

# Growing buildings

How to design circular and sustainable buildings by using living organisms in architecture

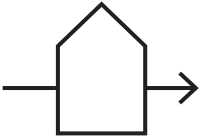
Kamila Waszkowiak  
P5 presentation - 31/12/2018  
Mo Smit | Hubert van der Meel | Foteini Setaki

# **WHY?**

## Problem statement

# HOUSING IN THE NETHERLANDS

## NON-ECOLOGICAL



### LINEAR

Construction made in old-fashion, uncircular way

## ANTI-SOCIAL



### PRE-DESIGNED

Futher inhabitants have nothing to say about the design

## EXPENSIVE



### SCARCE

By 2020, that shortage is expected to grow to 235 thousand homes.



### OUTSOURCING

Housing complex is not providing all needed facilities and services



### INTROVERT

New housing projects are rarely community-oriented



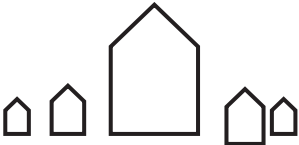
### COSTLY

An average person needs to spend 10 year worth salary to buy an average house



### SINGLE-USE

Building designed without thinking about possible re-use



### SPRAVLING

More and more houses are build on the fringe of the cities



### SMALL

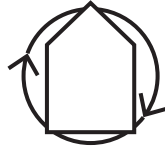
Over the past few years, relatively more studio apartments were built in cities for starters

**WHAT?**

Towards modern housing

# HOUSING OF THE FUTURE

## ECO-FRIENDLY



### CIRCULAR

Cradle to Cradle - all materials can be reused, recycled, upcycled or degraded

## SOCIAL



### SELF-DESIGNED

Inhabitants having direct influence on the design

## ECONOMICAL



### SELF-SUFFICIENT

Producing food, energy and clean water for inhabitants



### SUSTAINABLE

No damage policy - all materials used are not harmful to the environment or inhabitants



### SHARED

Common spaces for inhabitants



### SELF-PRODUCING

Producing part of the building materials on the site



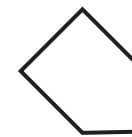
### ECOLOGICAL

Carrying about nature and inhabitants well-being



### CITY-MAKING

Providing services and places for the whole neighbourhood



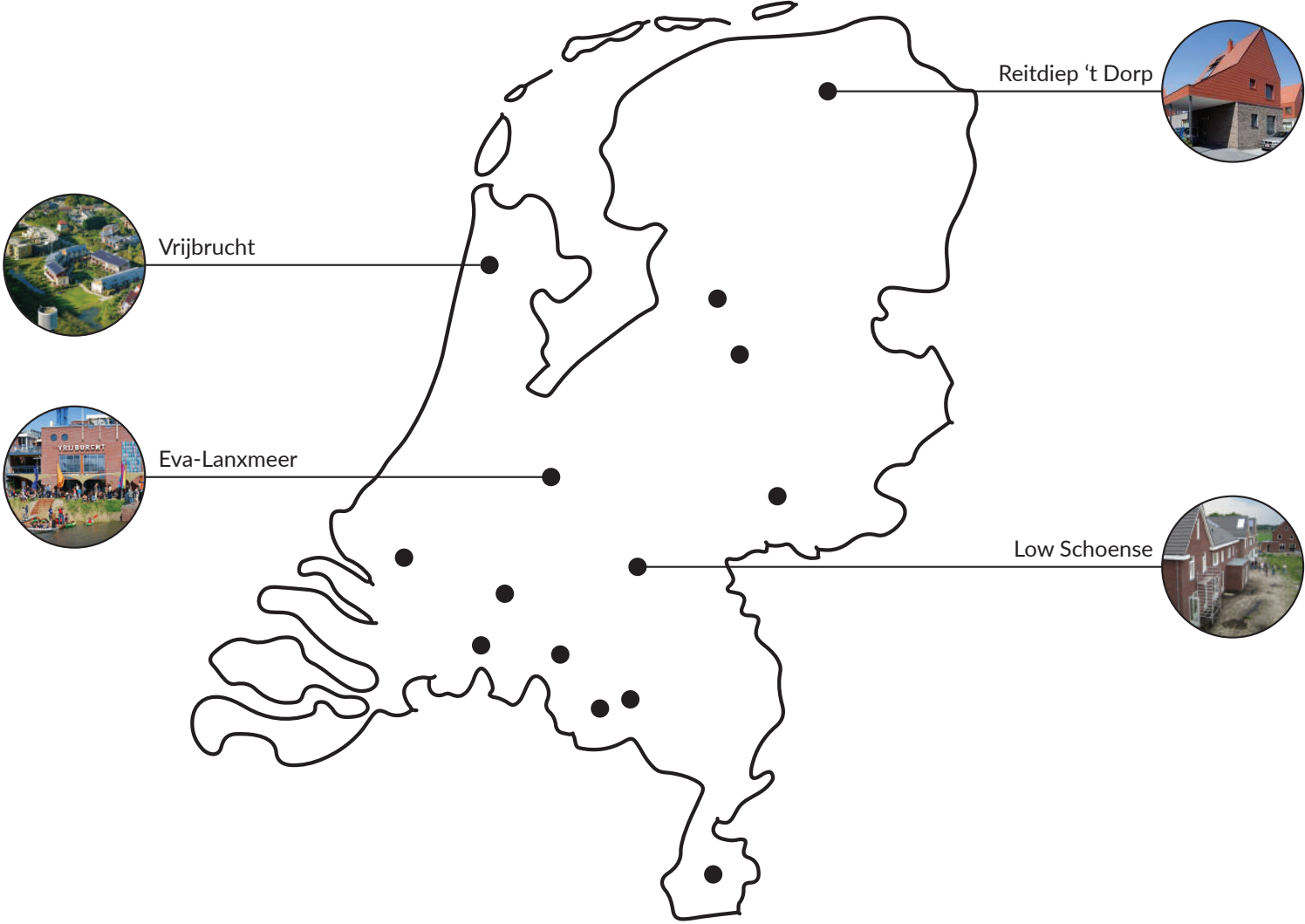
### FLEXIBLE

Design allowing the owners to easily change the layout of their apartments

# **CPC - COLLECTIVE PRIVATE COMMISSIONING**

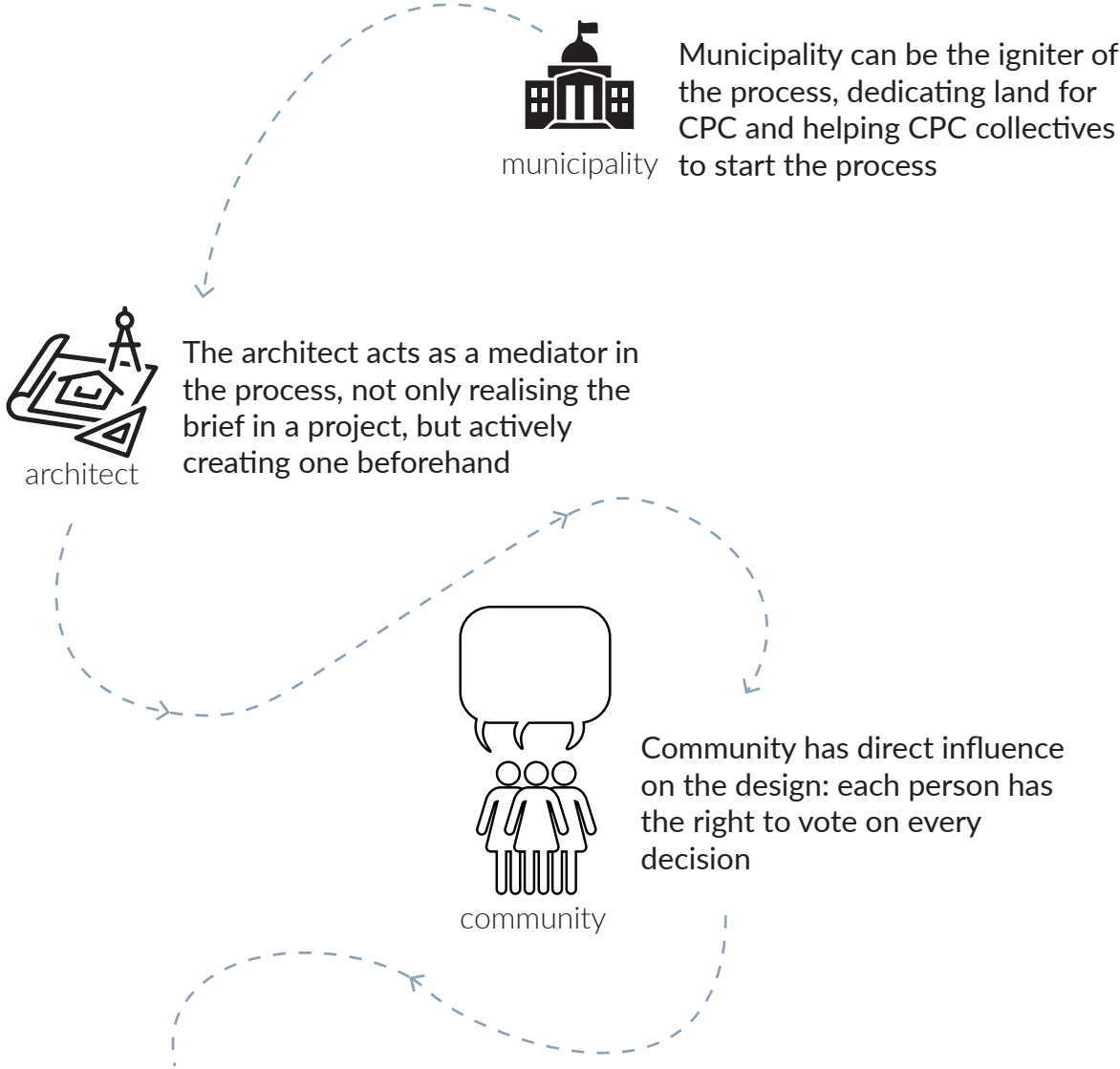
# CPC - COLLECTIVE PRIVATE COMMISSIONING

in the Netherlands



# CPC - COLLECTIVE PRIVATE COMMISSIONING

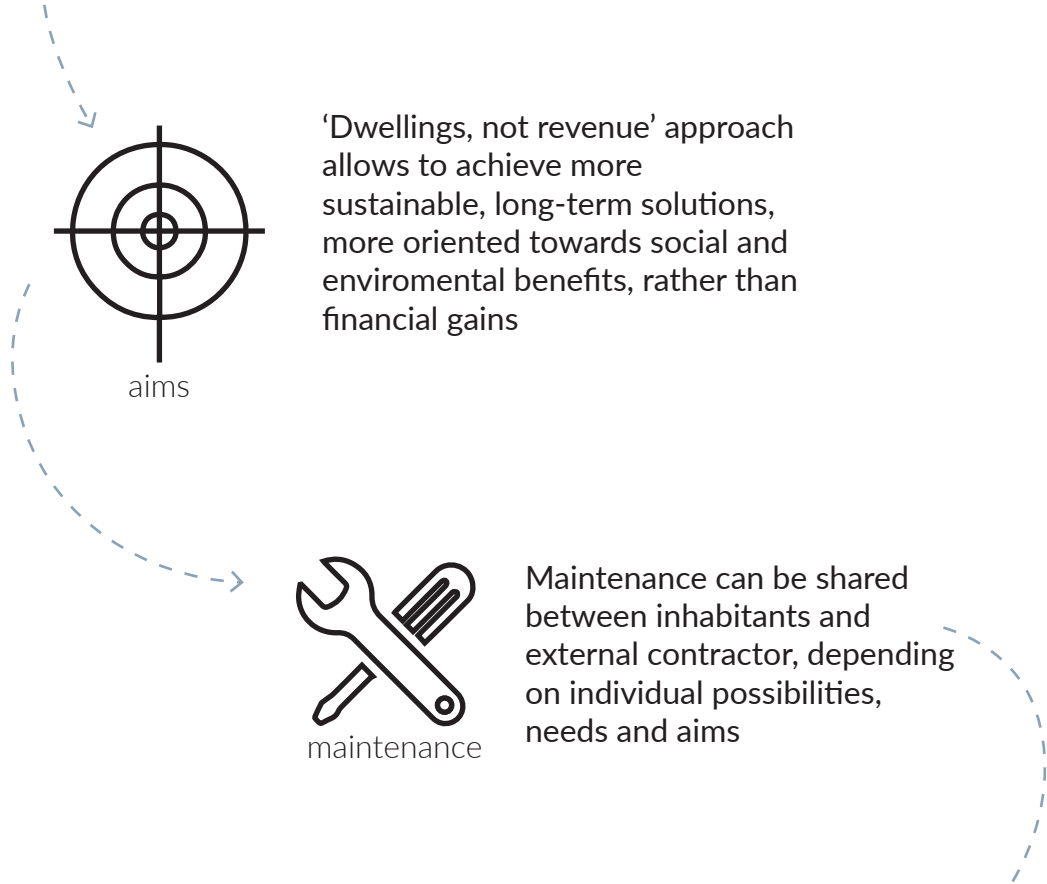
## actors and factors





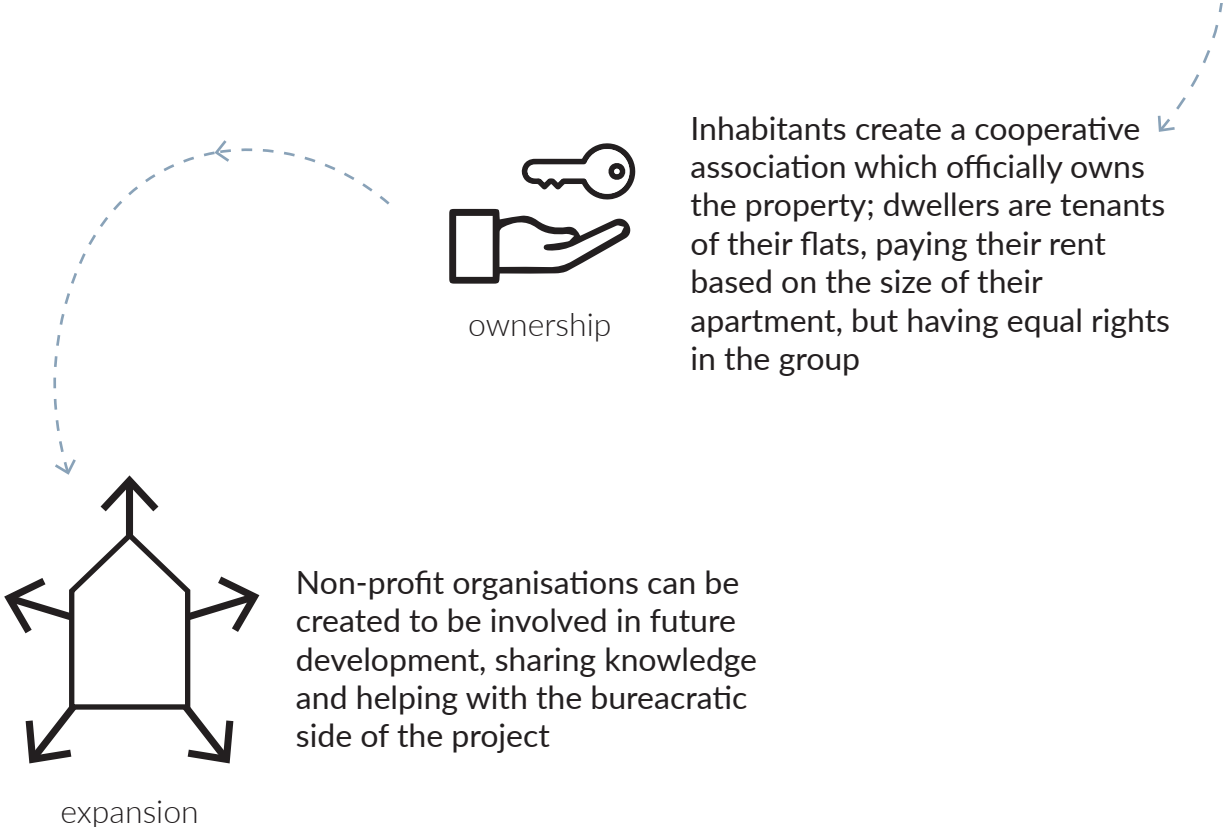
# CPC - COLLECTIVE PRIVATE COMMISSIONING

actors and factors



# CPC - COLLECTIVE PRIVATE COMMISSIONING

## actors and factors



# CPC - COLLECTIVE PRIVATE COMMISSIONING

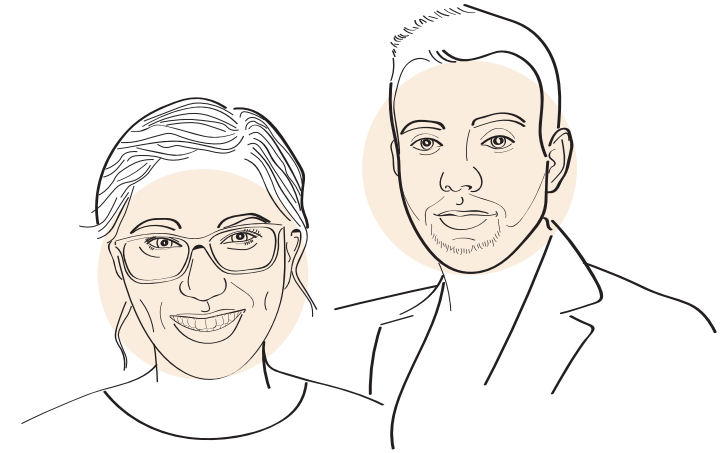
Theoretical commissioners



**Emi and Rafat**



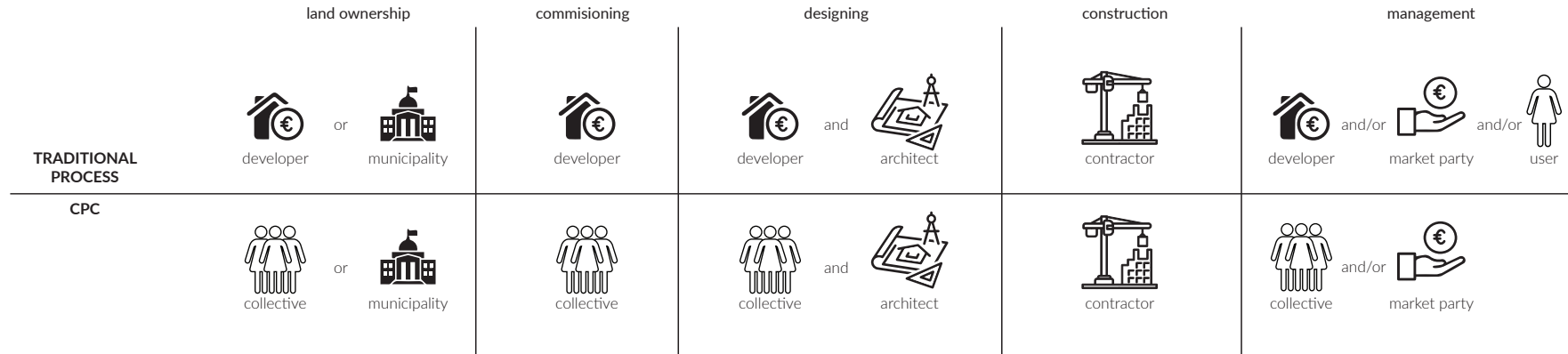
**Barbara and Davide**



**Paulina and Marek**

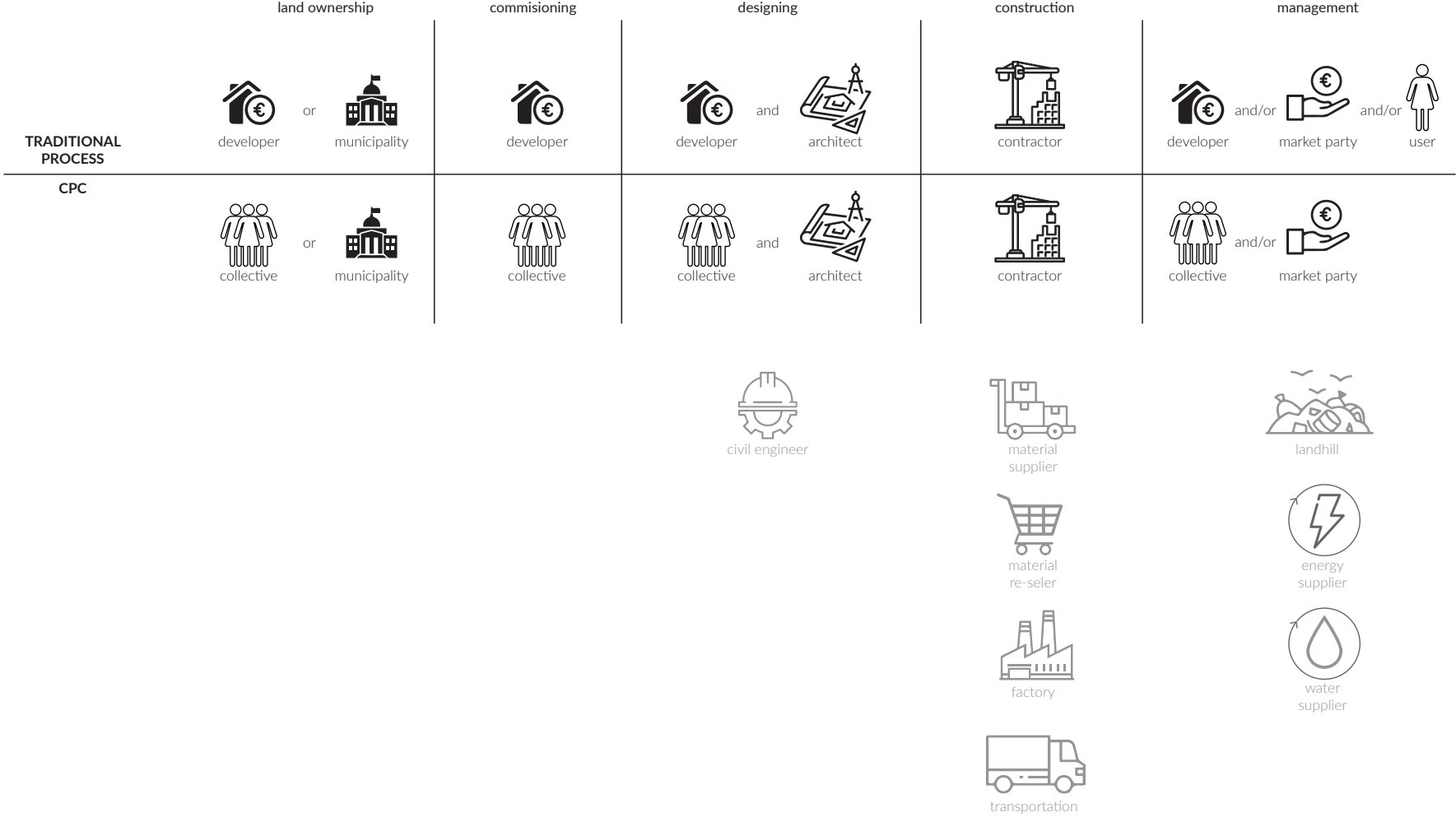
# CPC - COLLECTIVE PRIVATE COMMISSIONING

actors and factors



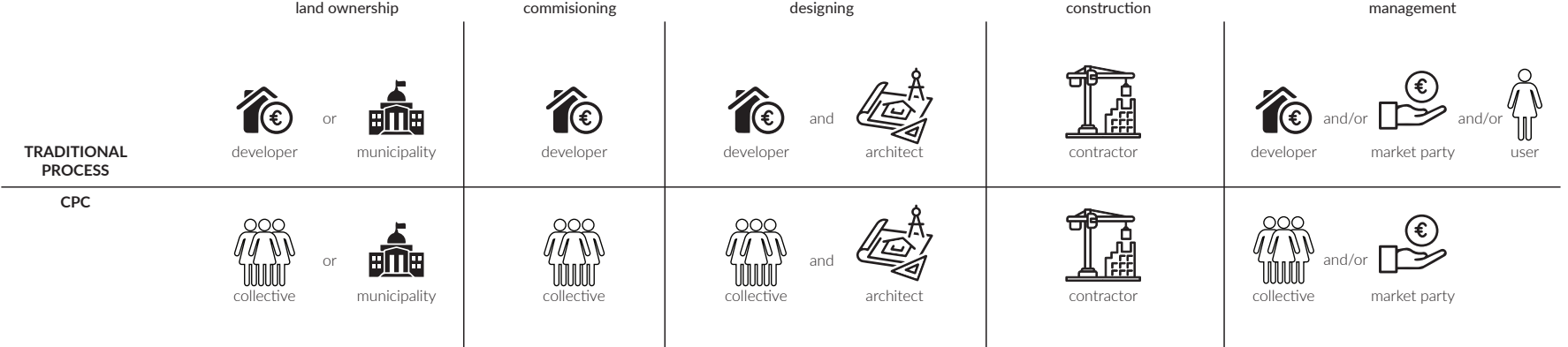
# CPC - COLLECTIVE PRIVATE COMMISSIONING

## actors and factors

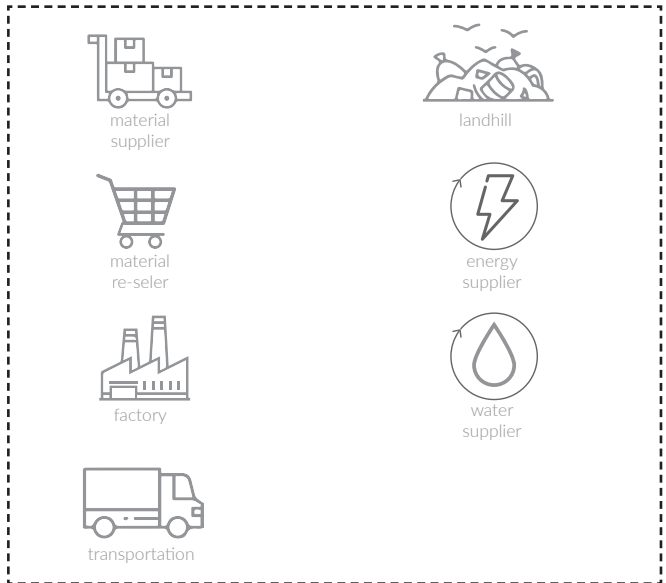


# CPC - COLLECTIVE PRIVATE COMMISSIONING

## actors and factors



civil engineer



**HOW?**

Growing architecture - towards nature

# FASCINATION

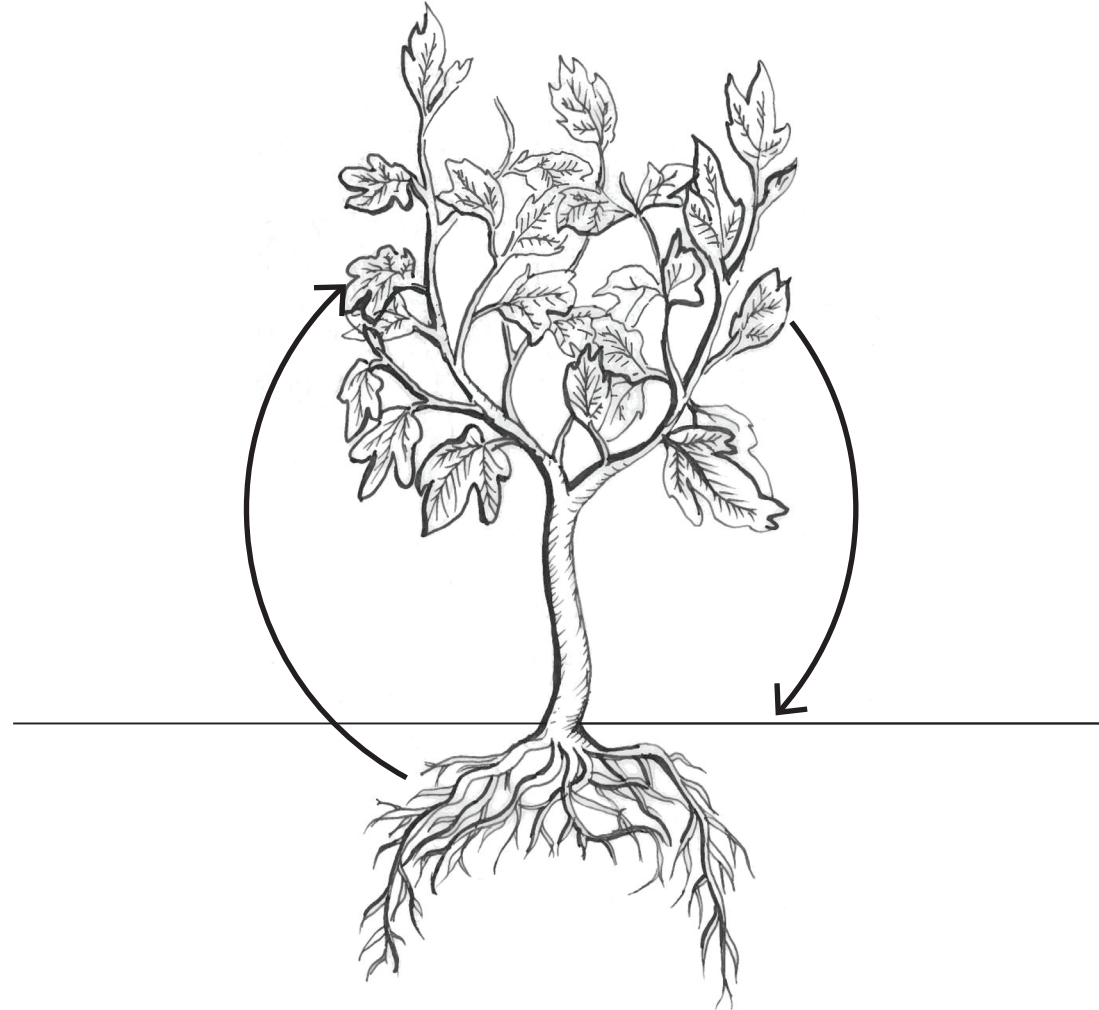
Nature





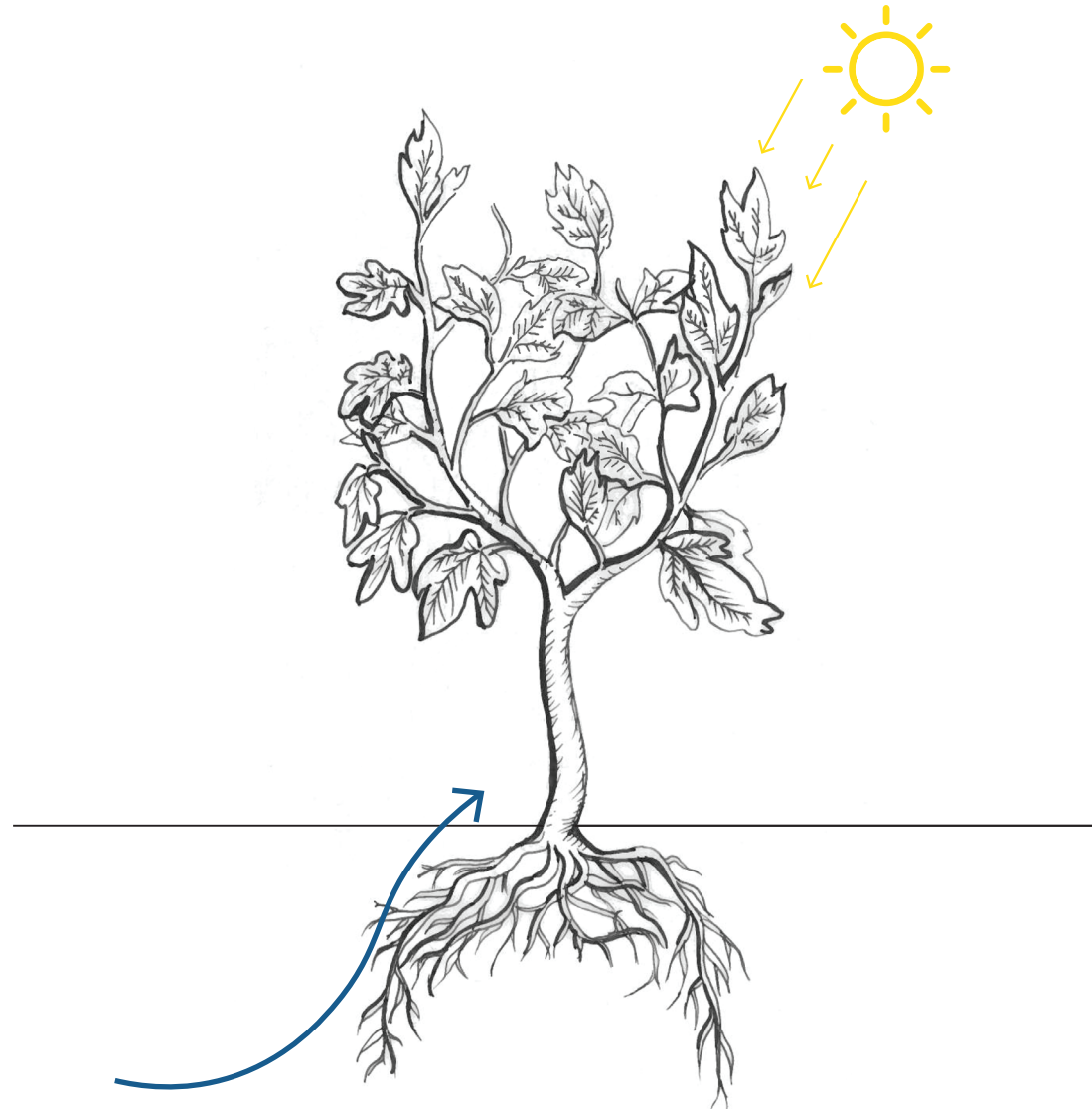
# FASCINATION

Benefits of nature



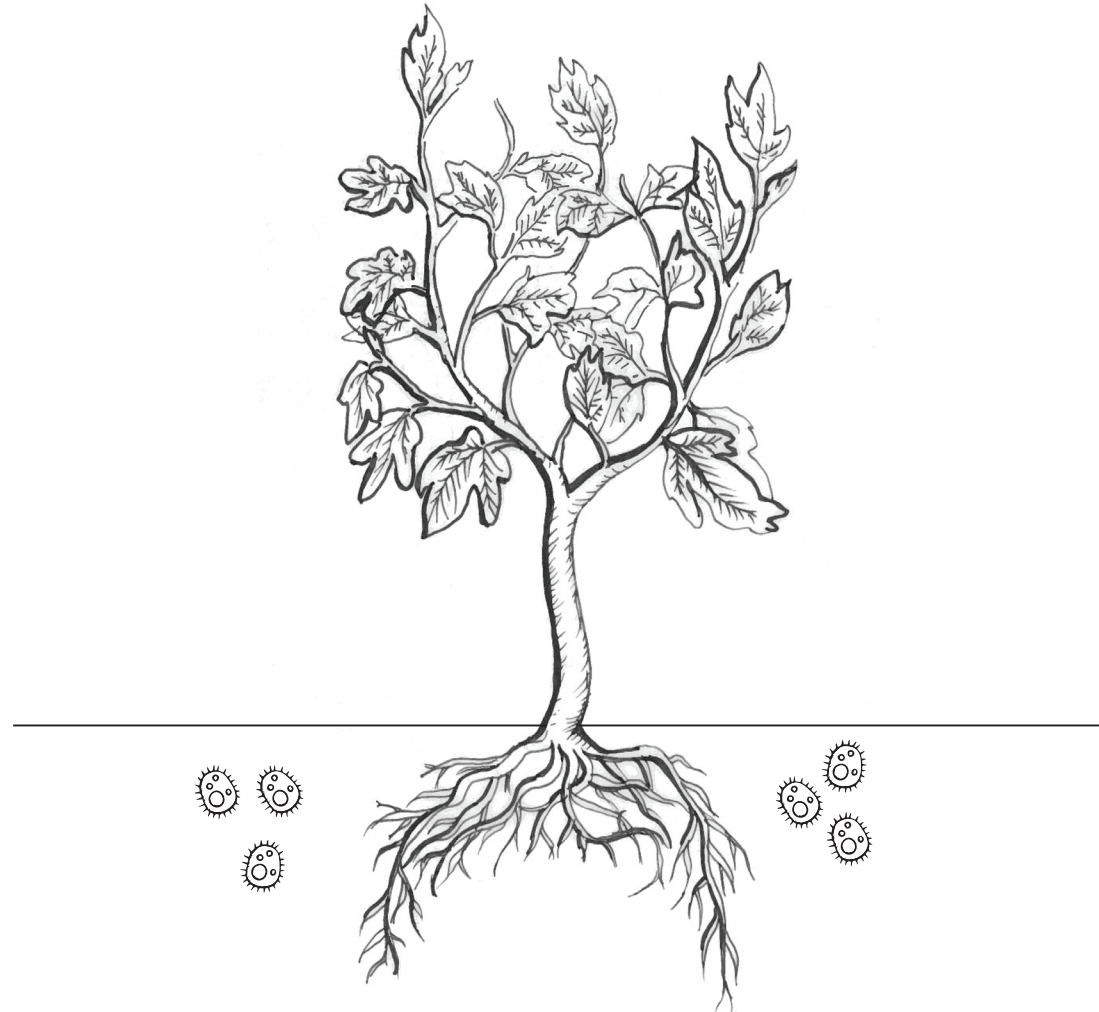
# FASCINATION

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Benefits of nature



































# **RESEARCH**

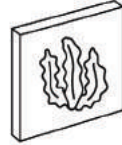
Growing buildings: what are the benefits of techniques integrating living organisms in architecture?

# RESULTS

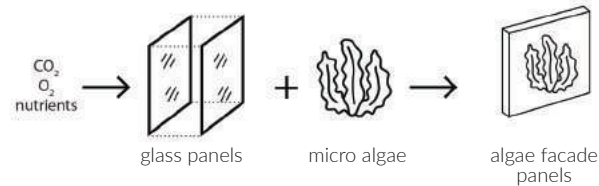
## Glossary of the techniques

		<b>Bacteria-grown bricks</b>
		<b>Mycelium-grown brick</b>
		<b>Mycelium building frameworks</b>
		<b>Mycelium thermal insulation</b>
		<b>Mycelium sound insulation</b>
		<b>Tree-shaping</b>
		<b>Baubotank</b>
		<b>Tree shading and cooling</b>
		<b>Tree water management</b>
		<b>Tree pollution reduction</b>
		<b>Algae lamp</b>
		<b>Algae elevation panels</b>
		<b>Algae in ETFE cushions</b>
		<b>Green roof</b>
		<b>Living wall system</b>
		<b>Green facade</b>
		<b>Plantecaping</b>
		<b>Hydroponics</b>
		<b>Aeroponics</b>
		<b>Photosynthesis lamp</b>
		<b>NASA Clean Air Study Plants</b>
		<b>Living Machine System</b>
		<b>Sound diminishing</b>
		<b>Vertical farming</b>
		<b>Constructed wetland</b>
		<b>Aquaponics</b>

# CLADDING: algae facade panels



## SYSTEM:



## ADVANTAGES:

Having the plantation on the site, the carbon footprint is reduced to the minimum; it works the whole year, independently from the weather.

## DISADVANTAGES:

Limited visibility.

## QUANTITIES:

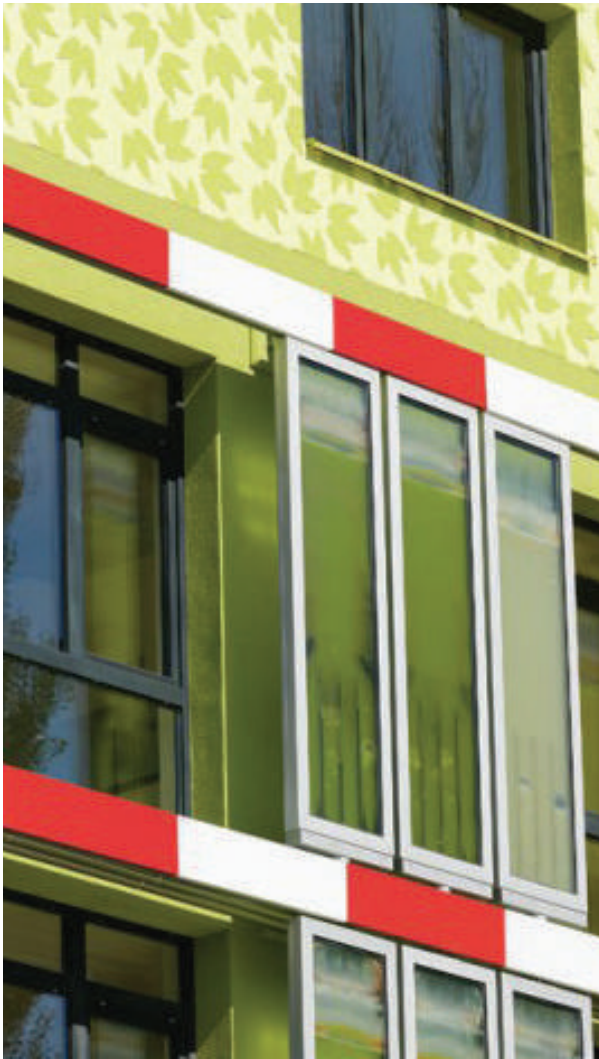
**10%** efficiency of conversion from light to biogas, and **38%** from light to heat.

## FACILITIES:

Water pump, storage space for harvested algae, biogas plant, water tank.

## SUPPLY:

Water (max. 24l for each panel)

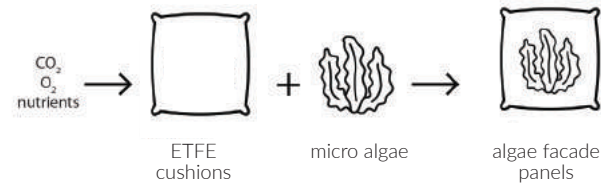


# CLADDING:

## algae ETFE



### SYSTEM:



### ADVANTAGES:

Having the plantation on the site, the carbon footprint is reduced to the minimum; it works the whole year, independently from the weather.

### DISADVANTAGES:

Limited visibility. The technology is new and underdeveloped.

### QUANTITIES:

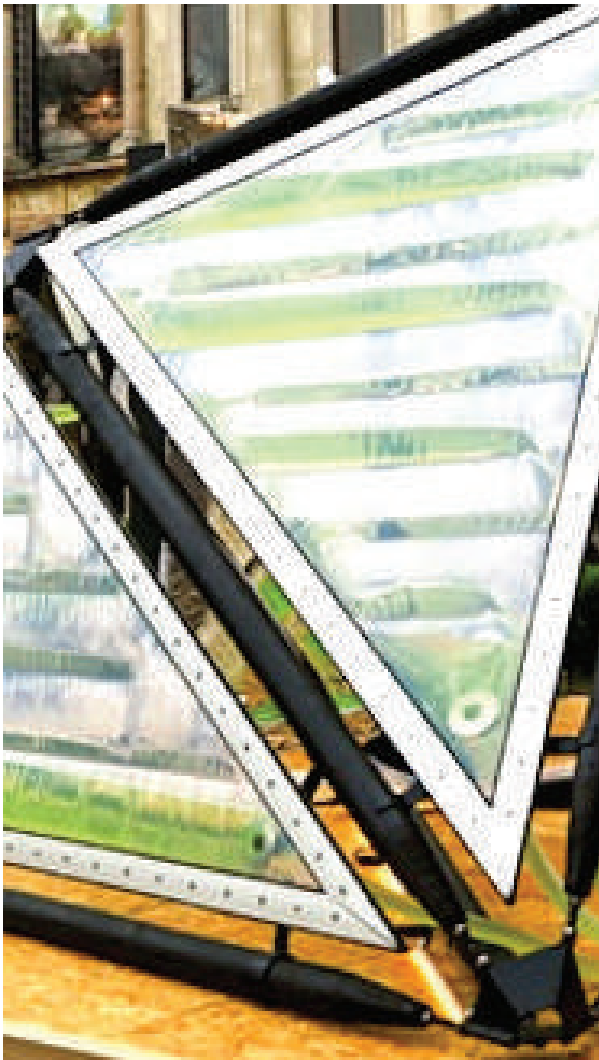
**10%** efficiency of conversion from light to biogas, and **38%** from light to heat.

### FACILITIES:

Water pump, storage space for harvested algae.

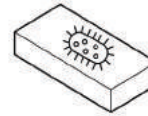
### SUPPLY:

Water



# BUILDING MATERIALS

## bacteria brick



### PRODUCTION:



### ADVANTAGES:

Unnecessity of high temperatures significantly lowers the carbon footprint, compared to traditional brick production.

### DISADVANTAGES:

The technology is new and undeveloped.

### QUANTITIES:

**2-5 days** for growing and drying.

A pilot plant produces **500 bricks a week** on average, with capacity for 1,500.

### FACILITIES:

Computer numerical controlled (CNC) deposition machine

### SUPPLY:

An aqueous solution containing urea and calcium chloride, urease enzyme broth, loose aggregate material (sand).



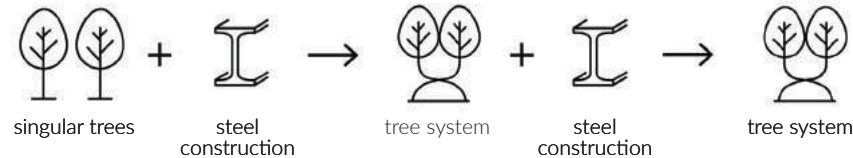


# BUILDING MATERIALS

## baubotanik



### PRODUCTION:



### ADVANTAGES:

Even after finalization, the construction is still alive, growing, and it is responsible for the atmospheric conditions.

### DISADVANTAGES:

Long waiting time and a need for an additional bearing construction.

### QUANTITIES:

**10-20 years** of tree growth.

### FACILITIES:

No extra facility is required.

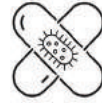
### SUPPLY:

Additional steel construction, bearing the floor mass before trees are mature.

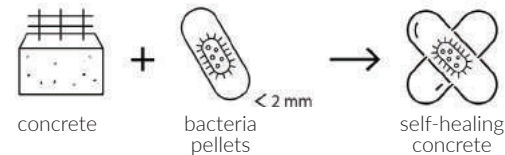


# BUILDING MATERIALS

## self-healing concrete



### PRODUCTION:



### ADVANTAGES:

Preventive reinforcement adding could be neglected, and the thickness of elements could be smaller. Less frequent maintenance makes the construction cheaper and easier in case of hard-to-reach structures (eg. tunnels, bridges).

### DISADVANTAGES:

Higher cost of production compared to conventional methods.

### QUANTITIES:

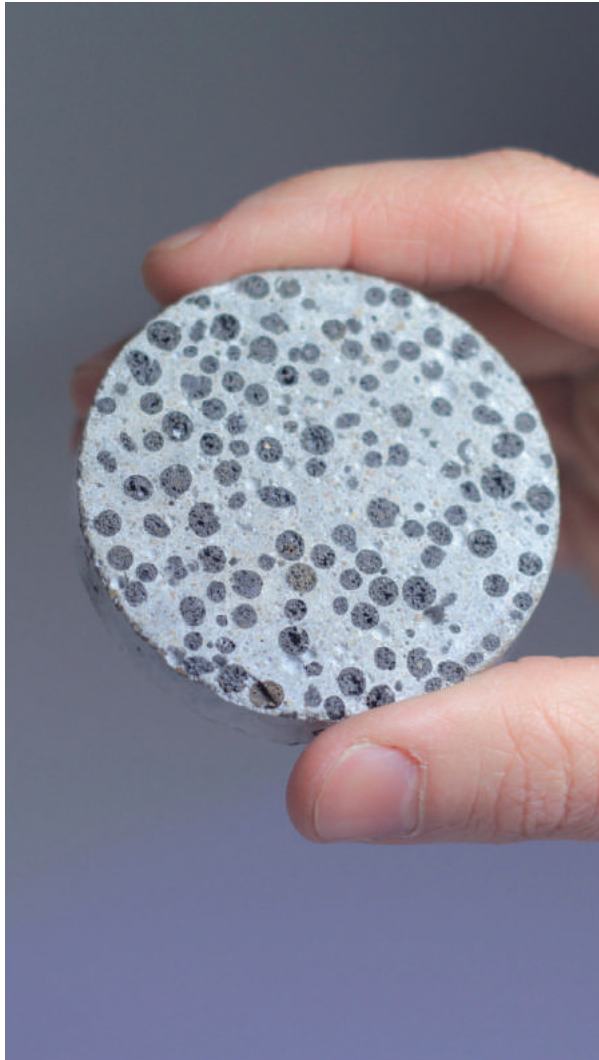
It takes only **3 weeks** to seal any slit, no matter how long it is.

### FACILITIES:

No extra facility is required.

### SUPPLY:

No extra supply is required.

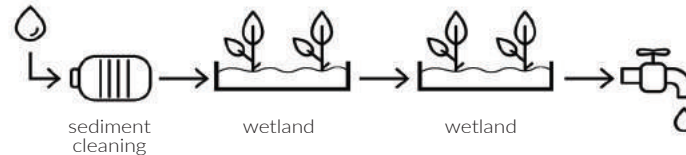


# CLEANING AND PURIFYING

## Living Machine System



### SYSTEM:



### ADVANTAGES:

Water is purified with low-energy cost, without any pollution, chemicals or by-products.

### DISADVANTAGES:

The system needs a lot of space, usually indoors.

### QUANTITIES:

**1m<sup>2</sup>** has capacity to clean around **250l** of waste water.

### FACILITIES:

Anaerobic reactor, anoxic reactor and/or closed aerobic reactor; clarifier (additional tank for separating remaining solids from the water).

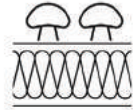
### SUPPLY:

No extra supply is required.

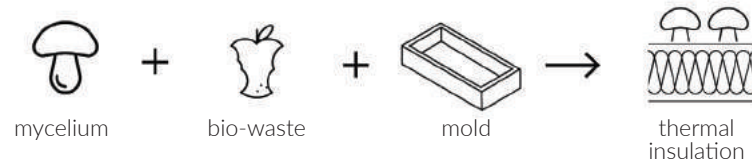


# INSULATION AND CLADDING

## fungus thermal insulation



### PRODUCTION:



### ADVANTAGES:

Compared to EPS, a 15% thicker panel of fungus thermal insulation is performing comparable thermal insulation; the material is fully biodegradable.

### DISADVANTAGES:

Thicker layer of insulation.

### QUANTITIES:

Less than **2 weeks** for production.

### FACILITIES:

Aerated Bed Reactor system, developed by Ecoative Design

### SUPPLY:

Low-value crop waste; preferable sawdust, in proportion around 1:1 to the mass of mycelium



# **NEW HOUSING TYPOLOGY**

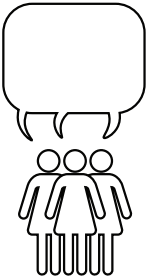
# NEW HOUSING TYPOLOGY



Collective Private Comissioning (CPC) allow to save up to 20% of construction costs, compared to traditional construction.

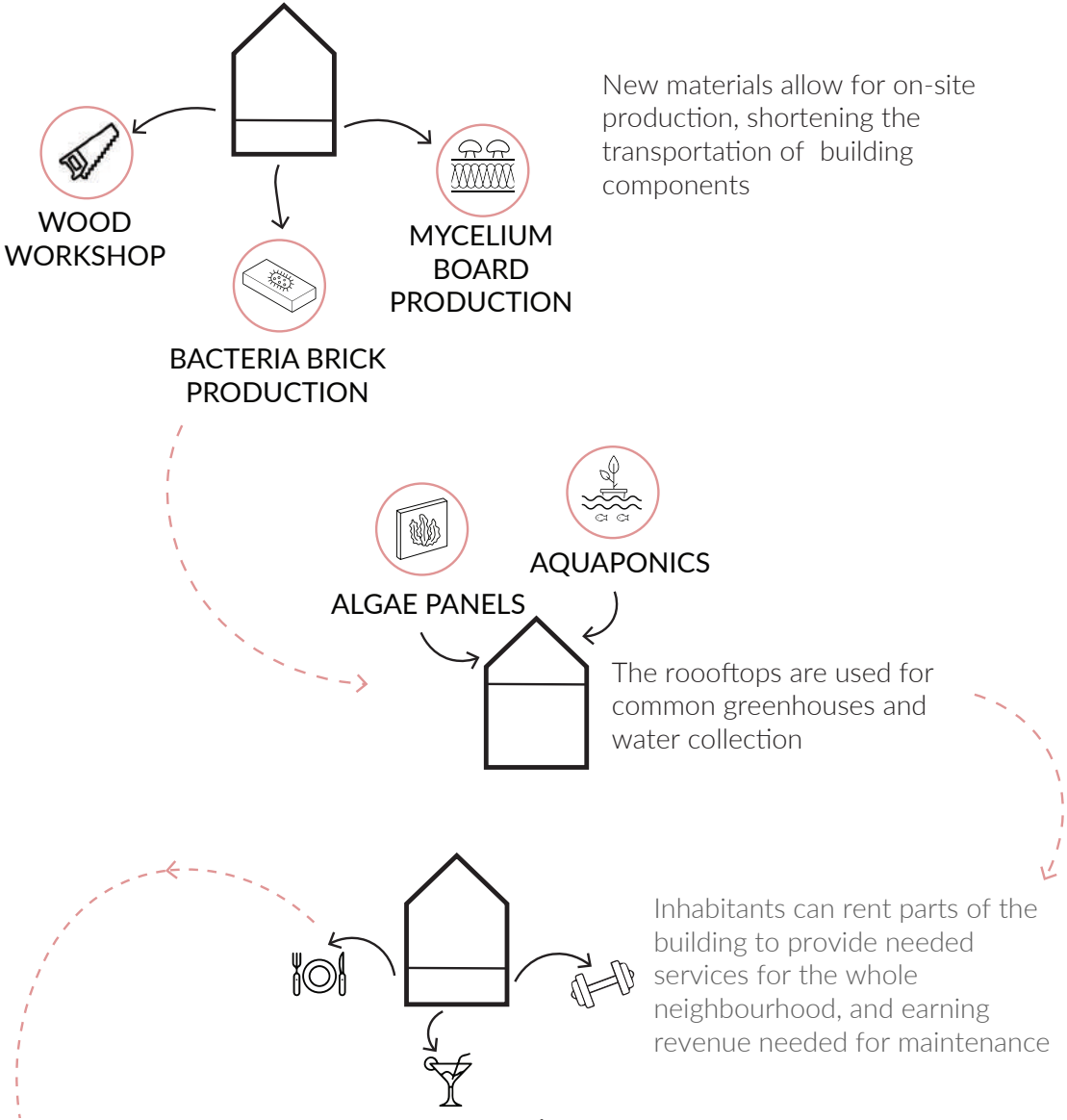


Collective is created before the construction starts, giving a chance for stronger community of inhabitants in the future.



Collective has a direct influence of the project and services located in it

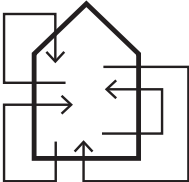
# NEW HOUSING TYPOLOGY



# NEW HOUSING TYPOLOGY



Flexible space and on-site production allows inhabitants to design and re-design their apartments



Water, waste and energy circulation is embedded in the project



Use of recyclable materials allows for future changes without negative impact on the environment



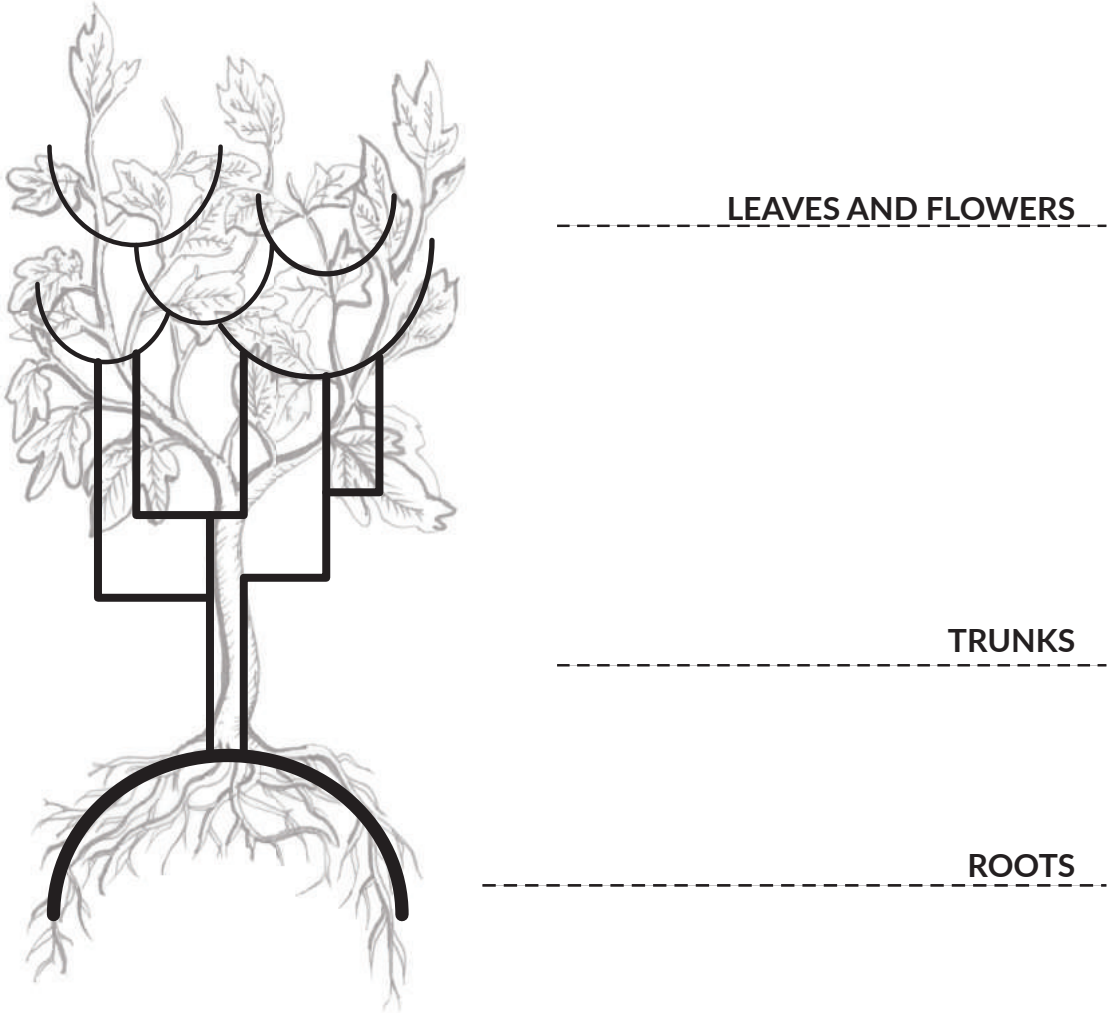
# NEW HOUSING TYPOLOGY

architectural language



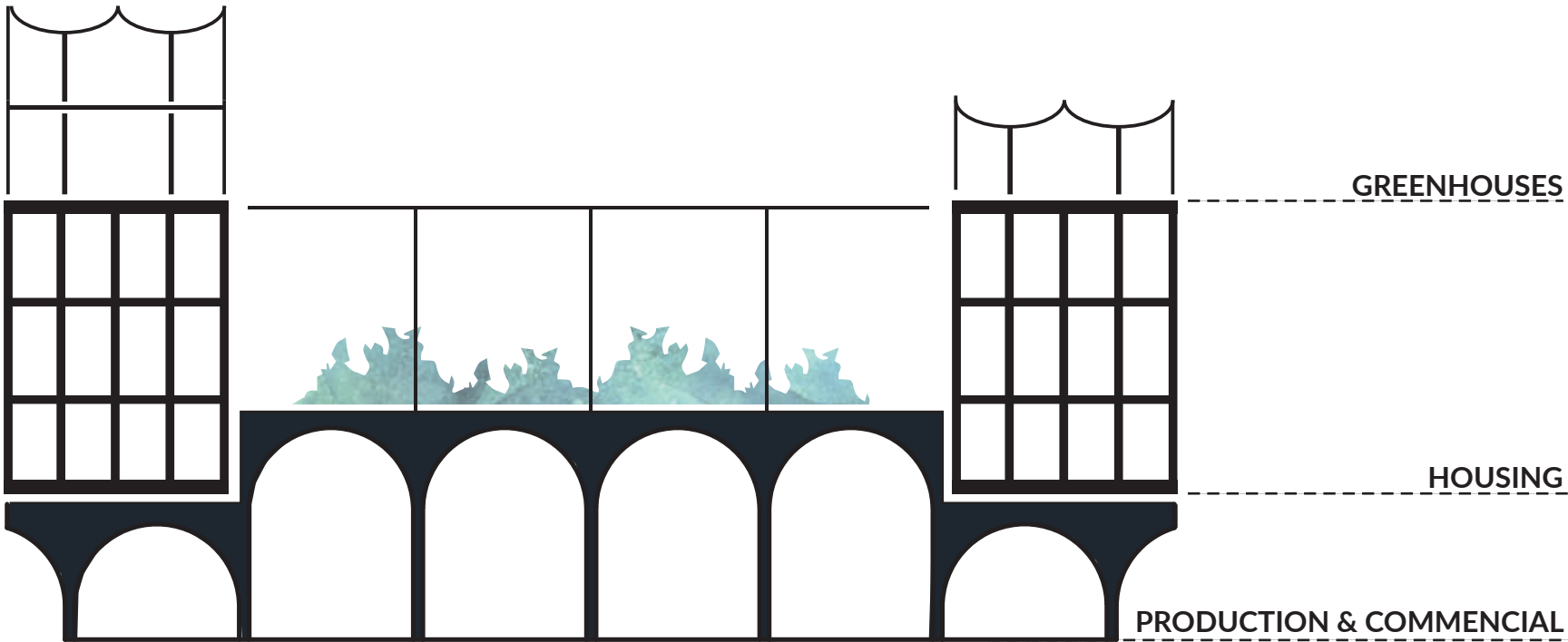
# NEW HOUSING TYPOLOGY

architectural language

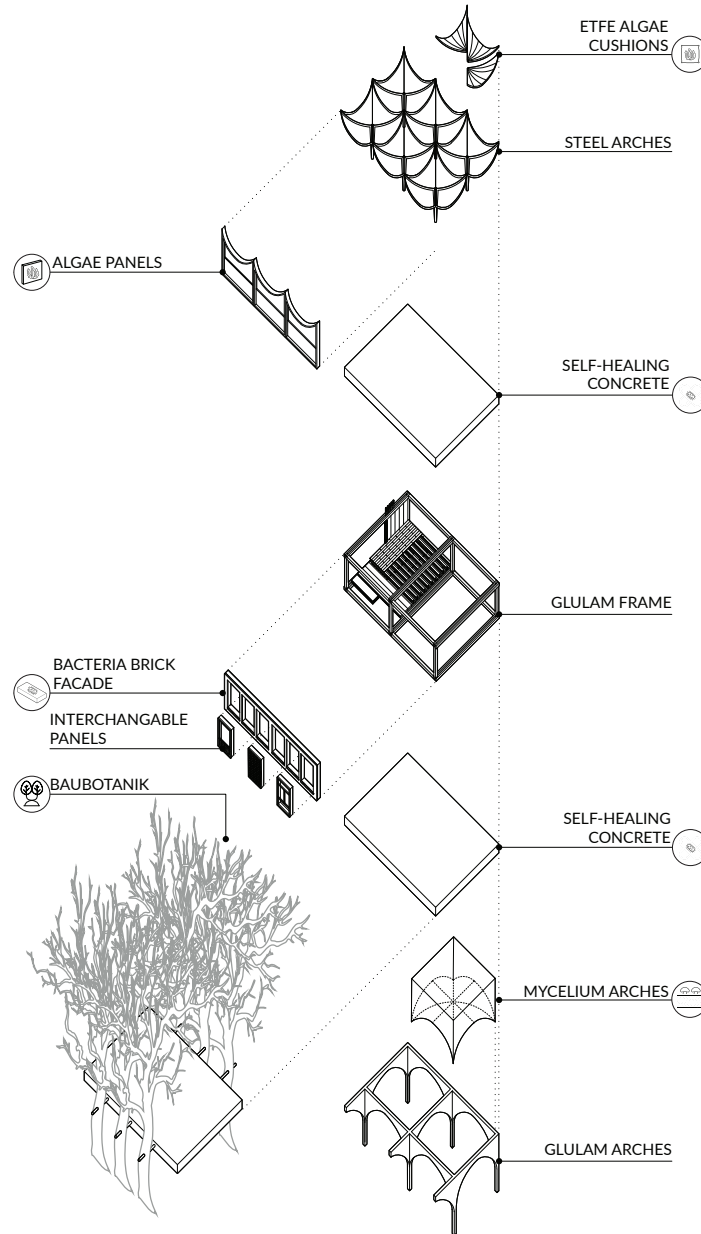


# NEW HOUSING TYPOLOGY

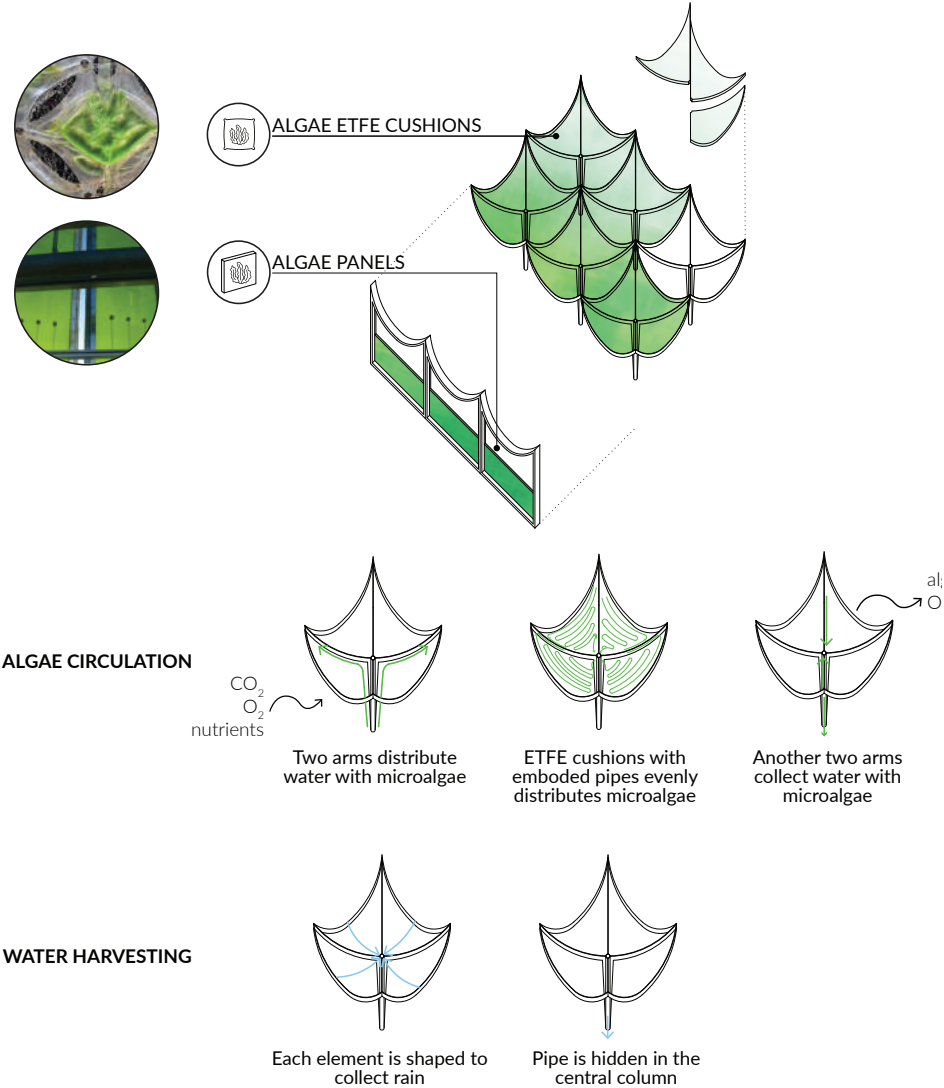
architectural language



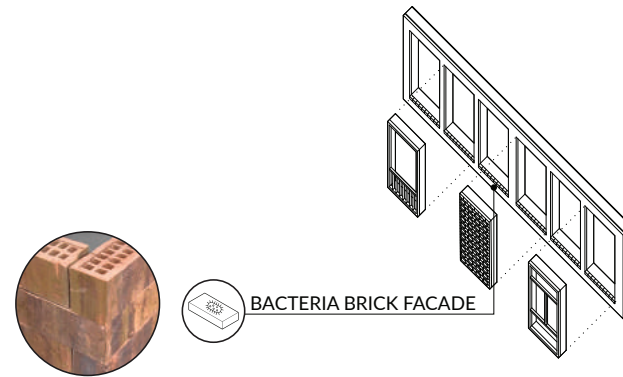
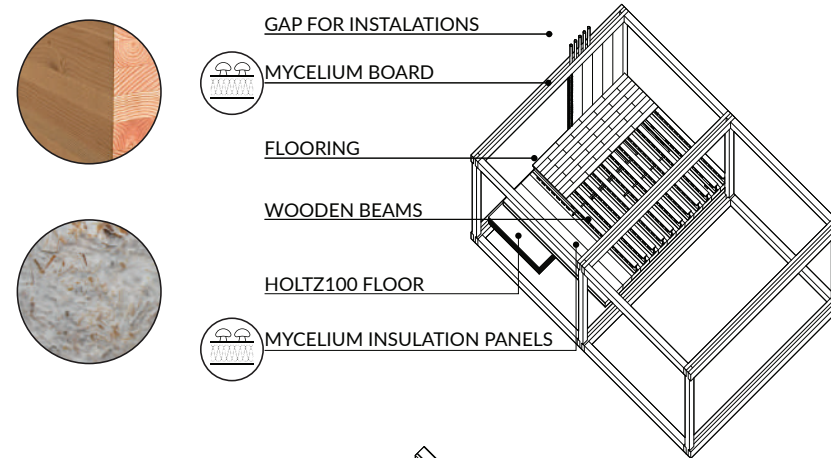
# NEW BUILDING TECHNIQUES



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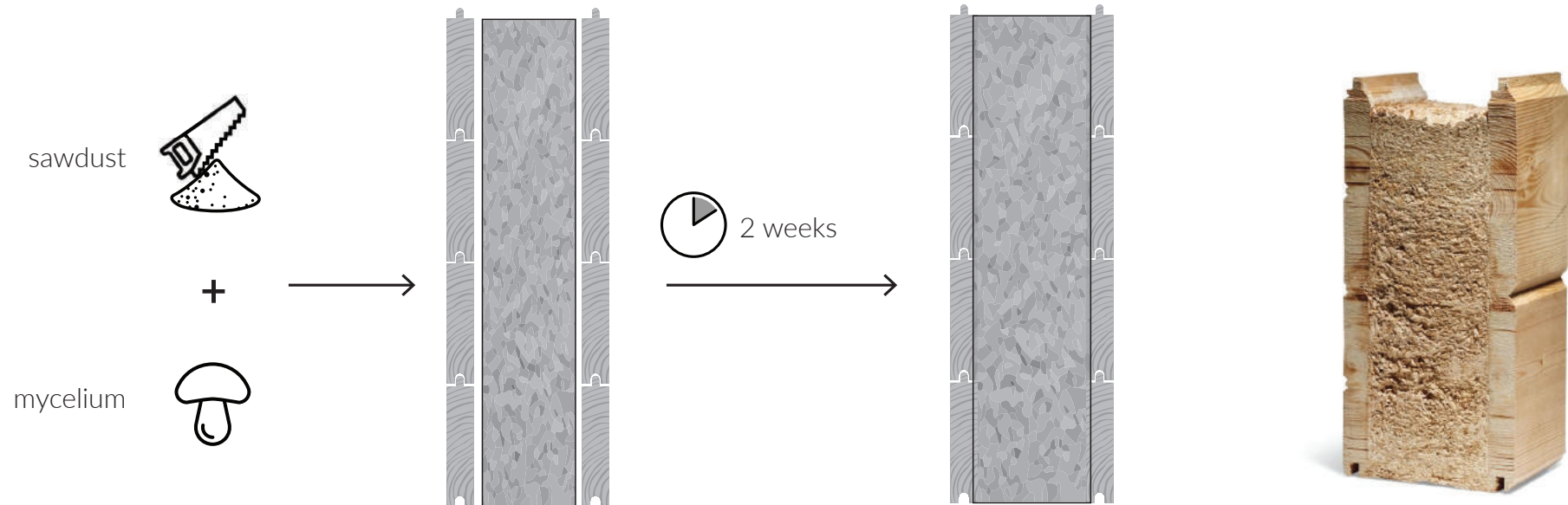


# NEW BUILDING TECHNIQUES

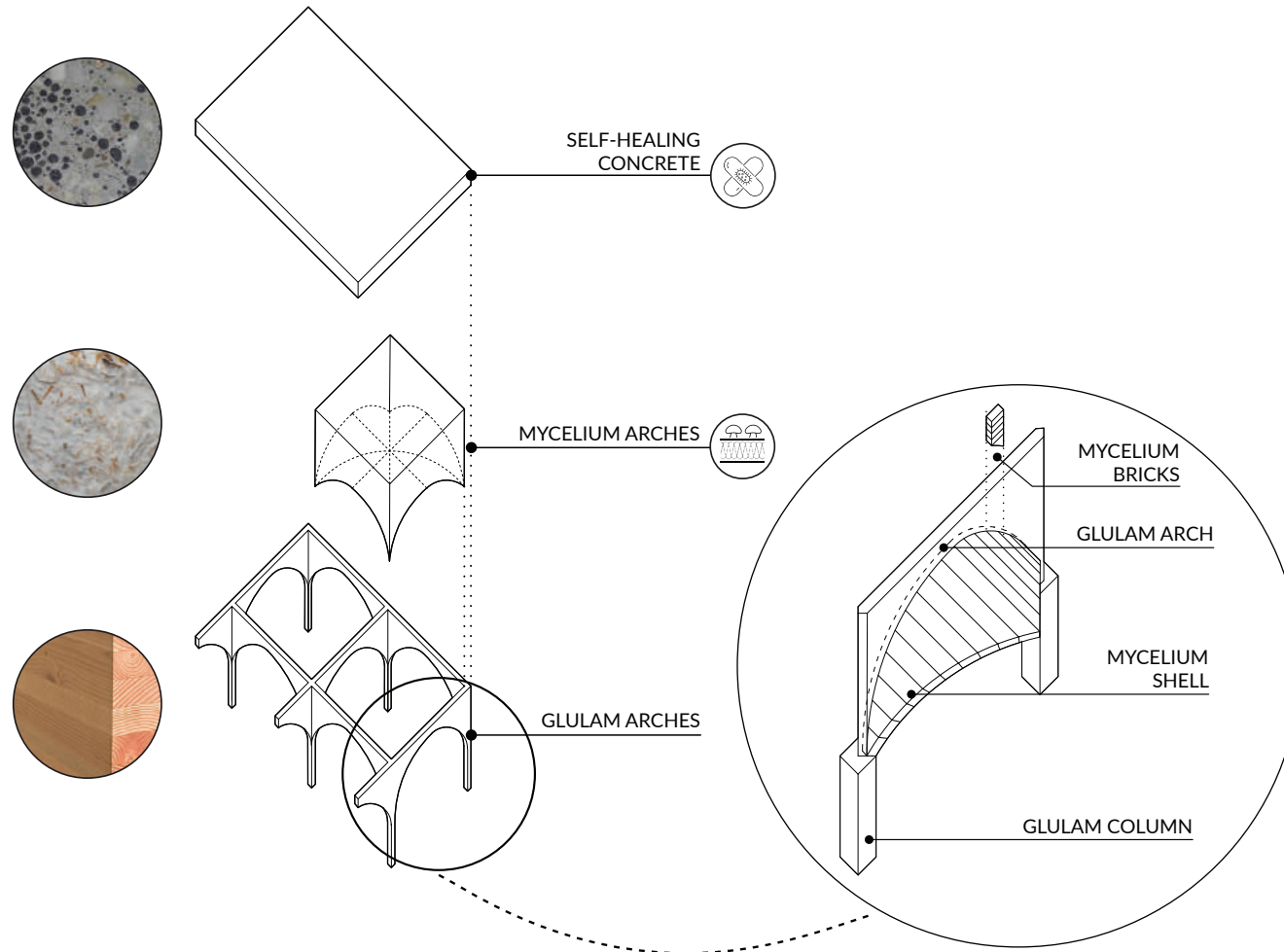


# BUILDING MATERIALS

## mycelium sandwich panel

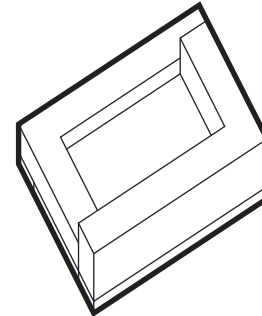
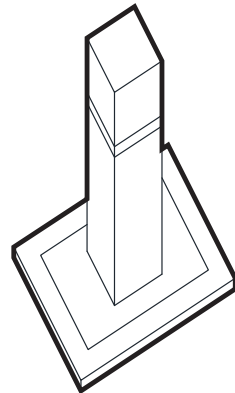
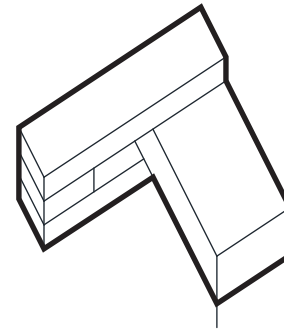
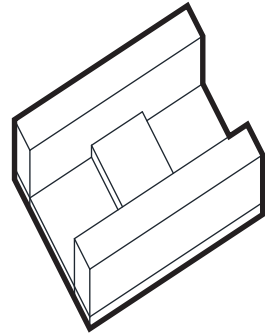
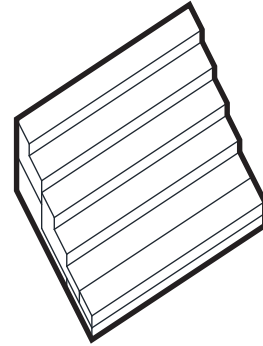
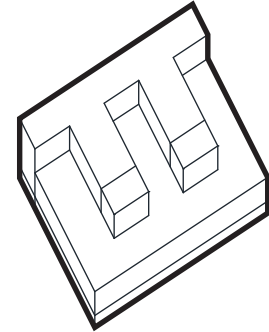


# NEW BUILDING TECHNIQUES

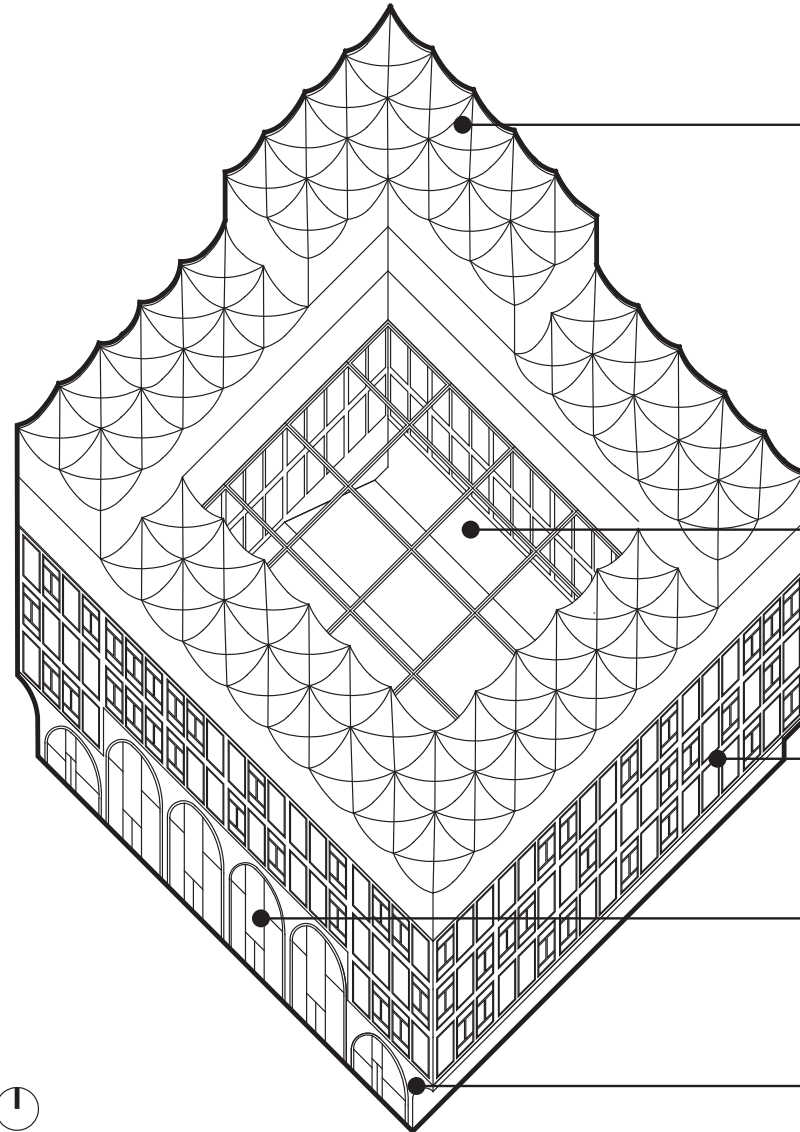




# MODERN HOUSING



# MODERN HOUSING



GREENHOUSE with aquaponics  
situated on the rooftop and oriented  
towards the sun

LIVING MACHINE SYSTEM  
located in common winter garden, meeting  
place of the inhabitants

HOUSING  
composed of 60m<sup>2</sup> units

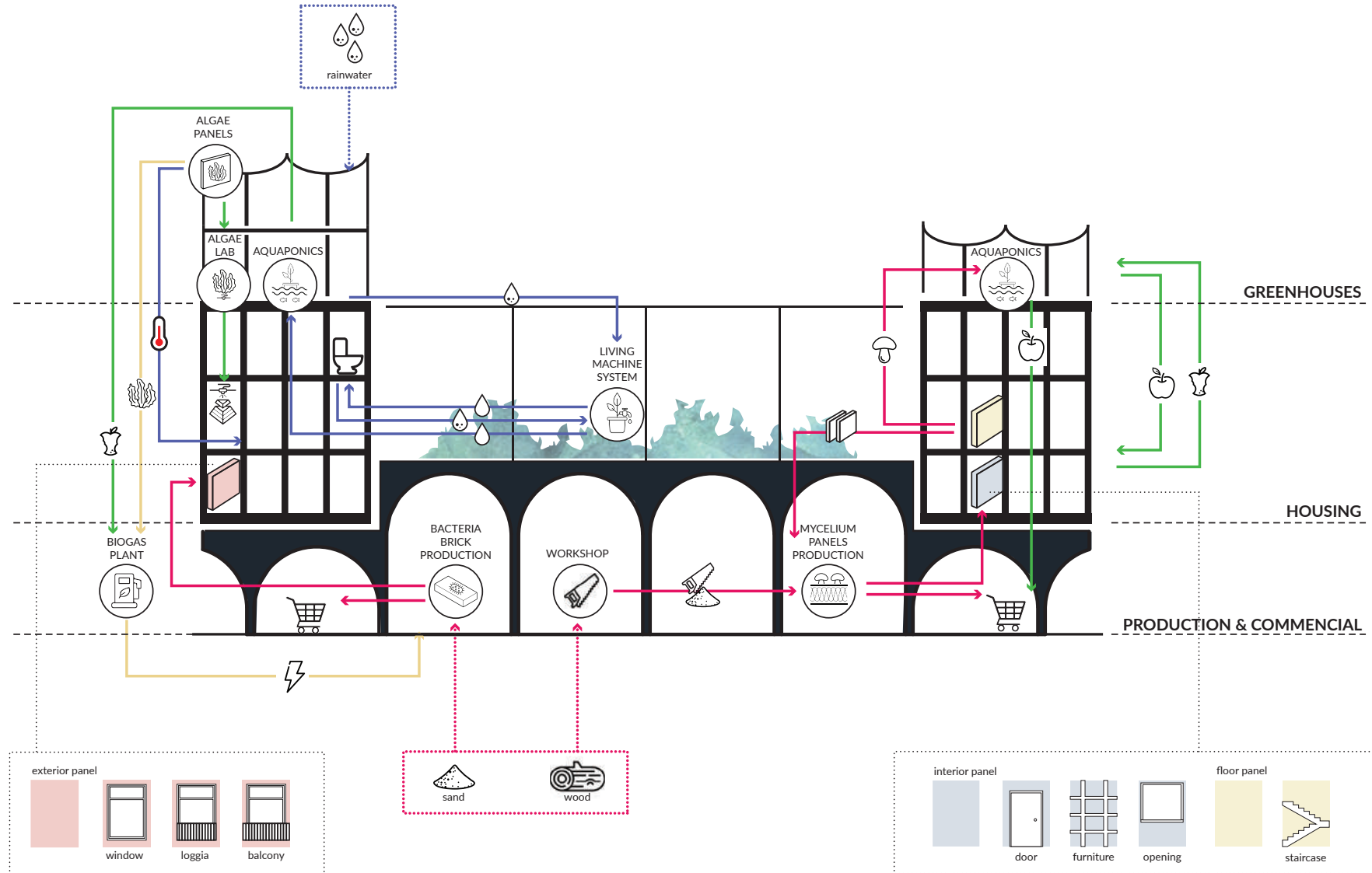
PRODUCTION  
situated in the middle, of the block, partially  
double-height

COMMERCIAL SPACE  
in the ground floor, along the street



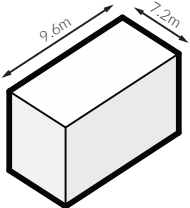
# DESIGN

## circulation



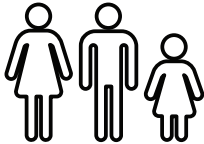
# MODERN HOUSING

## raw numbers



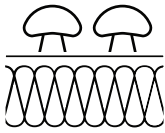
### 65 m<sup>2</sup> apartment

internal walls: 25 m  
 external walls: 36 m  
 floor boards: 65 m<sup>2</sup>  
 [+20%]

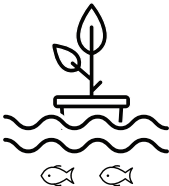


### Regular Dutch person

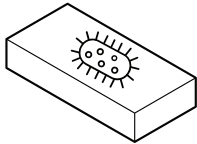
greens: 46.4 kg/year/p.p.  
 legumes: 1.5 kg/year/p.p.  
 herbs: 13.5 kg/year/p.p.  
 fish: 36.9 kg/year/p.p.  
 water: 107 l/day/p.p.



one panel length: 0,6 m  
 interior panels: 40 panels  
 external panels: 60 panels  
 floor panels: 50 panels  
 one apartment: 150 panels



aquaponics: 3.8 kg/m<sup>2</sup>  
 hydroponics: 2.6 kg/m<sup>2</sup>  
 vertical farming: 73 kg/m<sup>2</sup>



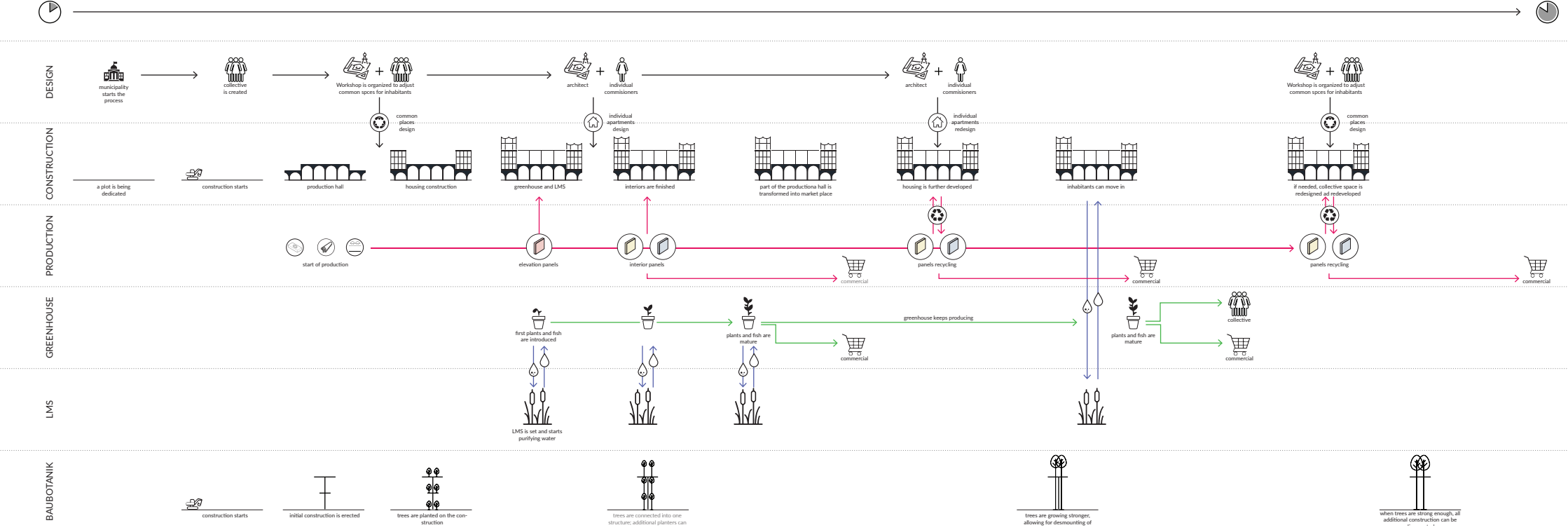
facade: 14 m  
 ~400 bricks  
 [+20%]



Living Machine System: 250 l/m<sup>2</sup>

# MODERN HOUSING

## CPC process timeline



# MODERN HOUSING

## Commissioners' influence

1. Which spaces are going to be rented and to whom.
2. Which additional services are going to be provided.
3. What types of common spaces are going to be provided to the community and what are the rules of using them.
4. Who to sell or rent the apartments.
5. What to grow in the greenhouses.
6. Who should be employed for maintenance and what is the range of responsibilities.

**BINCKHORST**

# BINCKHORST





# BINCKHORST

Industrial area under transformation into housing district



# TRANSFORMATION

existing situation



# TRANSFORMATION

existing communication



# TRANSFORMATION

new connections and pocket parks



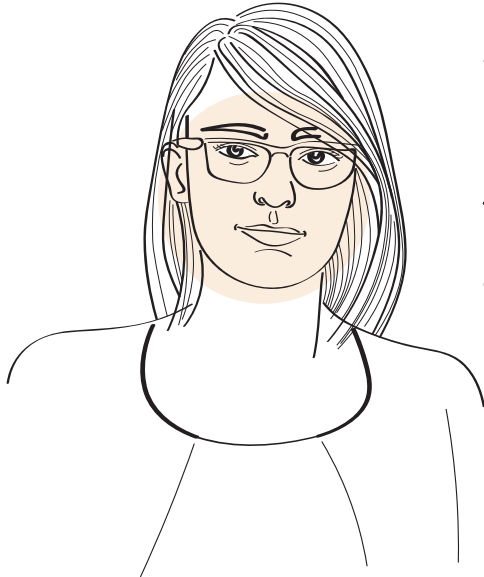
# TRANSFORMATION

design plot



# MODERN HOUSING

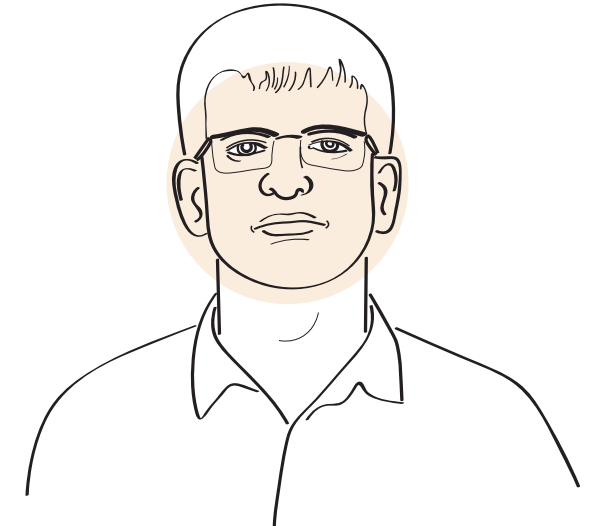
## Commissioners' requirements



I'd like to have a **swimming pool** and a **co-working office**, so I don't have to work from home.

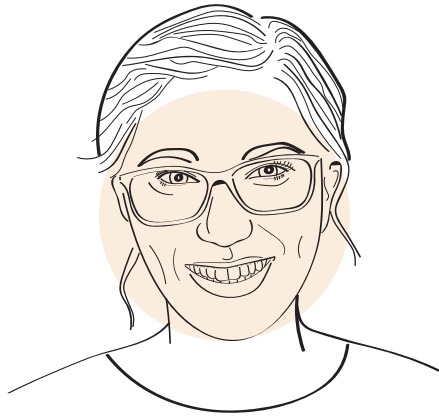
I'd like to share laundry room with other inhabitants. It would be nice to have also **common event space with the kitchen**.

We know at least **10 other couples**, that would be interested in this project.



# MODERN HOUSING

## Commissioners' requirements



We would like to rent some apartments for students.

It would be nice to have a **nursery** in vicinity. I don't like to work where I live, so I don't need any work space.

I'd like to have a **gym** in the complex. Maybe a small cinema?

We would like to share **laundry room** with the inhabitants.



# MODERN HOUSING

## Commissioners' requirements



We can share a laundry room and a **common living room**, but not much more.

We think it's better if an external company takes care of common spaces. It's much easier.

We are not eager to rent apartments for students, but we're open for **tourists and working people**.





# MODERN HOUSING

## Commissioners' requirements

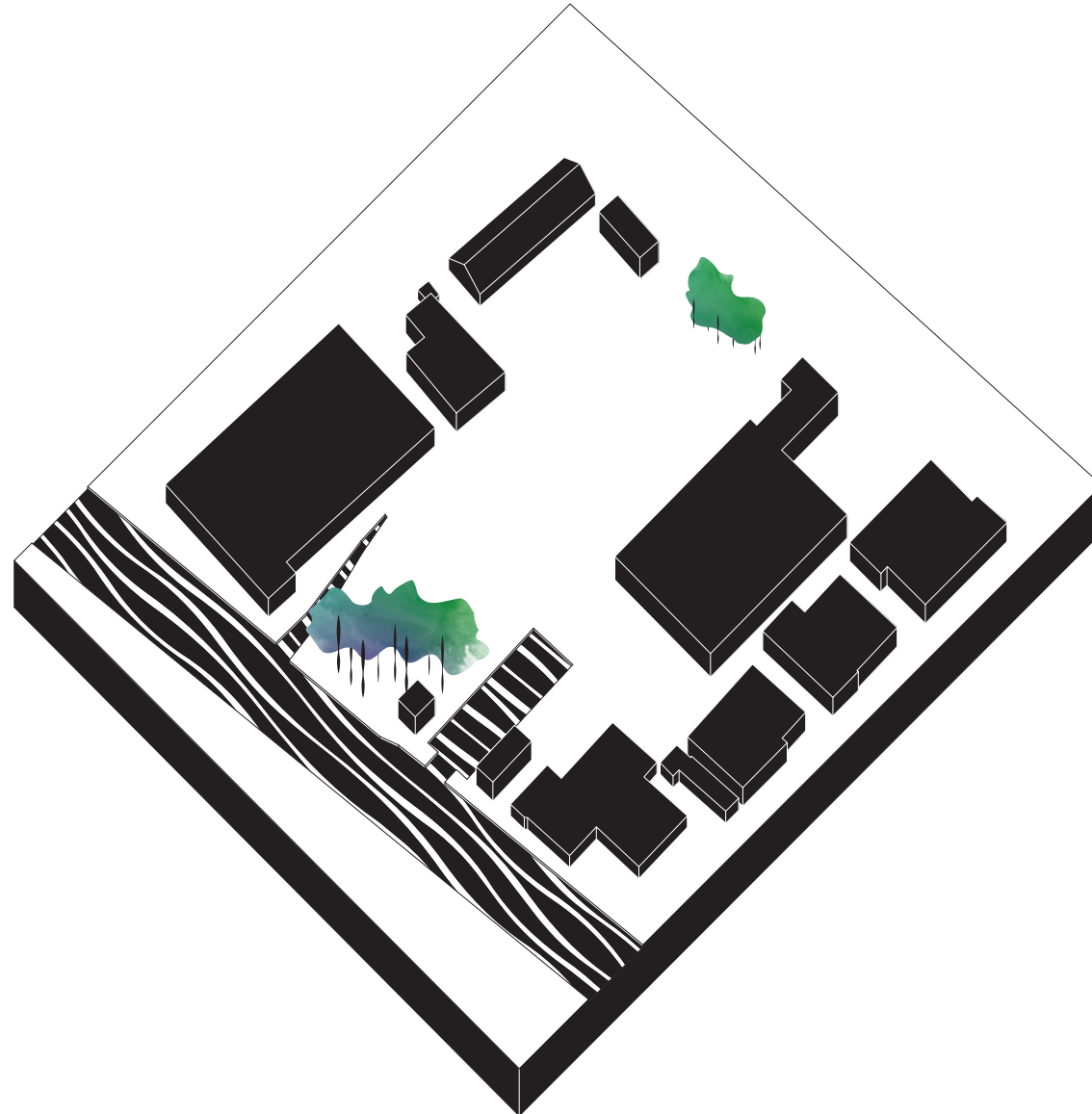


Each small community shall have its own living room  
Gym, nursery and co-working offices for inhabitants  
Shared laundry room  
10% of apartments dedicated for short-term rent  
Part of greenhouse space dedicated for inhabitants  
No parking space needed

# DESIGN

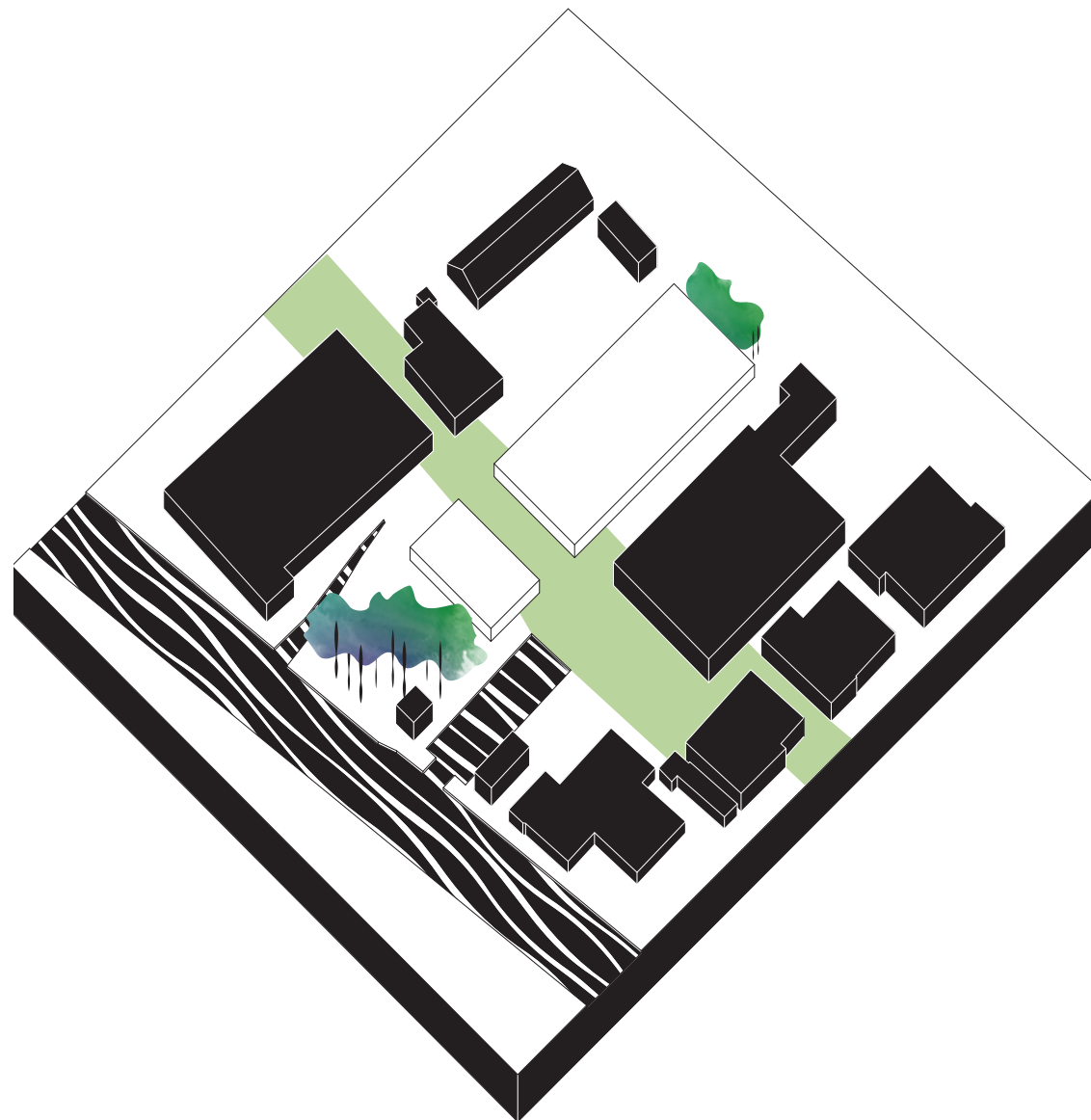
# DESIGN

Mass study



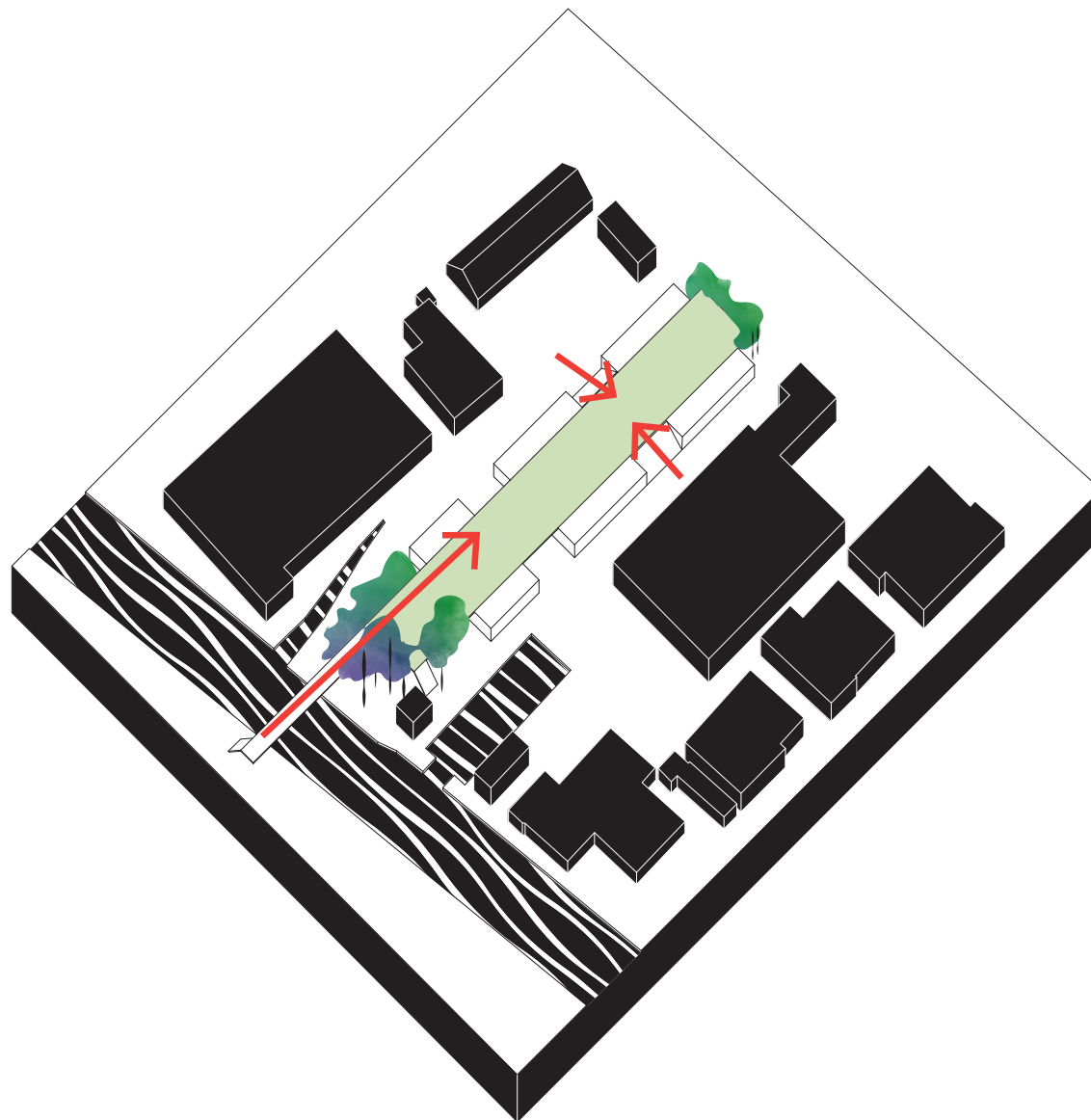
# DESIGN

Mass study



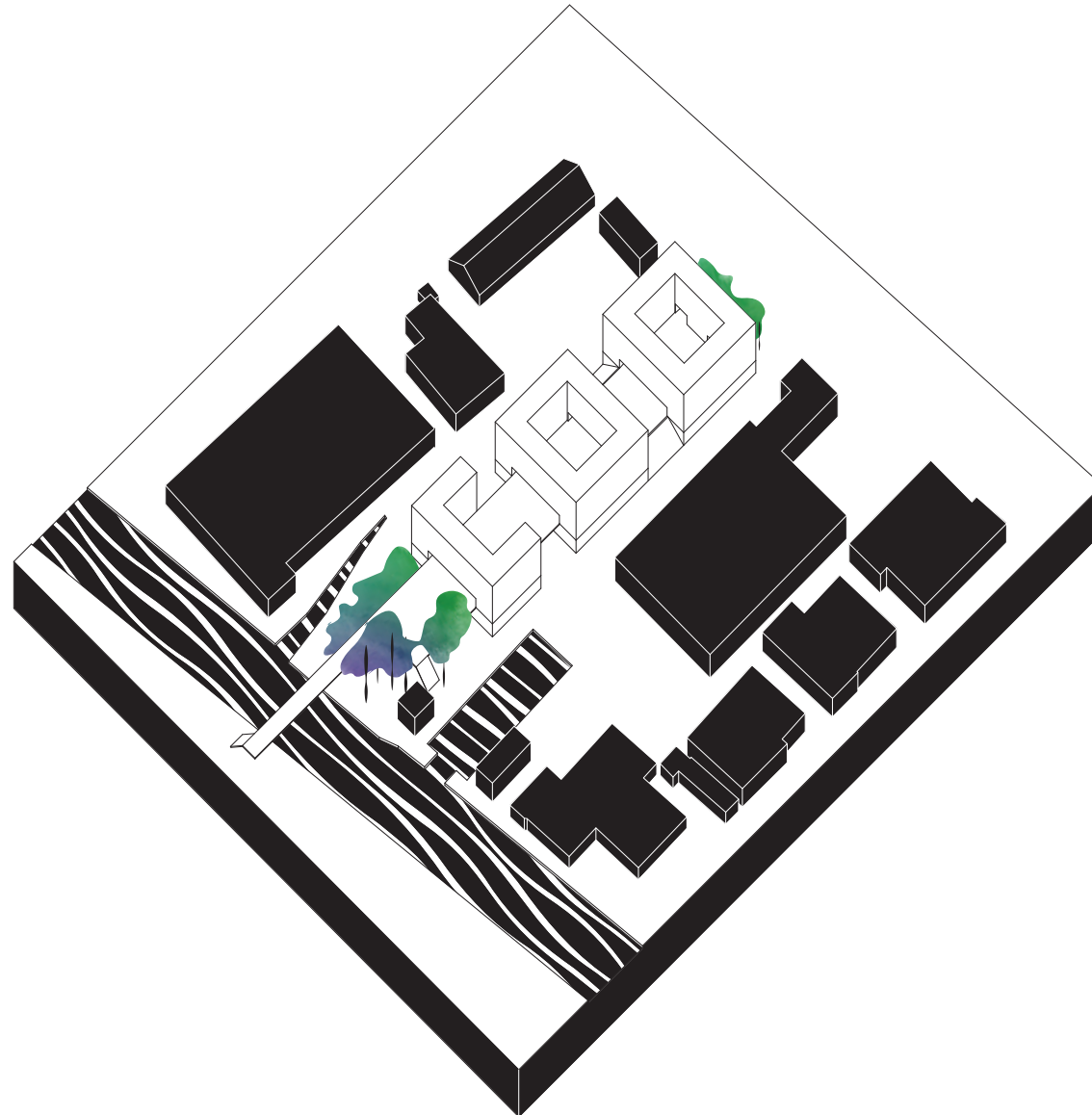
# DESIGN

Mass study



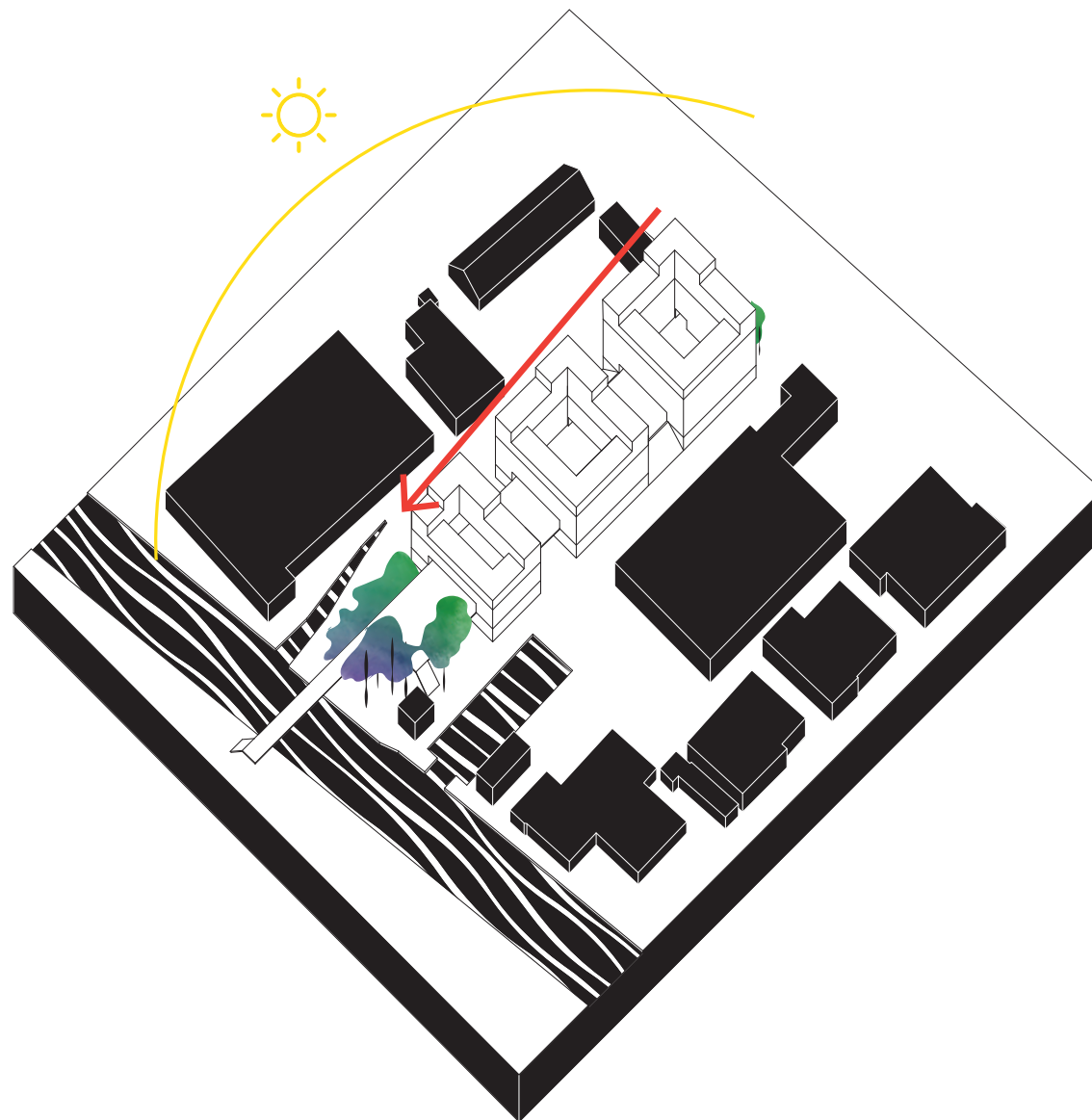
# DESIGN

Mass study



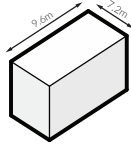
# DESIGN

Mass study



# DESIGN

## materials calculations



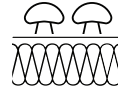
65 m<sup>2</sup> apartment

internal walls: 25 m  
 external walls: 36 m  
 floor boards: 65 m<sup>2</sup>  
 [+20%]



Regular Dutch person

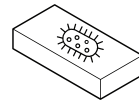
greens: 46.4 kg/year/p.p.  
 legumes: 1.5 kg/year/p.p.  
 herbs: 13.5 kg/year/p.p.  
 fish: 36.9 kg/year/p.p.  
 water: 107 l/day/p.p.



one panel length: 0,6 m  
 interior panels: 40 panels  
 external panels: 60 panels  
 floor panels: 50 panels  
 one apartment: 150 panels



aquaponics: 3.8 kg/m<sup>2</sup>  
 hydroponics: 2.6 kg/m<sup>2</sup>  
 vertical farming: 73 kg/m<sup>2</sup>



facade: 14 m  
 ~400 bricks  
 [+20%]



Living Machine System: 250 l/m<sup>2</sup>

90 x 65 m<sup>2</sup> apartment

→ max. 270 inhabitants



400m<sup>2</sup> of mycelium board  
 growing room allows to produce  
 1250 panels/week



Fish tank: 800 m<sup>2</sup>  
 Hydroponics: 2000 m<sup>2</sup>  
 Vertical farming: 400 m<sup>2</sup>  
 Living Machine System: 115 m<sup>2</sup>



11 weeks x 90 x 65 m<sup>2</sup> apartment



It takes 7 months before  
 the first fish are mature



6 machines (3500x7600) can  
 produce 2400 bricks in 5 days

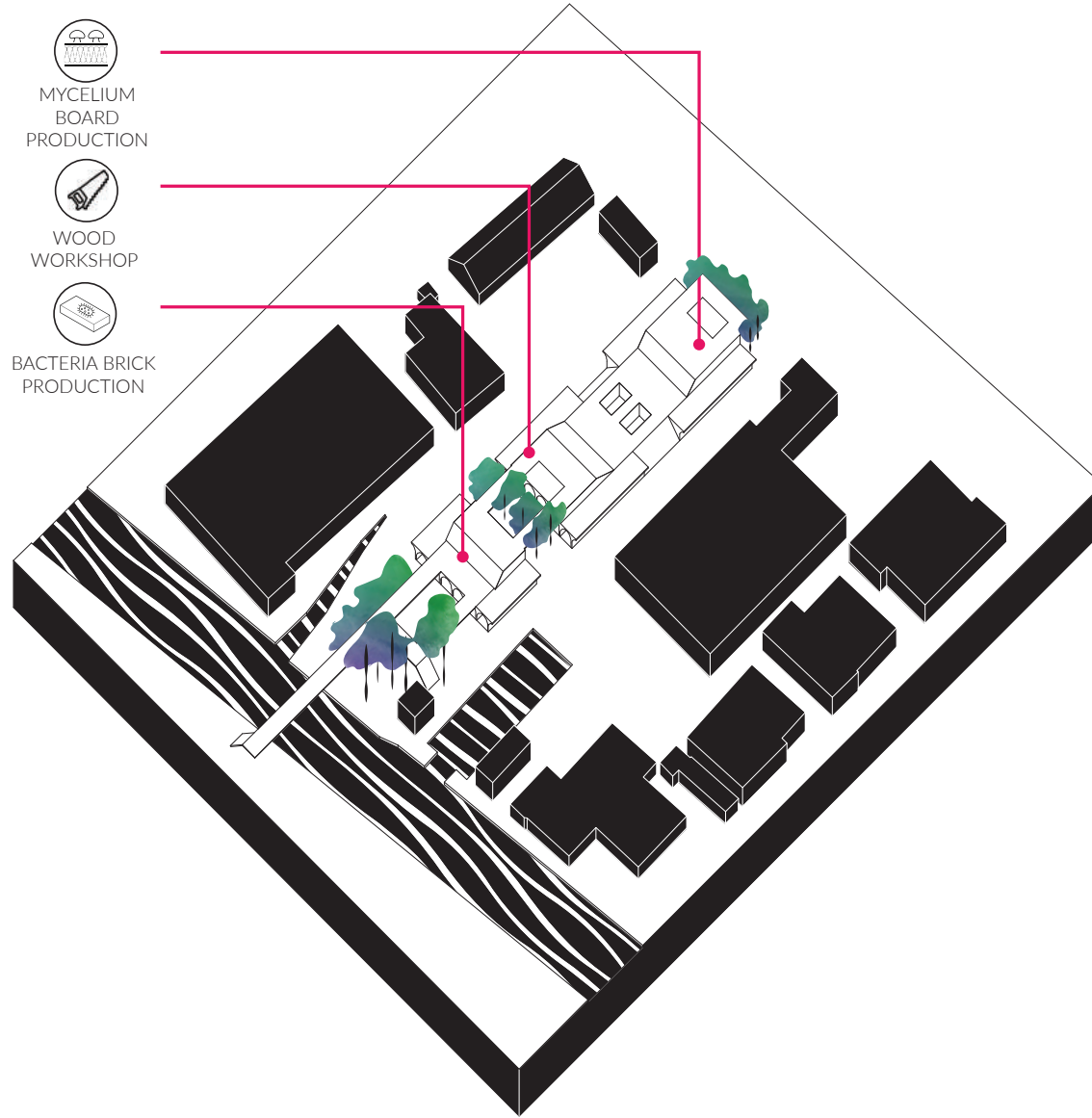


11 weeks x 90 x 65 m<sup>2</sup> apartment



# DESIGN

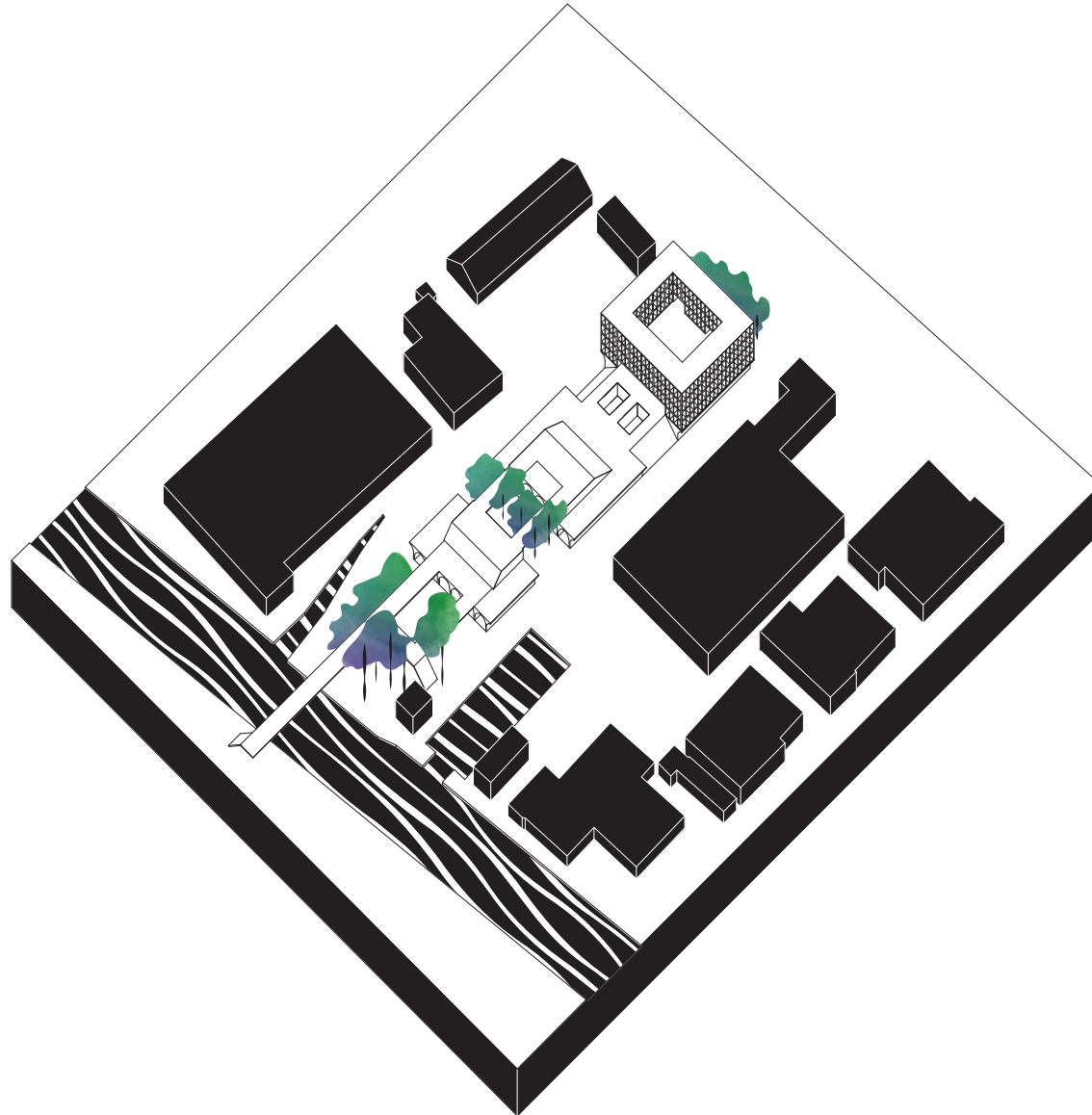
## construction timeline



- MYCELIUM BOARD PRODUCTION
- WOOD WORKSHOP
- BACTERIA BRICK PRODUCTION

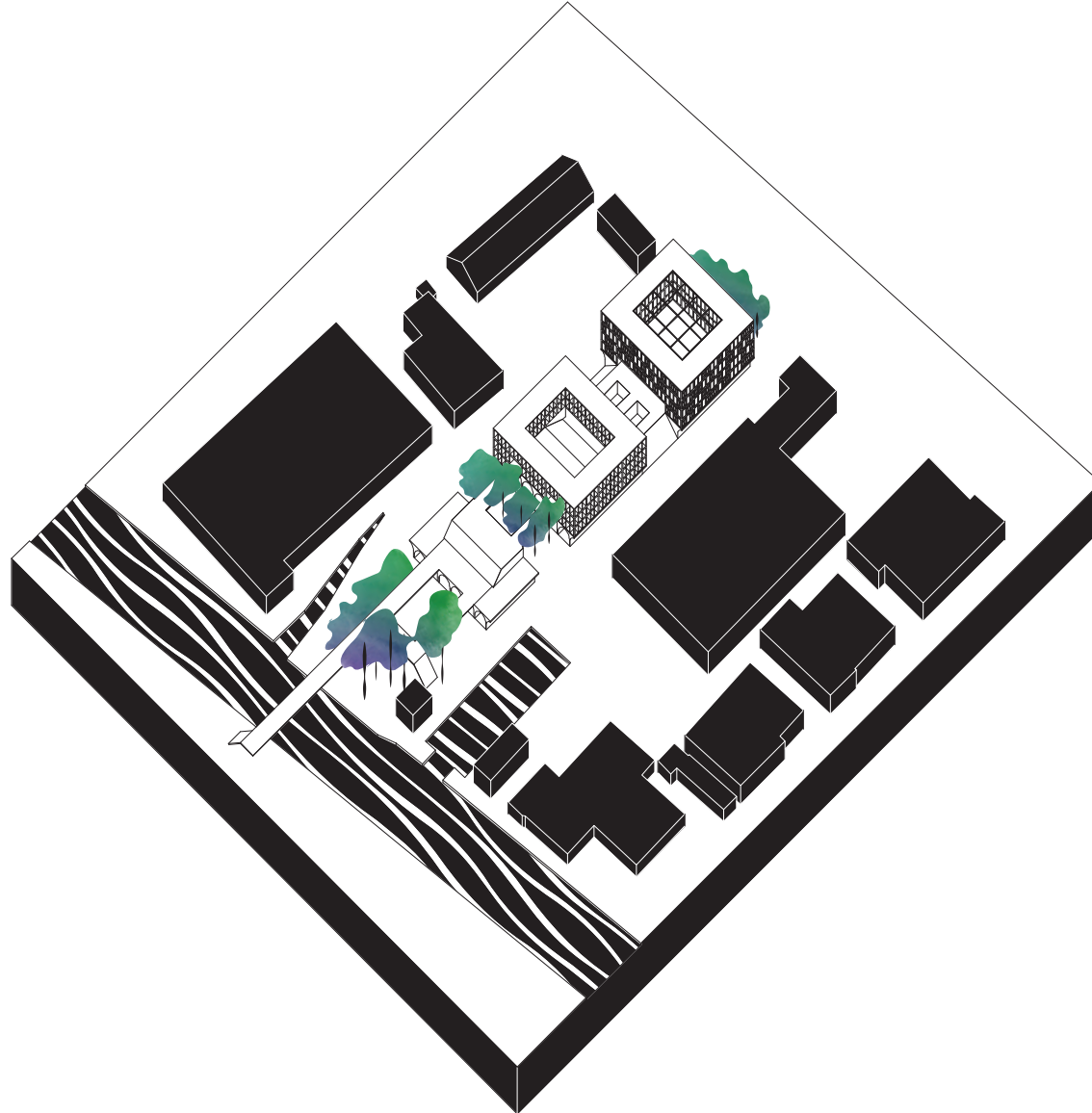
# DESIGN

construction timeline



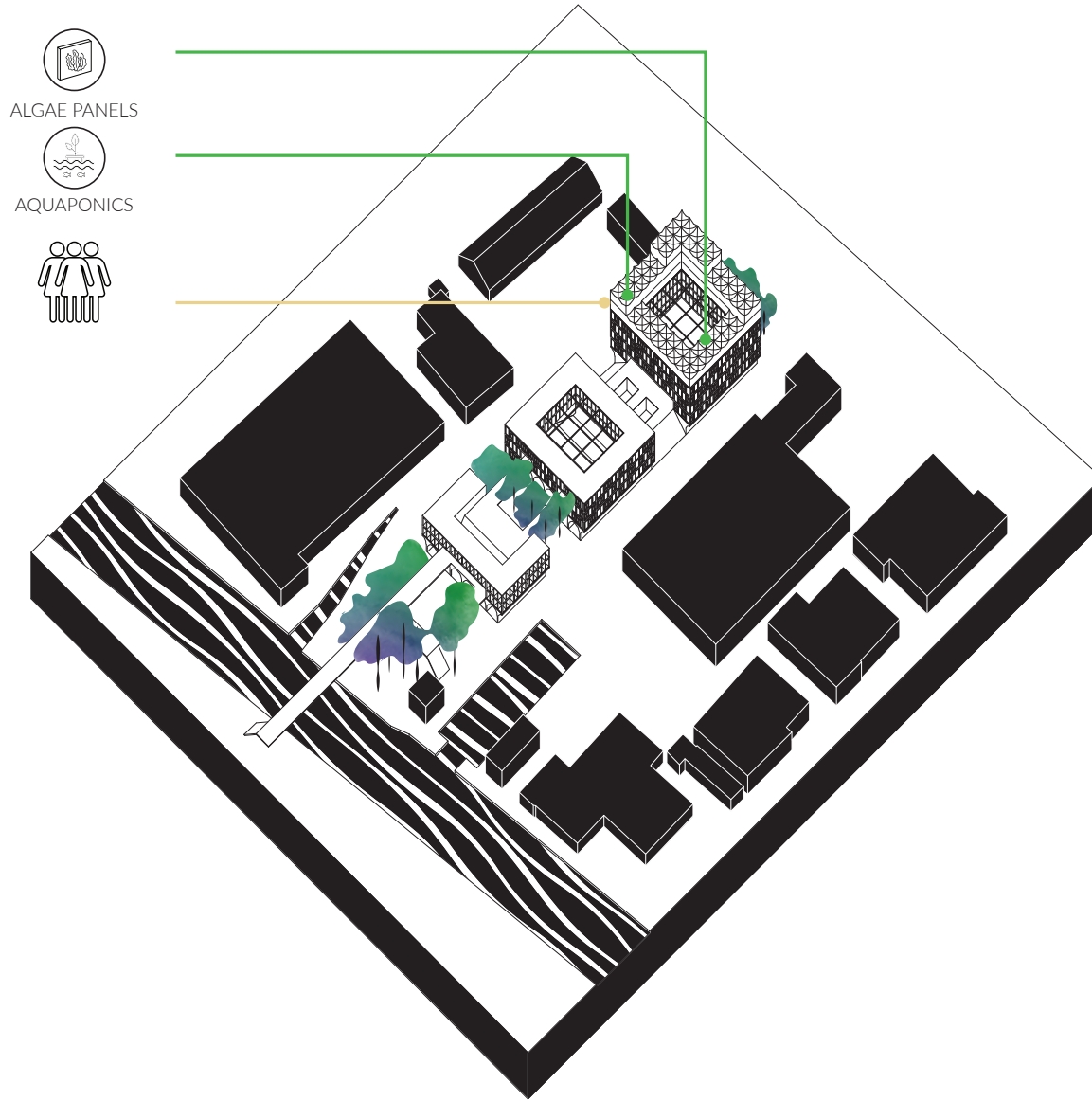
# DESIGN

construction timeline



# DESIGN

## construction timeline



ALGAE PANELS

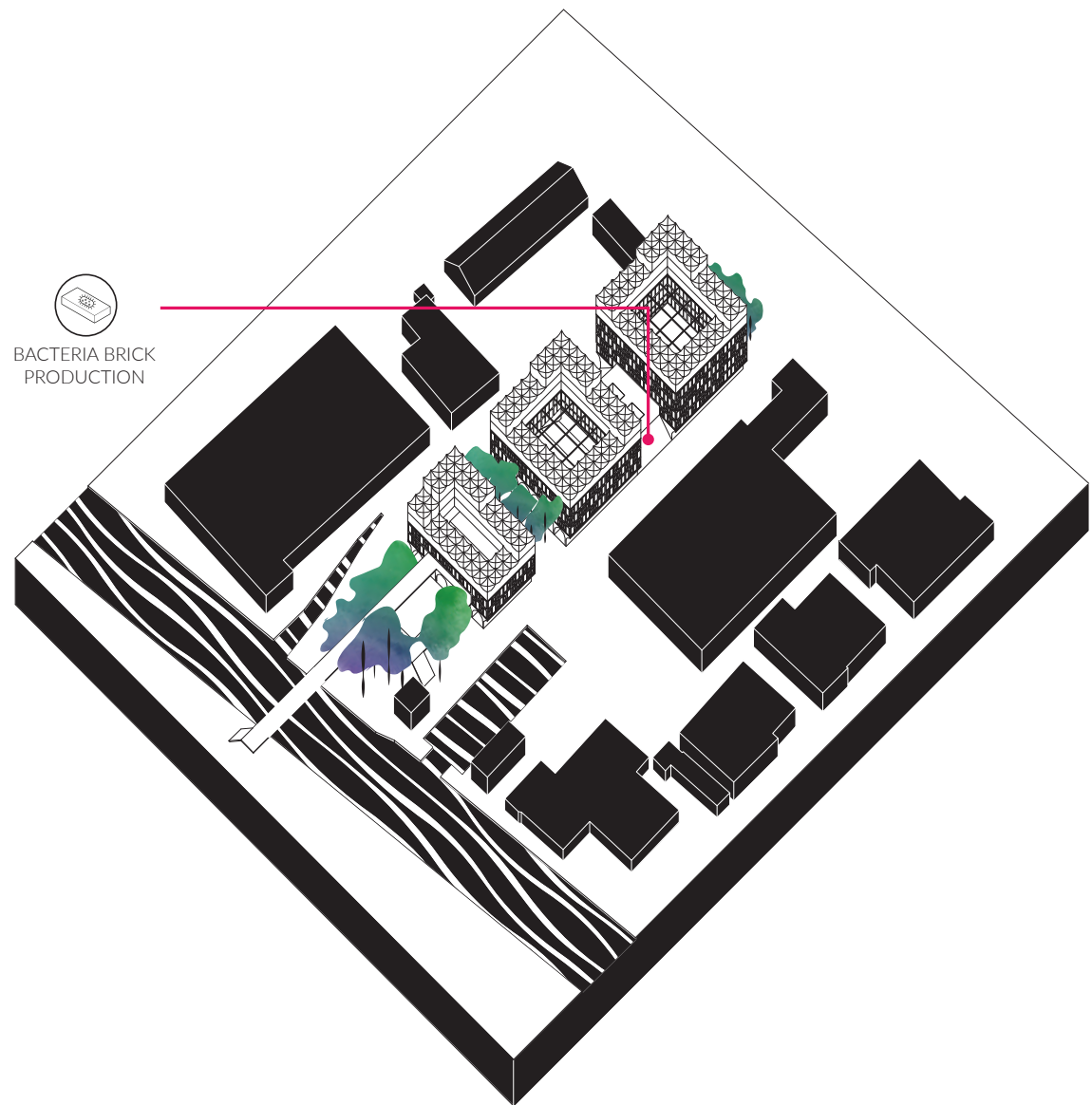


AQUAPONICS



# DESIGN

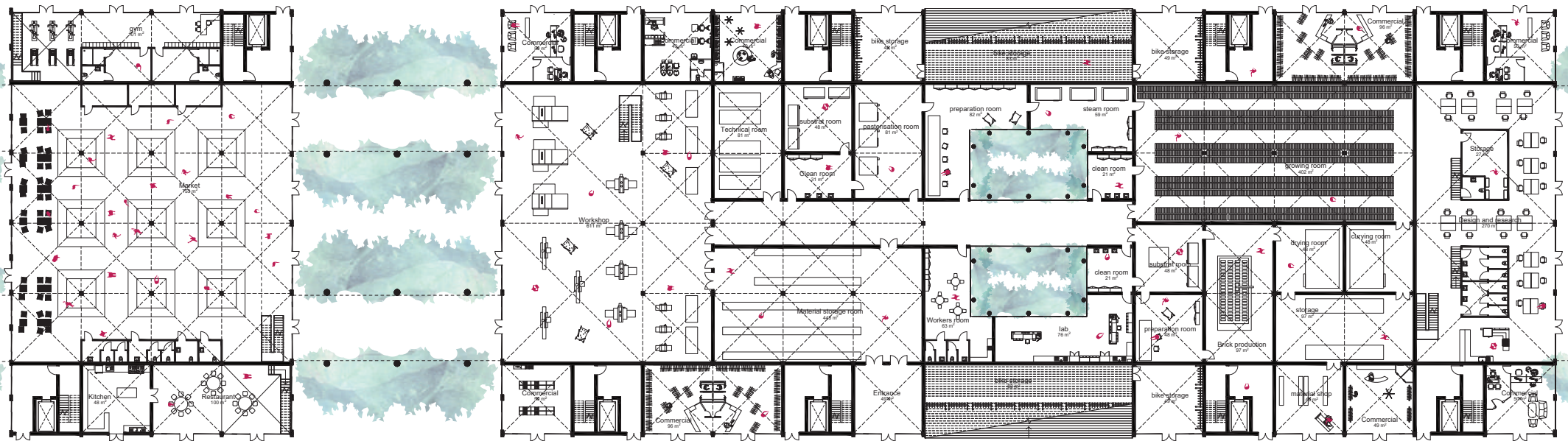
construction timeline



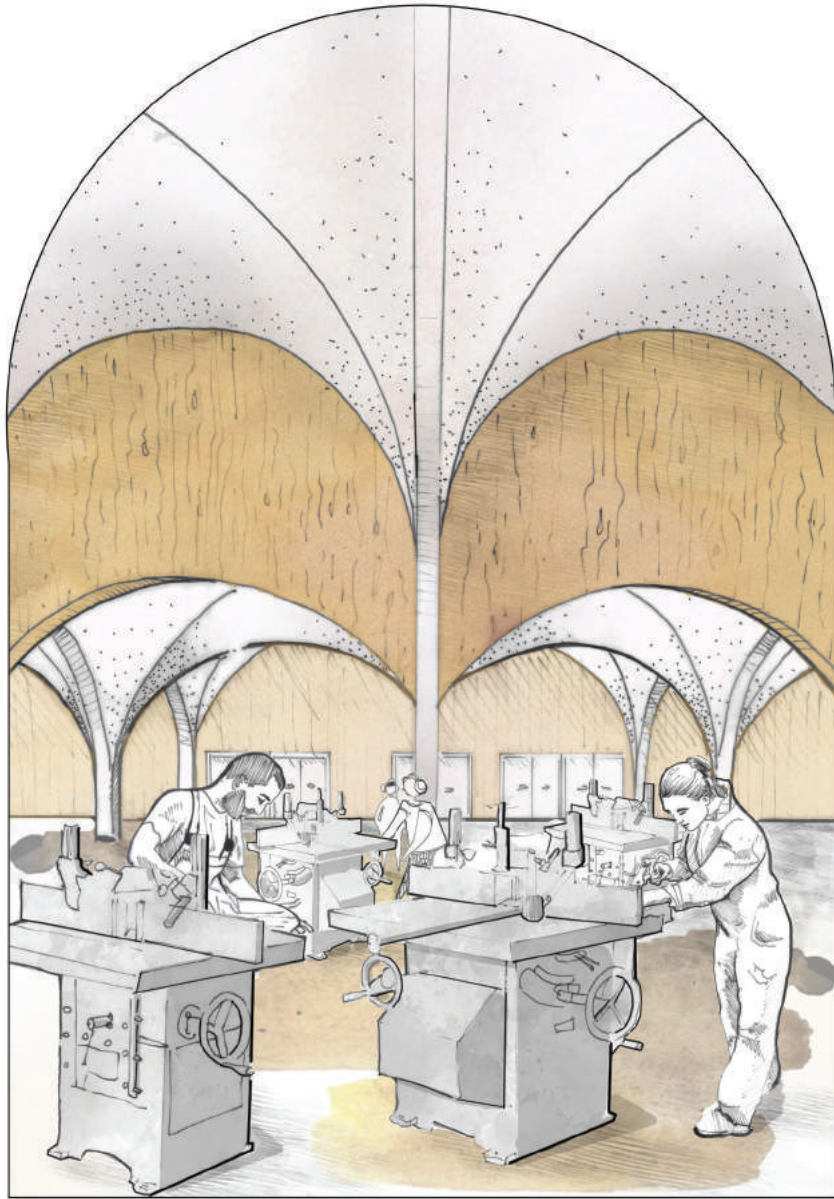
BACTERIA BRICK  
PRODUCTION

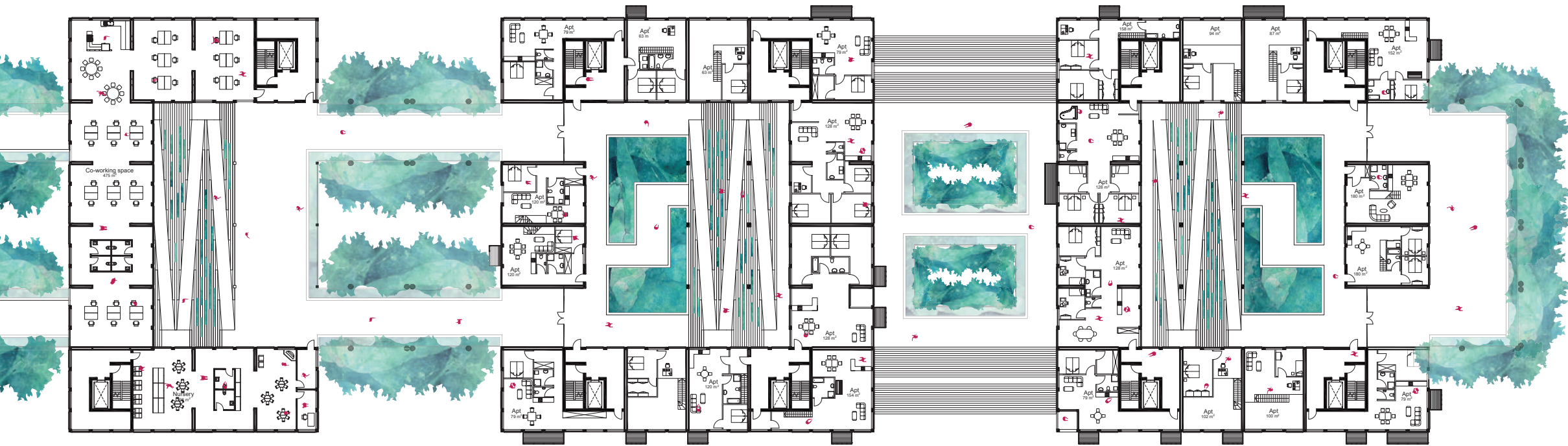
# PLANS AND SECTIONS

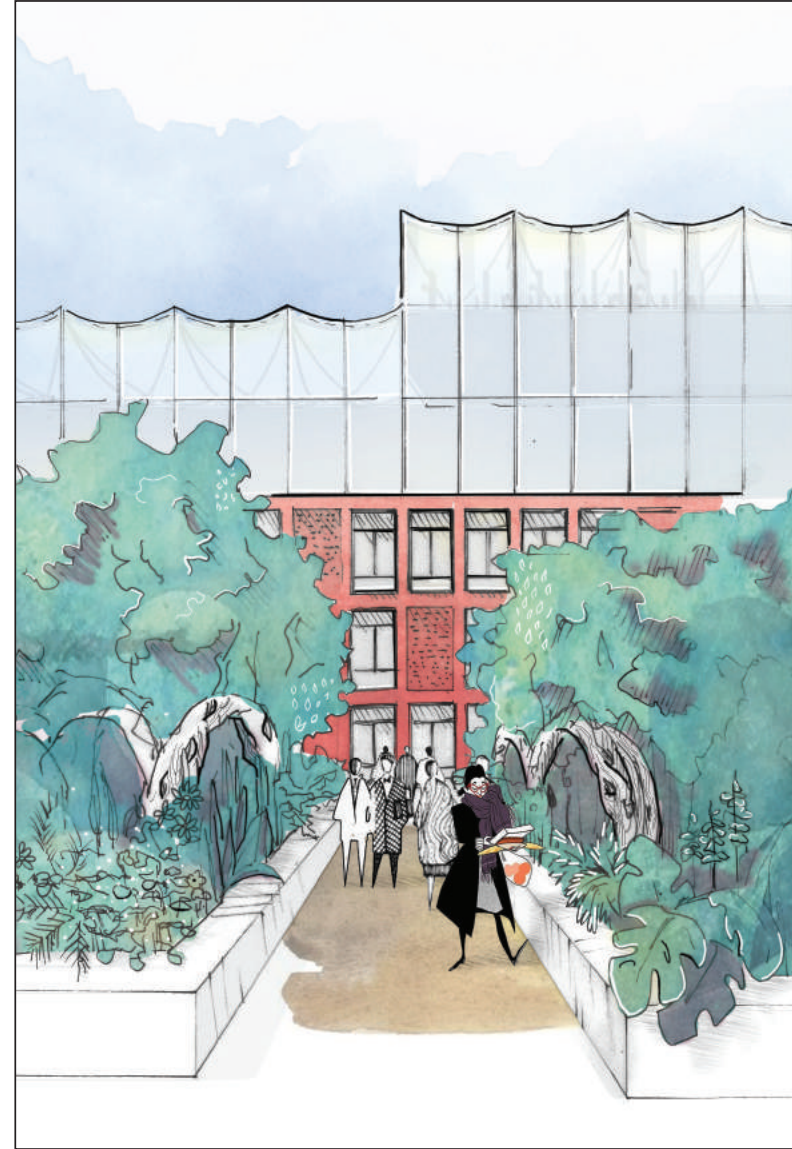


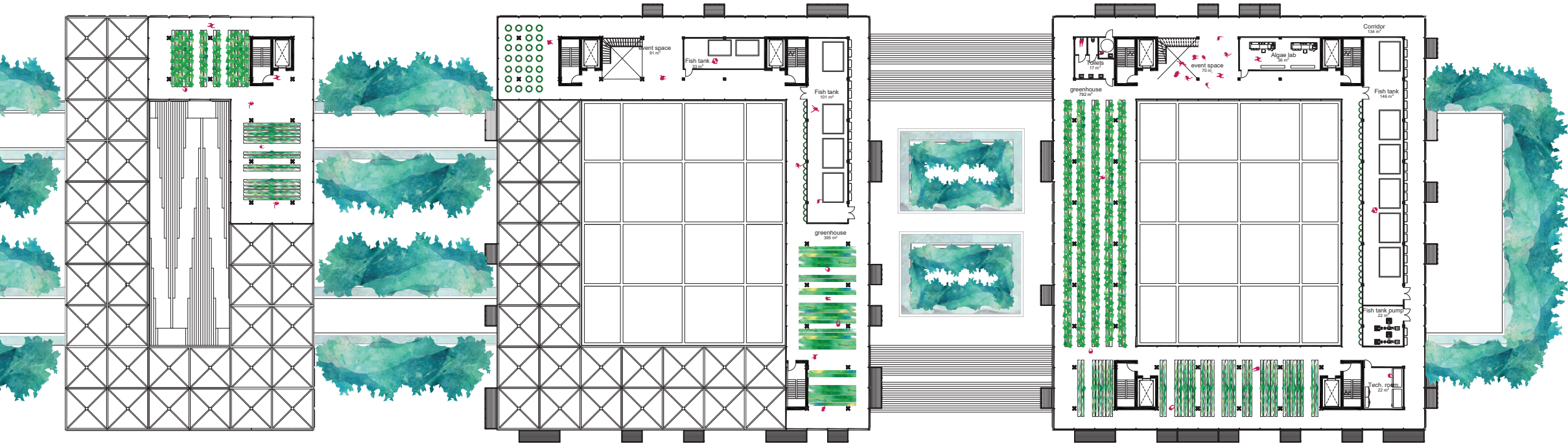


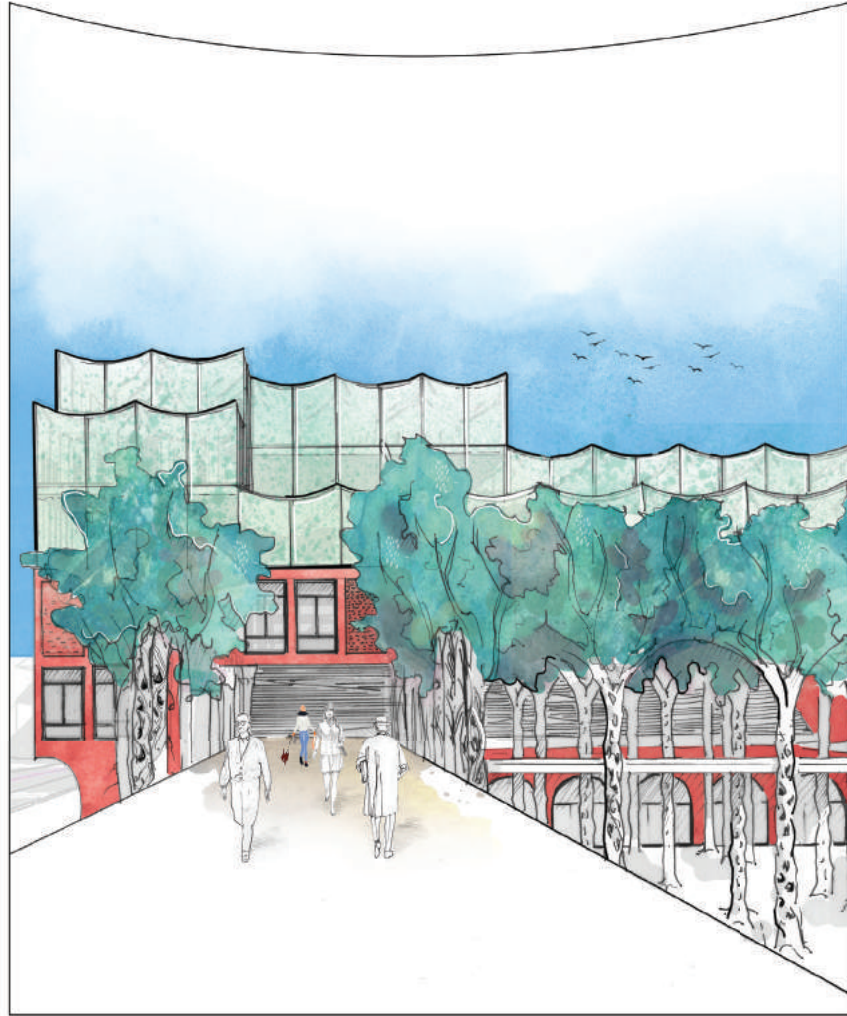






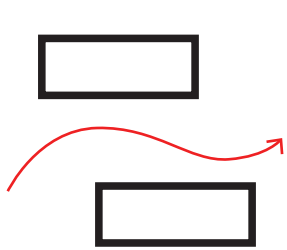




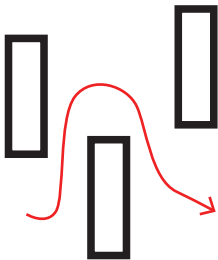


# DESIGN

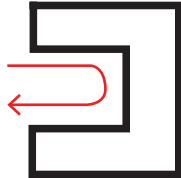
public vs. private



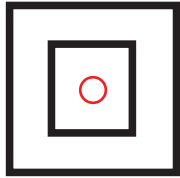
space to pass



space to wander



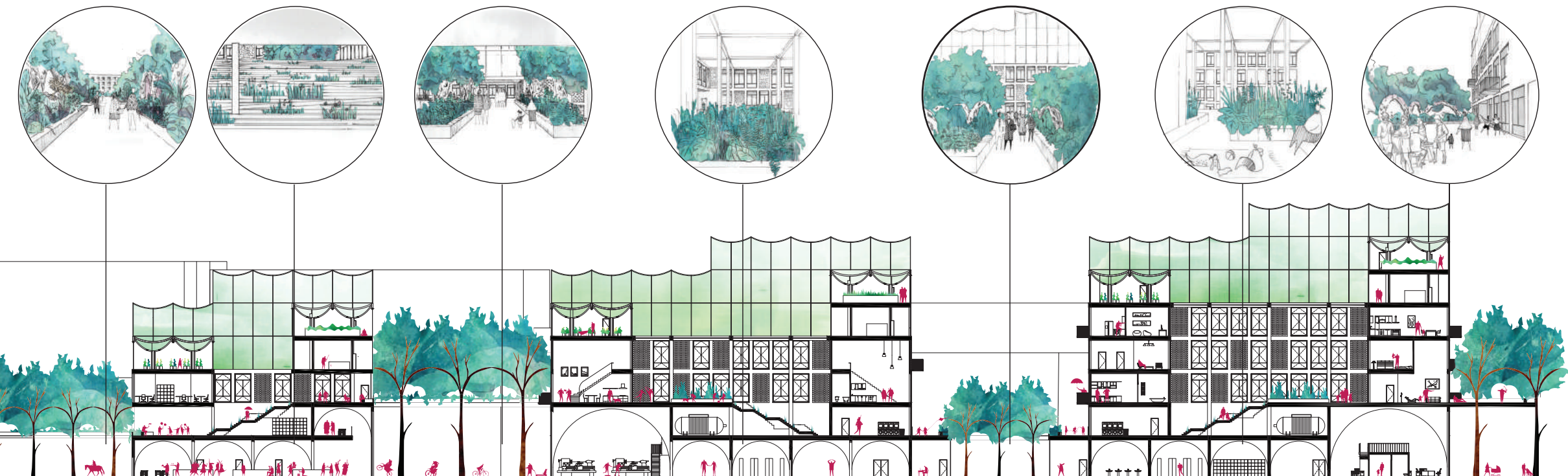
space to go



space to be

# DESIGN

green stripe



# DESIGN

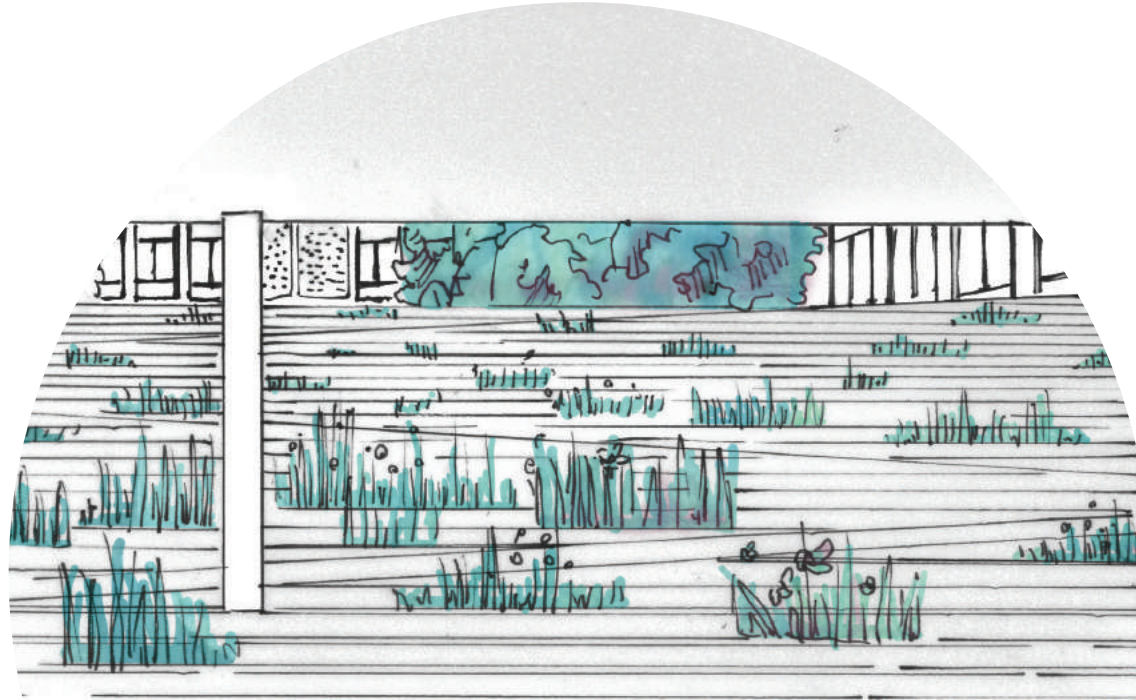
public bridge transforming into elevated park





# DESIGN

semi-public entrance



# DESIGN

semi-public passage



# DESIGN

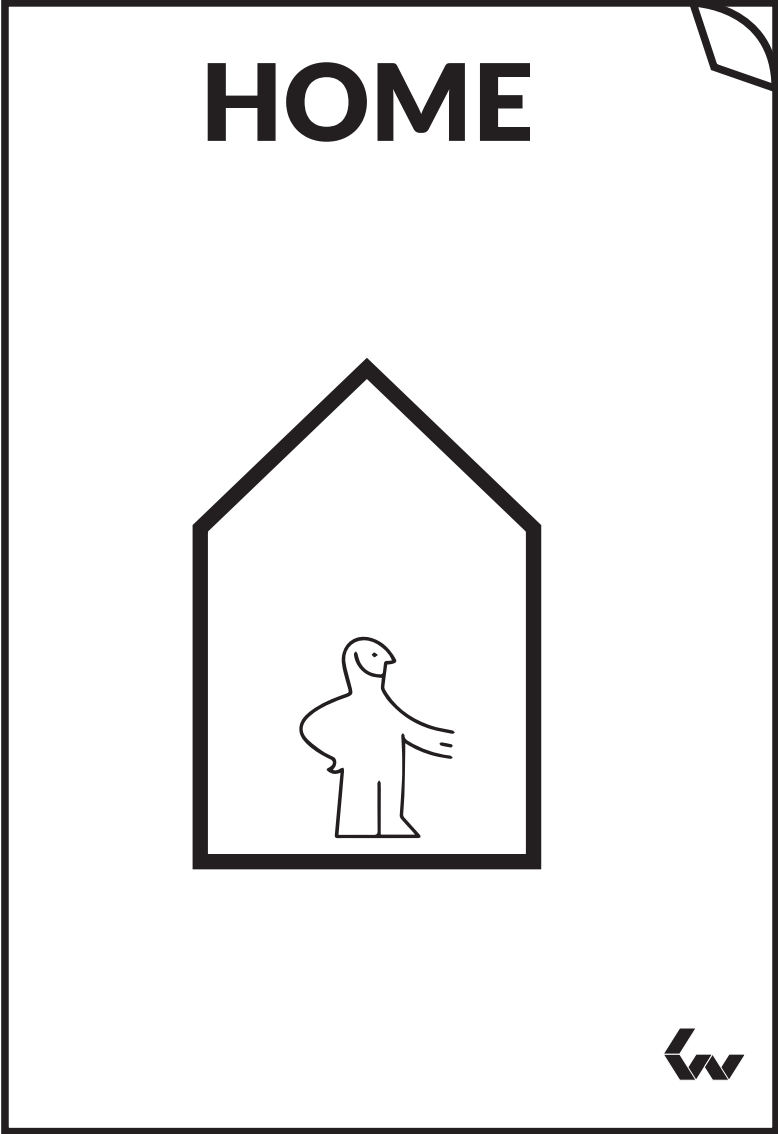
semi-private inner courtyard



# **PRIVATE APARTMENTS**

# MAKE YOUR OWN HOME

Manual



# MAKE YOUR OWN HOME

Emi and Rafat

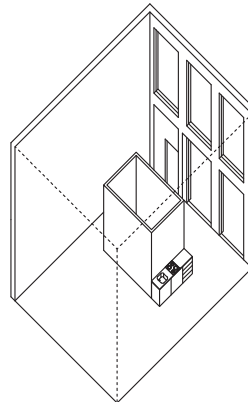


# MAKE YOUR OWN HOME

Emi and Rafat

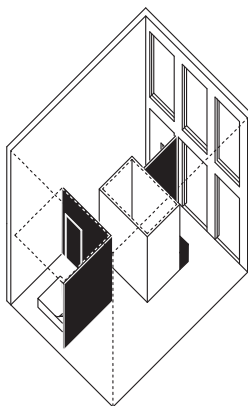


*We really enjoy the space in our new apartment! We did not want to clutter it, that's why decided to put only bathroom in the middle and the adjacent kitchenette. Maybe in the future we will add more walls, but now it works for at perfectly!*





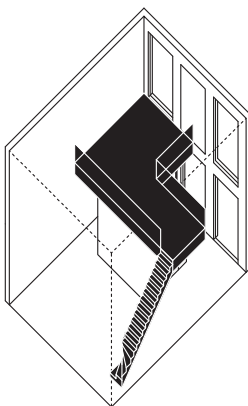
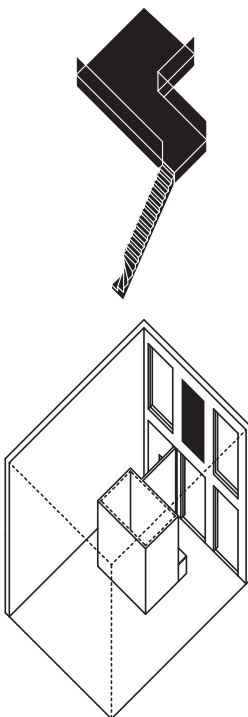
*After a year living in our new apartment, we decided to make some changes. We divided the entrance and finally bought a new, long kitchen! We also decided to create a small bedroom for us - so we have some more private space.*

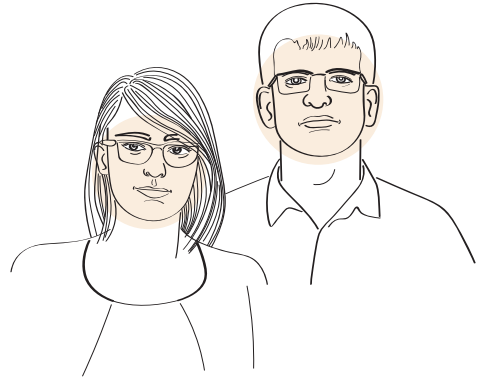




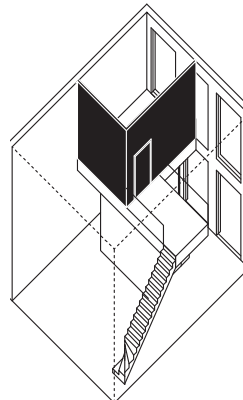
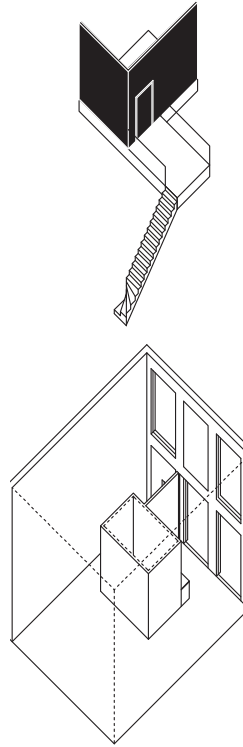


*We really missed our big living room! We decided to make another modification. This time, we added open mezzannino, where we put our bedroom. The view from there is amazing!*



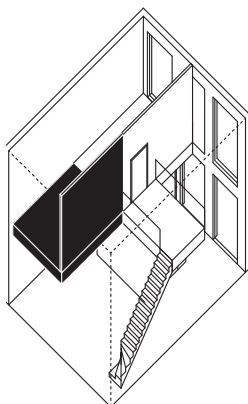
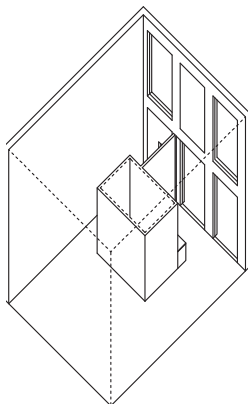
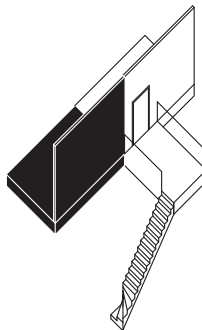


*After some time, we saved some more money to enclose our bedroom. i made it so much more silent and comfortable!*



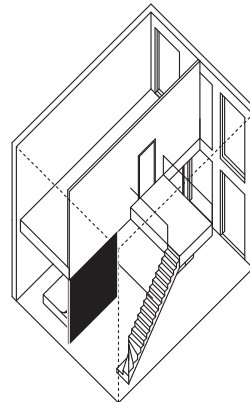
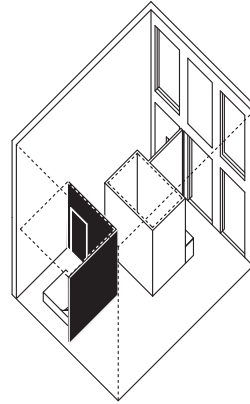
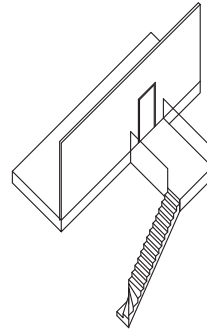


*Good news! We are having a baby. We will need more space, so we decided to extend our mezzanino. Now it's one, big room, but we can divide it in the future into two bedrooms.*

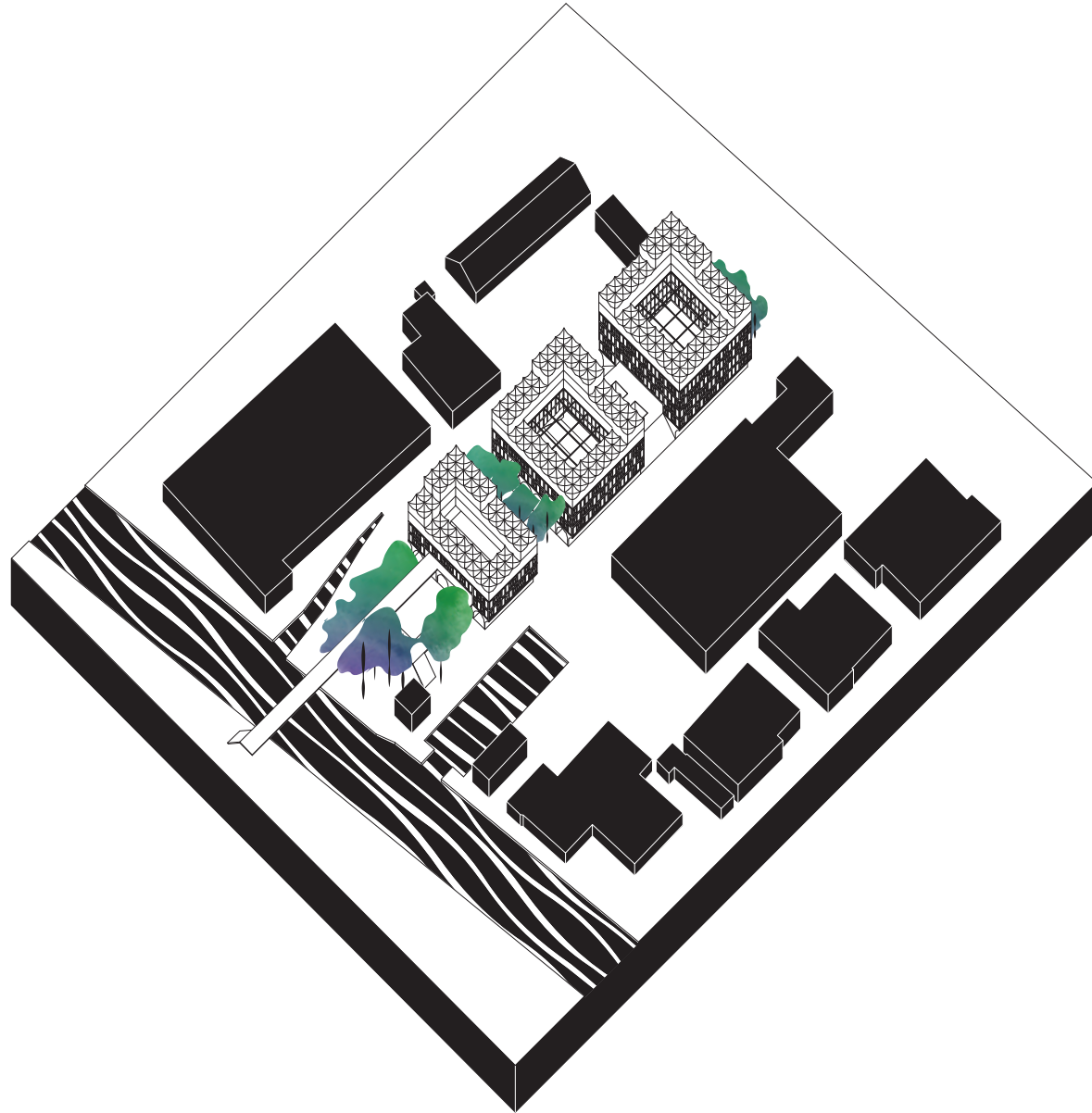


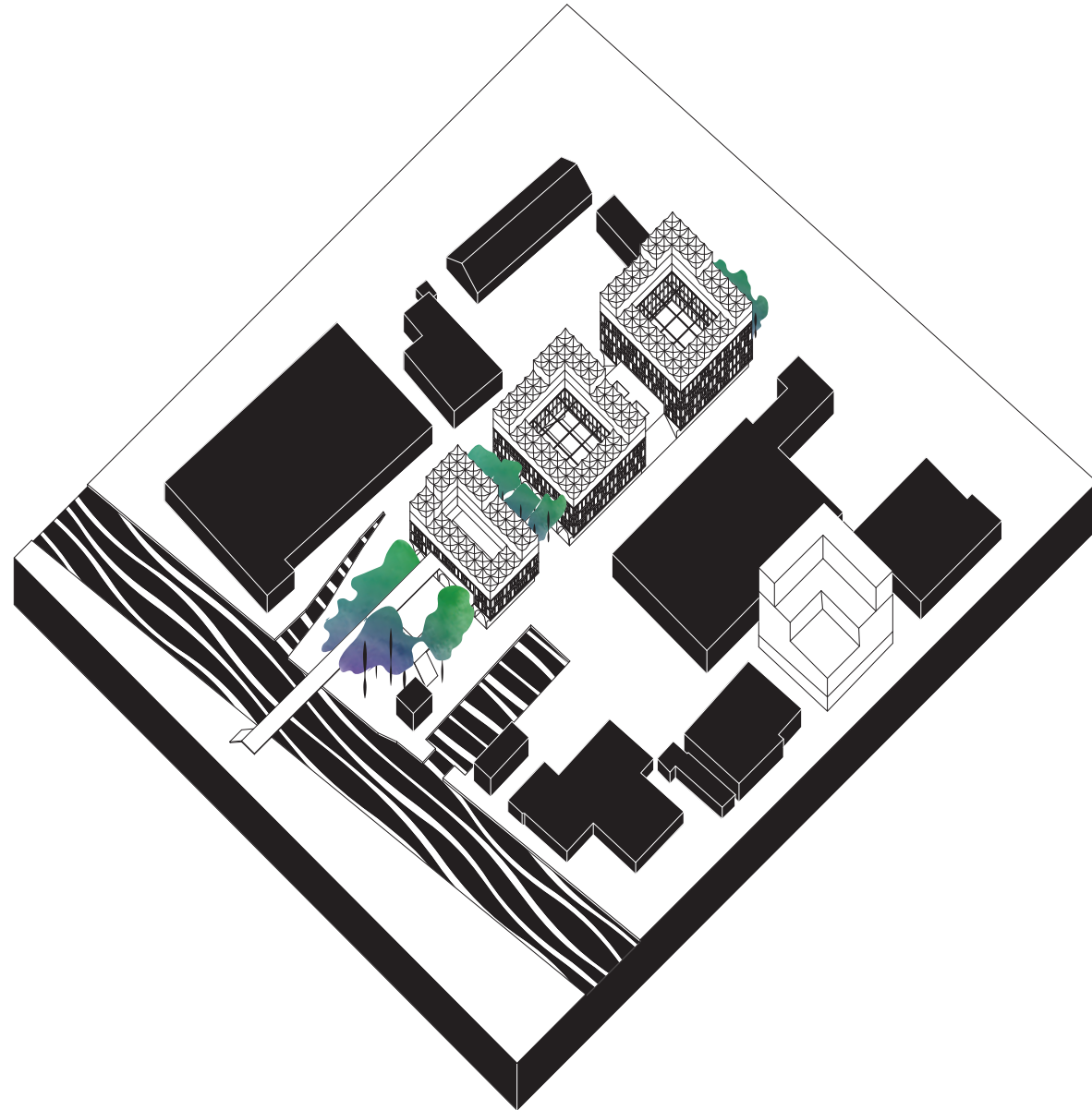


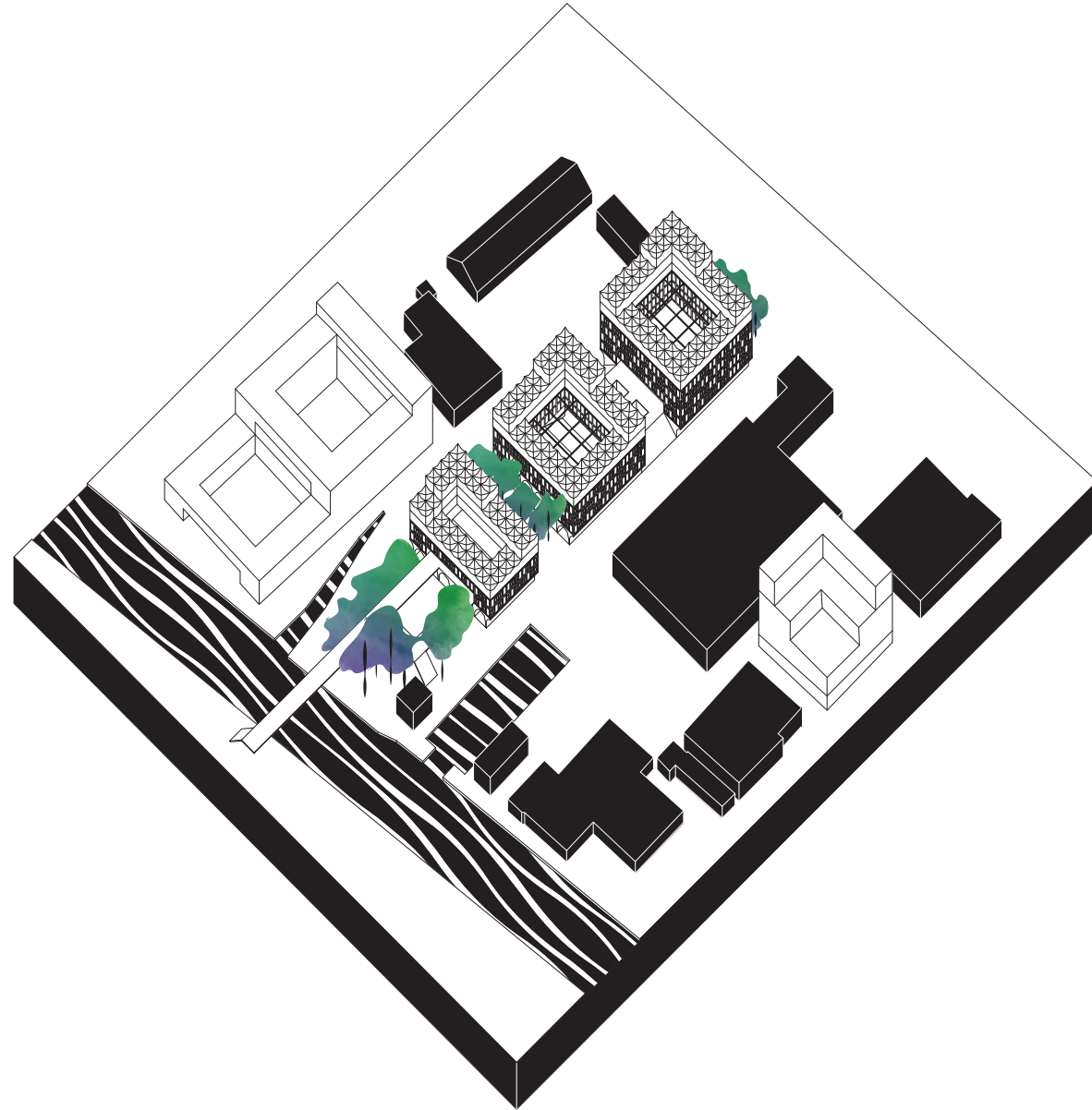
*Our son is betting bigger, so we decided to add one more bedroom. After some debates, we settled on re-creating our first bedroom on the ground floor.*



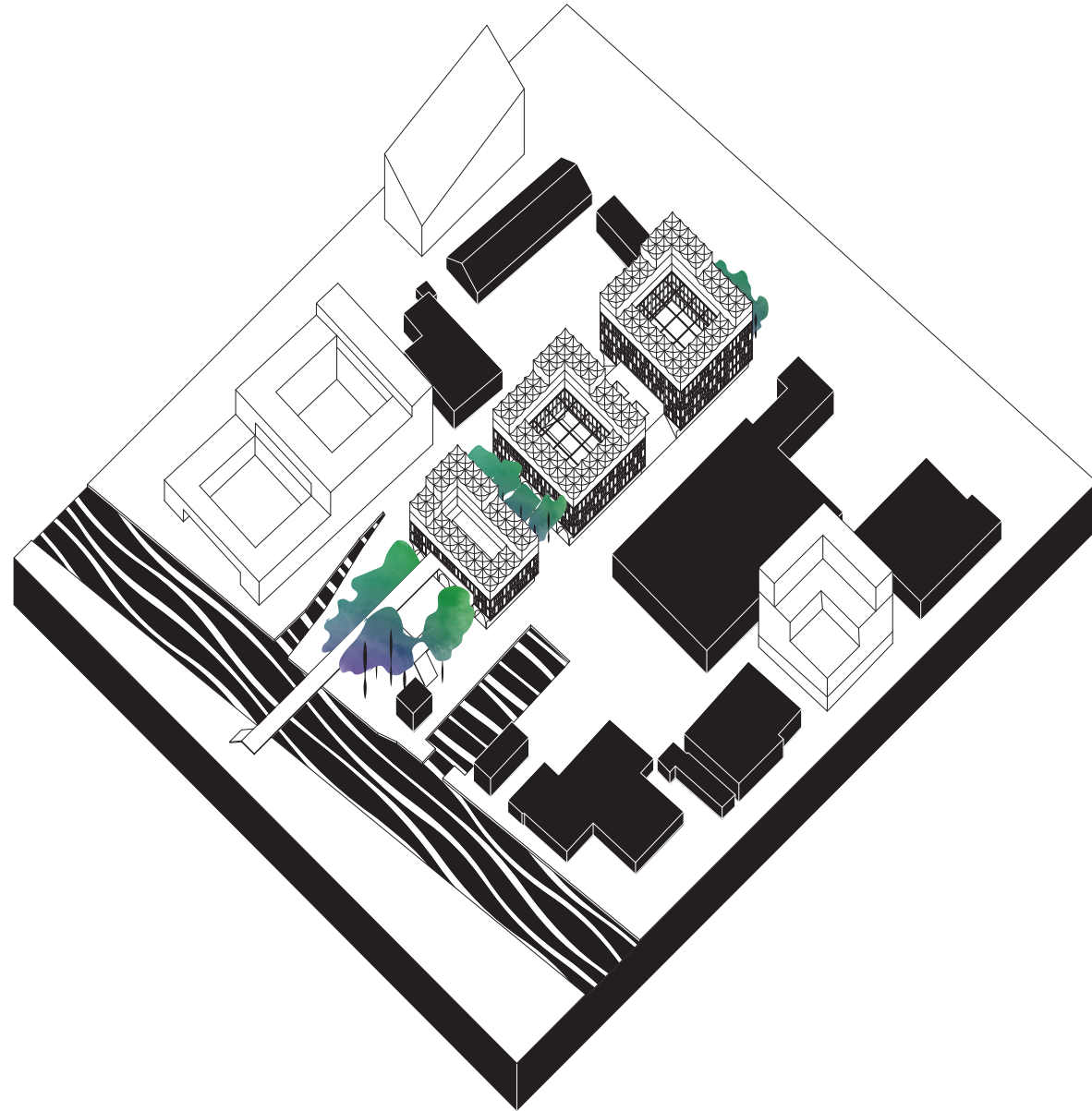
# **FUTURE DEVELOPMENT**



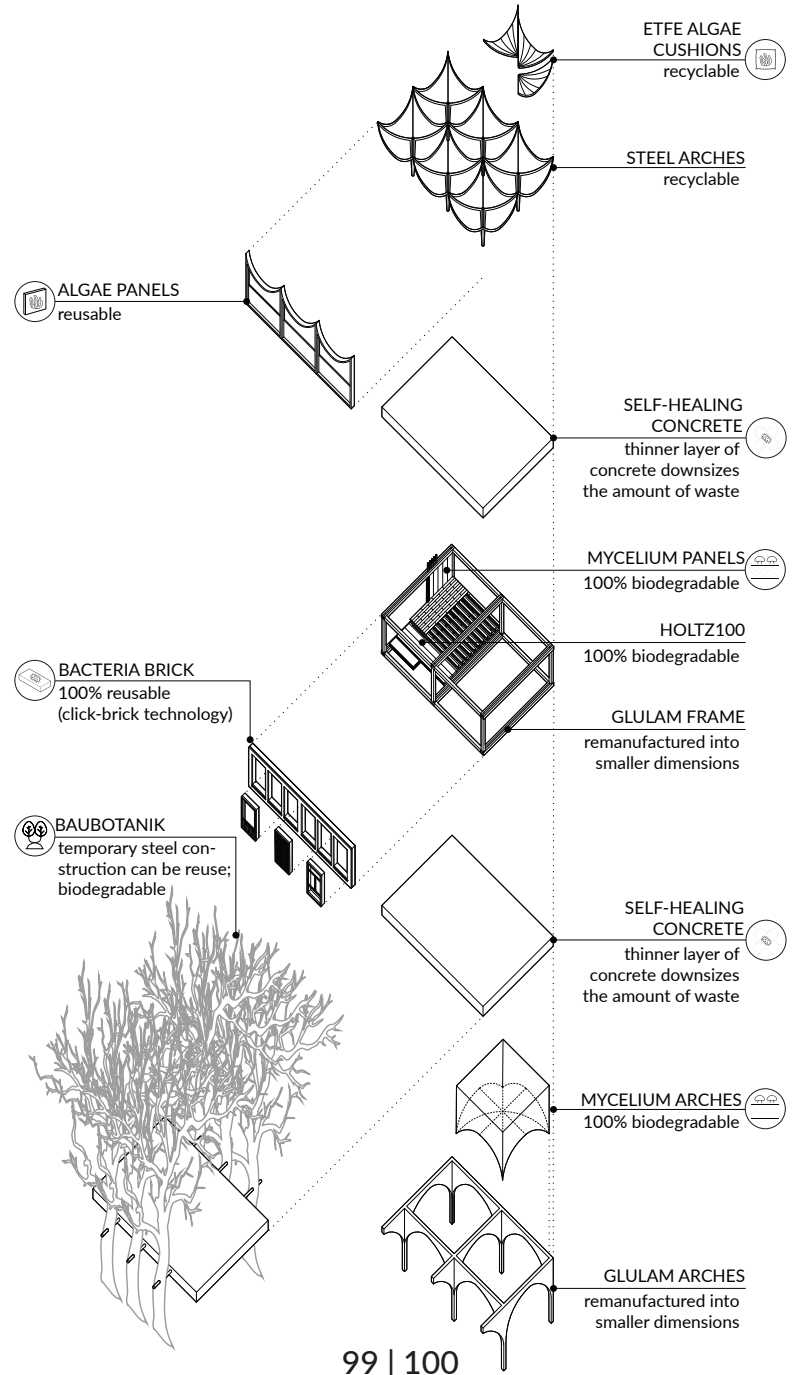








# REUSABILITY



# THANK YOU!

with special 'dziękuję' to: Enrico Liscio, Emilia & Rafał Łasochowie,  
Karolina Dyjach, Barbara Scalvini & Davide Cavalli, Thomas Fell, Paulina  
& Marek Szymaniak, mama Krzysia i tata Sławek