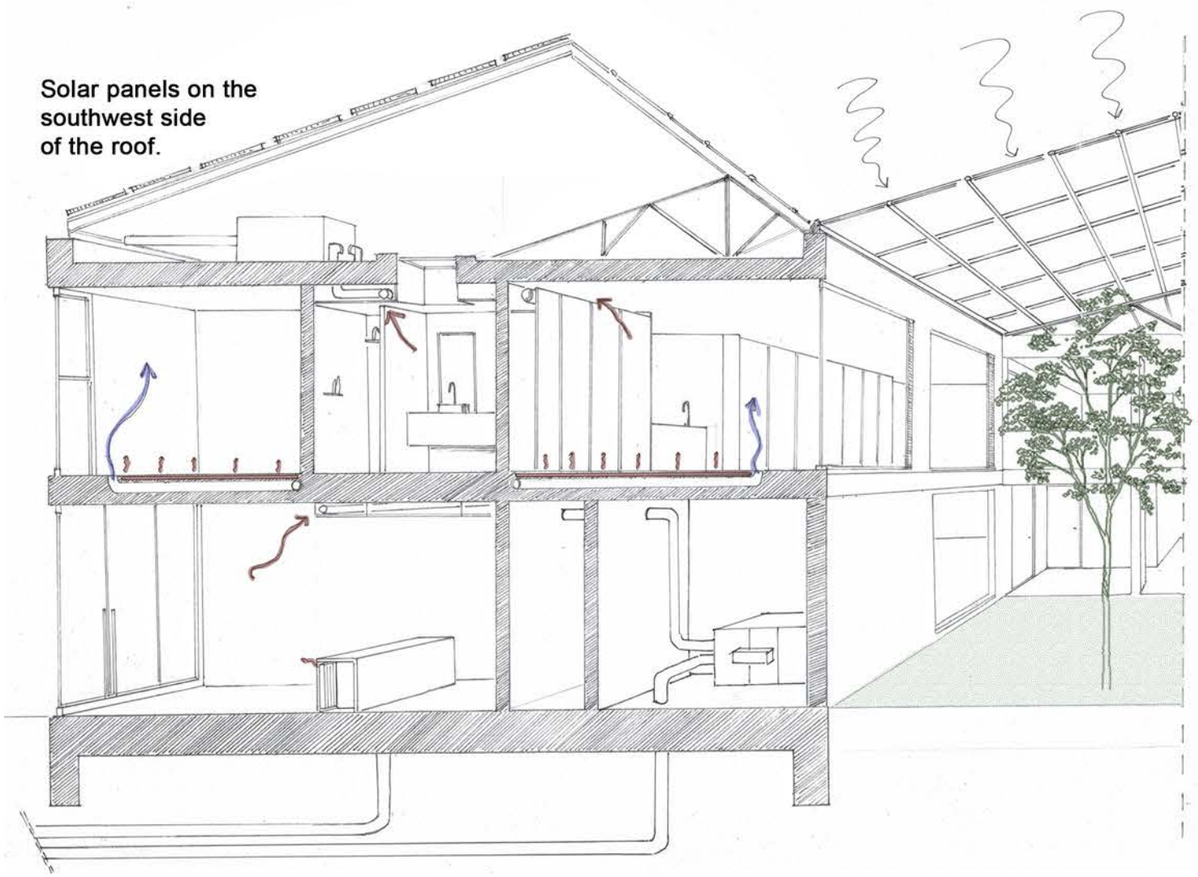
The view into the patio of a building block. Commercial spaces on the ground floor and housing on the first floor.

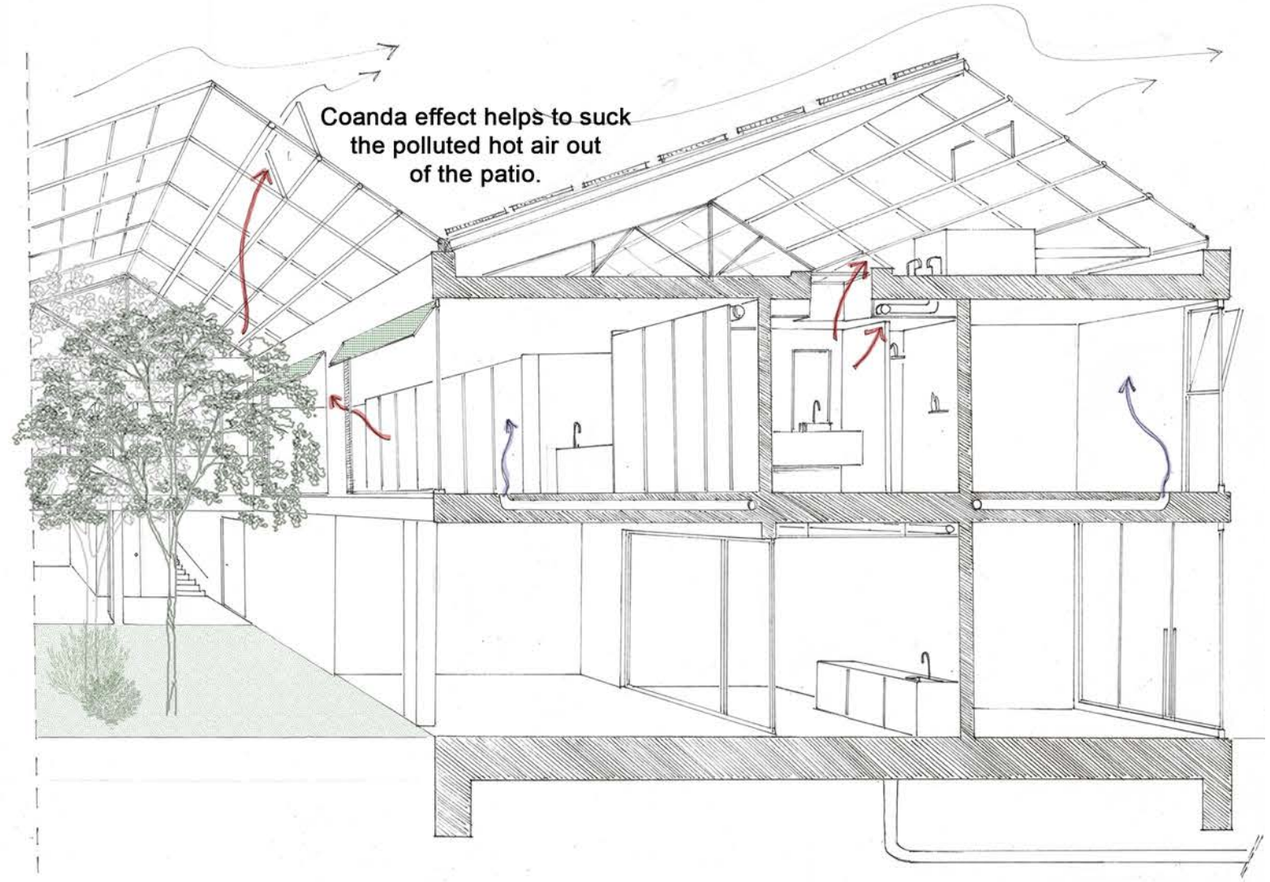
The old industrial construction works as framework for the new buildings. The open spaces are filled with plants and trees. Almost like nature is slowly invading Magazijn 44…

MAGAZIJN

During the winter the patio works as a greenhouse that catches the warmth of the sun and transfers it partly to the surrounding buildings. With this mechanism we reduce the energy costs for heating.

The warm polluted air leaves the building through the window openings and enters the patio. Because of the stacking effect the air warms up even more and rises quickly. On top of the patio windows are opened to create the chimney efect, that sucks the air even faster out of the patio.





Ground pipes pre heat the fresh air before it enters the building by benefitting from the soil temperature 2 to 4 m under the ground level. When the air enters the building, it will have an average temperature of 15°C.This way the air groups need to heat the air way less when compared to a classic system.

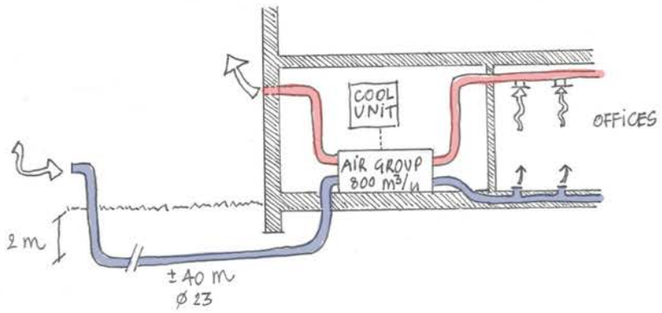
The offices are heated with ventilo-convectors, connected to the heat network. In the housing units, the rooms are heated with floor heating.

During winter the ventilation is mostly mechanical. In the offices we use an air group to have a more controlled environment. In the housing units we use a heat recovery unit. Both installations are connected to the ground pipes.

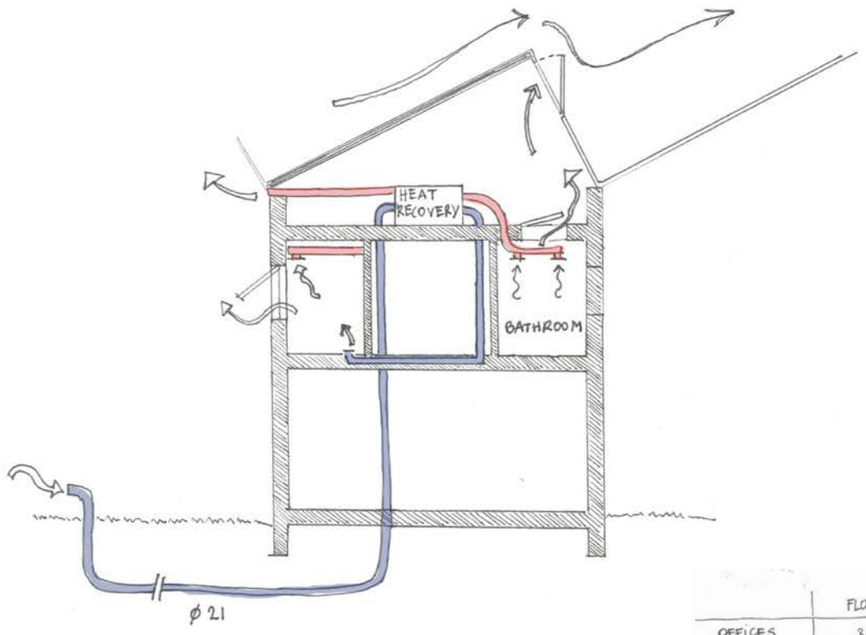
The vegetation in the patio, together with the solar screens on top of the windows help to keep the direct sun warmth out of the building.

During summer the ventilation in the housing units is hybrid. The ventilation system D+ is supported by natural systems. To create a more heavy air flow to cool down, the windows can be opened on the site of the patio. Also above each bathroom there is a skylight, that can be opened.

Ground pipes cool down the fresh air before it enters the building. When the air enters the building, it will have an average temperature of 15°C.This way the air groups need to cool down the air way less when compared to a classic system.



1. ventilation in offices and shops : controlled climate with a mechanical ventilation system D+



	FLOW	RATE
OFFICES	800	m³/u
COHOUSING	660	m³/u
APP 1.	280	m³/u
APP 2.	170	m³/u
APP 3.	280	m³/u
APP 4.	315	m³/u

2. hybrid ventilation in the apartments and co-housing units

The controlled climate in the offices and shops is obtained through a mechanical ventilation D+ system. To make the mechanical system more energy efficient, we connected ground pipes to the air group. Ground pipes pre heat / cool down the fresh air before it enters the building. This is a natural system benefitting from the soil temperature 2 to 4 m under the ground level. In order to warm / cool down the air enough, the pipes should be longer then 40m. When the air then enters the building, it will have an average temperature of 15°C, quite constant during the whole year. This way the air groups need to warm / cool down the air way less than with the classic system.

Since the climate in offices needs to be of high comfort, we installed a cool unit to the air group. Just in case, when extreme temperatures demand a higher cooling level. Regarding the ventilation distribution, we follow a logical system of air flow. The fresh, clean air is blown into the spaces via ventilation openings in the floor. The air warms up, and rises to the ceiling where it is extracted by the ventilation terminals in the false ceiling.

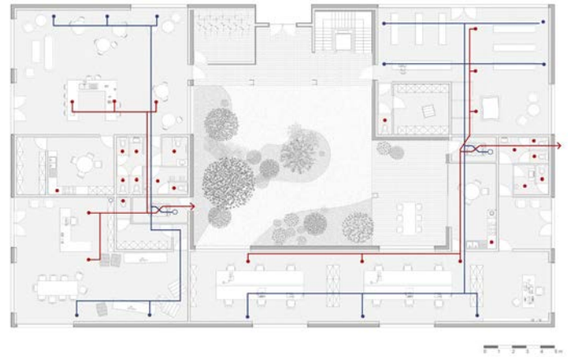
In the housing units, we use hybrid ventilation: a mechanical system D+ supported by natural ventilation. Heat recovery units (85% efficiency) are placed on the rooftop. To make the system more energy efficient, we use the same principle as in the offices: connecting a ground pipe to the installation. This way the installation needs to warm/ cool down the air less than with a classic system or during most mild days, the incoming temperature will be enough to provide a good living climate inside.

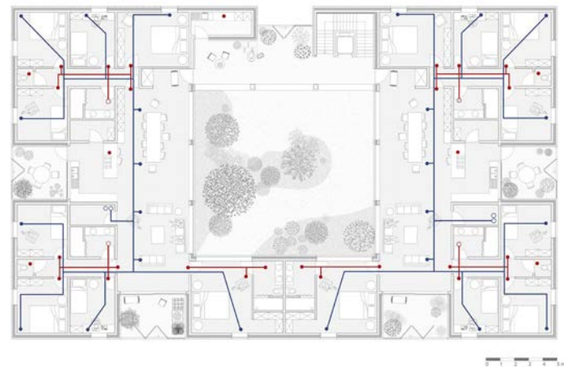
The fresh air is blown into the bedrooms, living rooms and dining rooms through openings in the floor. The air rises and is extracted by ventilation terminals above the doors. The polluted air is brought to the bathroom, where it leaves the building through the roof. It passes the heat recovery unit where it transfers its temperature partly to the new fresh air.

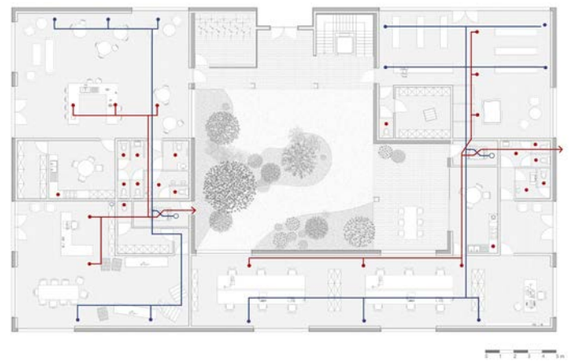
This system is supported by natural systems during summer. To create a more heavy air flow to cool down, the windows can be opened on the site of the patio. Also above each bathroom there is a skylight, that can be opened. The warm air then travels through the window openings to the patio. Because of the greenhouse effect, the warm air warms up more quickly and as a result also rises faster to the top of the patio. On top of the building two effects accelerate the process of extraction. The chimney effect and the coanda effect, that is made possible by the shape of the shed roofs and the south west wind.

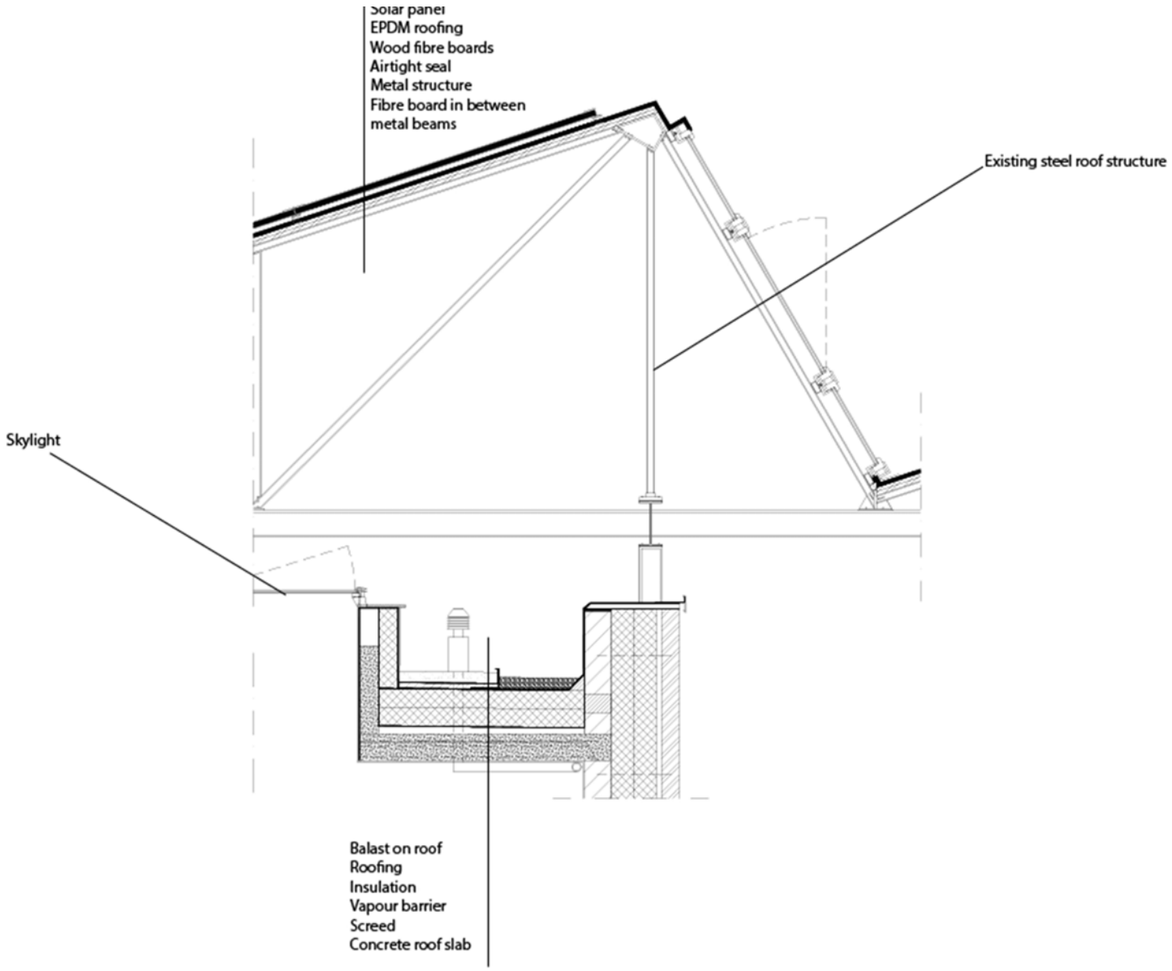
VENTILATION

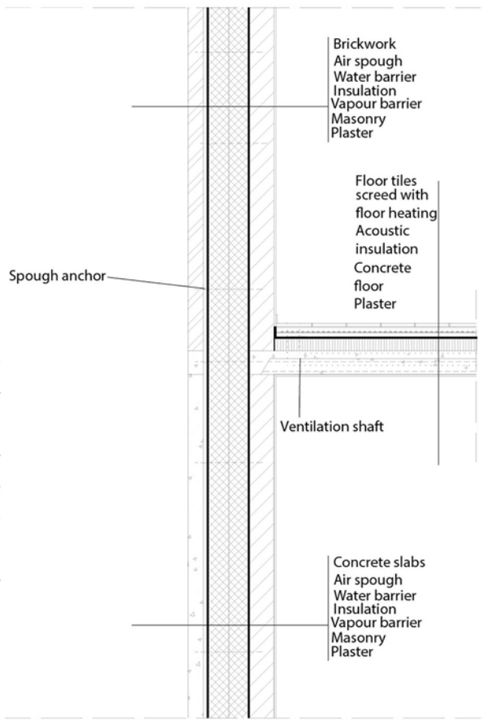
- extraction points
- main extraction duct
- pulsion points
- main pulsion duct / ground pipes







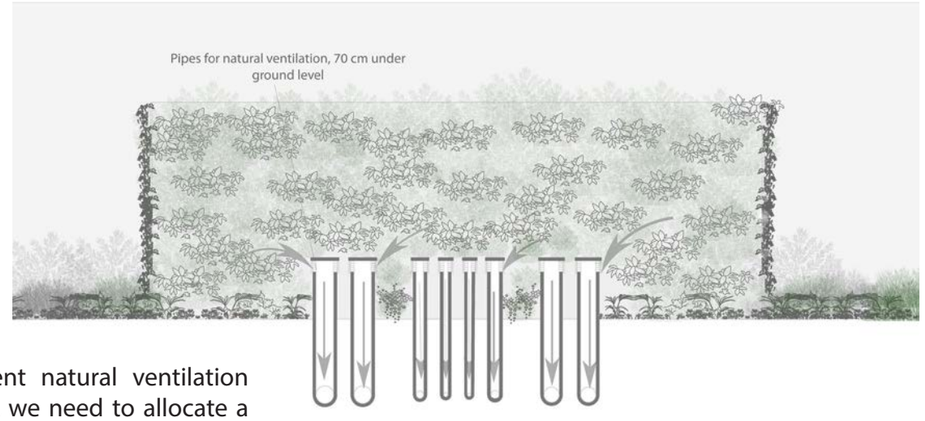




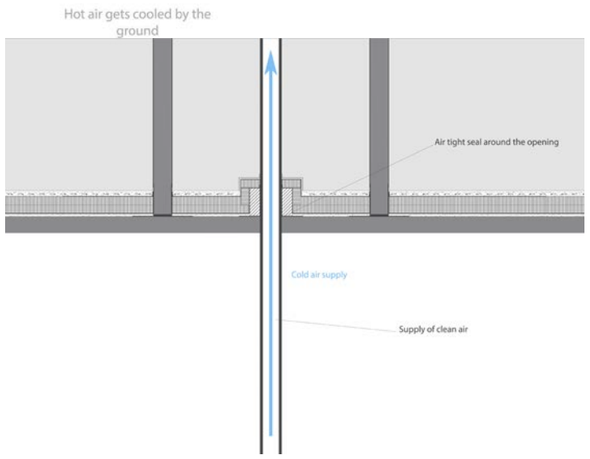
The materials of the existing buildings are used to make our new volumes in Magazijn 44. Concrete panels are recoverd to use as material for the facade of the offices and retail spaces. The brickwork is also recuperated to use for the facade of the residentual parts of our buildings. There is no transport needed because the deconstruction process is already on site.

DETAILS

NATURAL VENTILATION DETAIL



As we implement natural ventilation in our buildings, we need to allocate a place on site where put the supply. This is a place where all the tubes suck in the fresh air for the supply of the ventilation system. This place needs to be in an open area with and away from the building. As we put the supply tubes underground to cool or heat the air according to the season. We need at least 40m of piping to adequately cool or heat the air. That is why these aren't located in near proximity of the building. Furthermore, there is vegetation around supply vents to ensure that the air that gets sucked in is clean and fresh. Through this way we can supply our building with clean and fresh air via a natural system.



With our design we hope to re-activate the old Arsenaal site by making it an urban neighbourhood bursting with energy, literally and figuratively. The Arsenaal site will be an extension of the natural village, a car free zone filled with vegetation. A focal point where life, work and leisure emerge. These three functions also come back in the central piece of our site, the energy tower. Visible from a distance, it will become a new landmark of Ghentbrugge. A new tower is introduced, more fitted for the sustainable vision of the city Ghent.