Growing buildings

How to design circular and sustainable buildings by using living organisms in architecture
WHY?
Problem statement
HOUSING IN THE NETHERLANDS

**NON-ECOLOGICAL**

- **LINEAR**
  Construction made in old-fashion, uncircular way

**ANTI-SOCIAL**

- **PRE-DESIGNED**
  Further 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

**ECO-FRIENDLY SOCIAL ECONOMICAL**

- **NON-ECOLOGICAL ANTI-SOCIAL EXPENSIVE**

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

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

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

New housing projects are rarely community-oriented.
WHAT?
Towards modern housing
HOUSING OF THE FUTURE

ECO-FRIENDLY
- CIRCULAR: Cradle to Cradle - all materials can be reused, recycled, upcycled or degraded
- SUSTAINABLE: No damage policy - all materials used are not harmful to the environment or inhabitants
- ECOLOGICAL: Carrying about nature and inhabitants well-being

SOCIAL
- SELF-DESIGNED: Inhabitants having direct influence on the design
- SHARED: Common spaces for inhabitants
- CITY-MAKING: Providing services and places for the whole neighbourhood
- FLEXIBLE: Design allowing the owners to easily change the layout of their apartments

ECONOMICAL
- SELF-SUFFICIENT: Producing food, energy and clean water for inhabitants
- SELF-PRODUCING: Producing part of the building materials on the site
- PRE-DESIGNED: Further inhabitants have nothing to say about the design
- LINEAR: Construction made in old-fashioned, uncircular way

By 2020, that shortage is expected to grow to 235 thousand homes. An average person needs to spend 10 years worth salary to buy an average house. New housing projects are rarely community-oriented: Housing complex is not providing all needed facilities and services. Over the past few years, relatively more studio apartments were built in cities for starters. More and more houses are built on the fringe of the cities. Buildings are designed without thinking about possible re-use: Further inhabitants have nothing to say about the design. Further, all materials used are not harmful to the environment or inhabitants.
CPC - COLLECTIVE PRIVATE COMMISSIONING
CPC - COLLECTIVE PRIVATE COMMISSIONING
in the Netherlands

Municipality can be the igniter of the process, dedicating land for CPC and helping CPC collectives to start the process.

The architect acts as a mediator in the process, not only realising the brief in a project, but actively creating one beforehand.

‘Dwellings, not revenue’ approach allows to achieve more sustainable, long-term solutions, more oriented towards social and environmental benefits, rather than financial gains.

Inhabitants create a cooperative association which officially owns the property; dwellers are tenants of their flats, paying their rent based on the size of their apartment, but having equal rights in the group.

Non-profit organisations can be created to be involved in future development, sharing knowledge and helping with the bureaucratic side of the project.

Maintenance can be shared between inhabitants and external contractor, depending on individual possibilities, needs and aims.

Community has direct influence on the design: each person has the right to vote on every decision.

Examples include:
- Reitdiep ‘t Dorp
- Vrijbrucht
- Eva-Lanxmeer
- Low Schoense
CPC - COLLECTIVE PRIVATE COMMISSIONING

actors and factors

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expansion

Inhabitants

ownership

Municipality can be the igniter of the process, dedicating land for CPC and helping CPC collectives to start the process.
CPC - COLLECTIVE PRIVATE COMMISSIONING
Theoretical commissioners

Emi and Rafał
Barbara and Davide
Paulina and Marek
## CPC - COLLECTIVE PRIVATE COMMISSIONING

### actors and factors

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**TRADITIONAL PROCESS**

**CPC**
## CPC - COLLECTIVE PRIVATE COMMISSIONING

**actors and factors**

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- developer
- municipality
- civil engineer
- contractor
- architect
- material supplier
- supplier
- energy supplier
- water supplier
- transportation
- factory
- landfill
## CPC - COLLECTIVE PRIVATE COMMISSIONING

### Actors and Factors

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- **CPC**
  - collective or municipality
  - developer
  - architect
  - contractor
  - market party

### Supporting Actors and Factors

- **Civil Engineer**
- **Material Supplier**
- **Material Reseller**
- **Energy Supplier**
- **Factory**
- **Transportation**
- **Landfill**
- **Energy Supplier**
- **Water Supplier**
HOW?
Growing architecture - towards nature
FASCINATION
Benefits of nature
FASCINATION
Benefits of nature
FASCINATION
Benefits of nature
RESEARCH

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

![Diagram showing the production process of bacteria bricks]

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).
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:
- Concrete + bacteria pellets → self-healing concrete

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 (e.g., 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:
1m² 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:**

\[ \text{mycelium} + \text{bio-waste} + \text{mold} \rightarrow \text{thermal insulation} \]

**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 Commissioning (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 materials allow for on-site production, shortening the transportation of building components.

Inhabitants can rent parts of the building to provide needed services for the whole neighbourhood, and earning revenue needed for maintenance.

The rooftops are used for common greenhouses and water collection.

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

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

Water, waste and energy circulation is embedded in the project.

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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

---
LEAVES AND FLOWERS

---
TRUNKS

---
ROOTS
NEW HOUSING TYPOLOGY
architectural language
NEW BUILDING TECHNIQUES

- GLULAM ARCHES
- GLULAM FRAME
- MYCELIUM ARCHES
- SELF-HEALING CONCRETE
- BACTERIA BRICK FACADE
- INTERCHANGABLE PANELS
- ALGAE PANELS
- ETFE ALGAE CUSHIONS
- STEEL ARCHES

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

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

COMMERCIAL SPACE in the ground floor, along the street

HOUSING composed of 63m² units

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

ALGAE CIRCULATION

- Two arms distribute water with microalgae
- ETFE cushions with embedded pipes evenly distribute microalgae
- Another two arms collect water with microalgae

WATER HARVESTING

- Each element is shaped to collect rain
- Pipe is hidden in the central column

ALGAE ETFE CUSHIONS

ALGAE PANELS

SYSTEM:

ADVANTAGES:
- Having the plantation on the site, the carbon footprint is reduced to a 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
NEW BUILDING TECHNIQUES

ALGAE ETFE CUSHIONS
ALGAE PANELS
ETFE cushions micro algae algae ETFE

BACTERIA BRICK FACADE

GAP FOR INSTALATIONS
MYCELIUM BOARD
FLOORING
WOODEN BEAMS
HOLTZ100 FLOOR
MYCELIUM INSULATION PANELS

ADVANTAGES:
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FACILITIES:
Water pump, storage space for harvested algae.

SUPPLY:
Water
BUILDING MATERIALS
mycelium sandwich panel

sawdust

+ 2 weeks

mycelium

39 | 100
NEW BUILDING TECHNIQUES

SELF-HEALING CONCRETE

MYCELIUM ARCHES

GLULAM ARCHES

GLULAM ARCHES

GLULAM COLUMN

MYCELIUM SHELL

MYCELIUM BRICKS

GLULAM ARCH

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

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Less than 2 weeks for production.

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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
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 60m² units.

PRODUCTION situated in the middle, of the block, partially double-heigh.

COMMERCIAL SPACE in the ground floor, along the street.
MODERN HOUSING
raw numbers

65 m² apartment
- internal walls: 25 m
- external walls: 36 m
- floor boards: 65 m² [+20%]

one panel length: 0.6 m
- interior panels: 40 panels
- external panels: 60 panels
- floor panels: 50 panels
- one apartment: 150 panels

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

Regular Dutch person
- greens: 46.4 kg/year/p.p.
- legumes: 1.5 kg/year/p.p.
- fish: 36.9 kg/year/p.p.

- aquaponics: 3.8 kg/m²
- hydroponics: 2.6 kg/m²
- vertical farming: 73 kg/m²

Living Machine System: 250 l/m²

It takes 7 months before the first fish are mature.
MODERN HOUSING
CPC process timeline

- Design
  - Plot is dedicated
  - Construction starts
  - Housing production
  - Greenhouse and LMS
  - Interiors are finished
  - Housing is further developed

- Construction
  - Collective is created
  - Workshop is organized to adjust common spaces for inhabitants
  - LMS is set and starts purifying water
  - Commercial and residential
  - Interior panels start of production
  - First plants and fish are introduced
  - Plants and fish are mature
  - Greenhouse keeps producing
  - Commercial and residential
  - Interior panels recycling

- greenhouse
  - Trees are planted on the construction
  - Trees are connected into one structure; additional planters can be desmounted
  - Trees are growing stronger, allowing for desmounting of parts of the construction

- Initial construction
  - All additional construction can be dismounted when trees are strong enough

- Inhabitants can move in
  - If needed, collective space is redesigned and redeveloped
  - Workshop is organized to adjust common spaces for inhabitants
  - LMS is set and starts purifying water
  - Commercial and residential
  - Interior panels recycling

- BAUBOTANIK
  - GREENHOUSE PRODUCTION
  - CONSTRUCTION
  - DESIGN
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
Industrial area under transformation into housing district
TRANSFORMATION
existing situation
TRANSFORMATION
existing communication
TRANSFORMATION
new connections and pocket parks
TRANSFORMATION

design plot
We know at least 10 other couples that would be interested in this project.

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

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.
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**

materials calculations

65 m² apartment

- internal walls: 25 m
- external walls: 36 m
- floor boards: 65 m²
- one panel length: 6 m
- interior panels: 40 panels
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- one apartment: 150 panels

- facade: 14 m
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90 x 65 m² apartment

- 400 m² of mycelium board growing room allows to produce 1250 panels/week
- 6 machines (3500x760) can produce 2400 bricks in 5 days

- 11 weeks x 90 x 65 m² apartment

Living Machine System: 250 l/m²

Fish tank: 800 m³
Hydroponics: 2000 m³
Vertical farming: 400 m³
Living Machine System: 115 m³

It takes 7 months before the first fish are mature
DESIGN
construction timeline

MYCELIUM BOARD PRODUCTION

WOOD WORKSHOP

BACTERIA BRICK PRODUCTION

65 | 100
DESIGN
construction timeline
DESIGN
construction timeline
DESIGN
construction timeline

ALGAE PANELS
AQUAPONICS
DESIGN
public vs. private

PUBLIC

SEMI-PUBLIC

SEMI-PRIVATE

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

HOME
MAKE YOUR OWN HOME
Emi and Rafał
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 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 getting 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