

The Science Collective
a circular re-design of the Applied Physics building

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P5 presentation
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Engbert van der Zaag

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cyclifiers
material flow analysis
reuse potential

roadmap

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program
facade
climate concept

INTRODUCTION

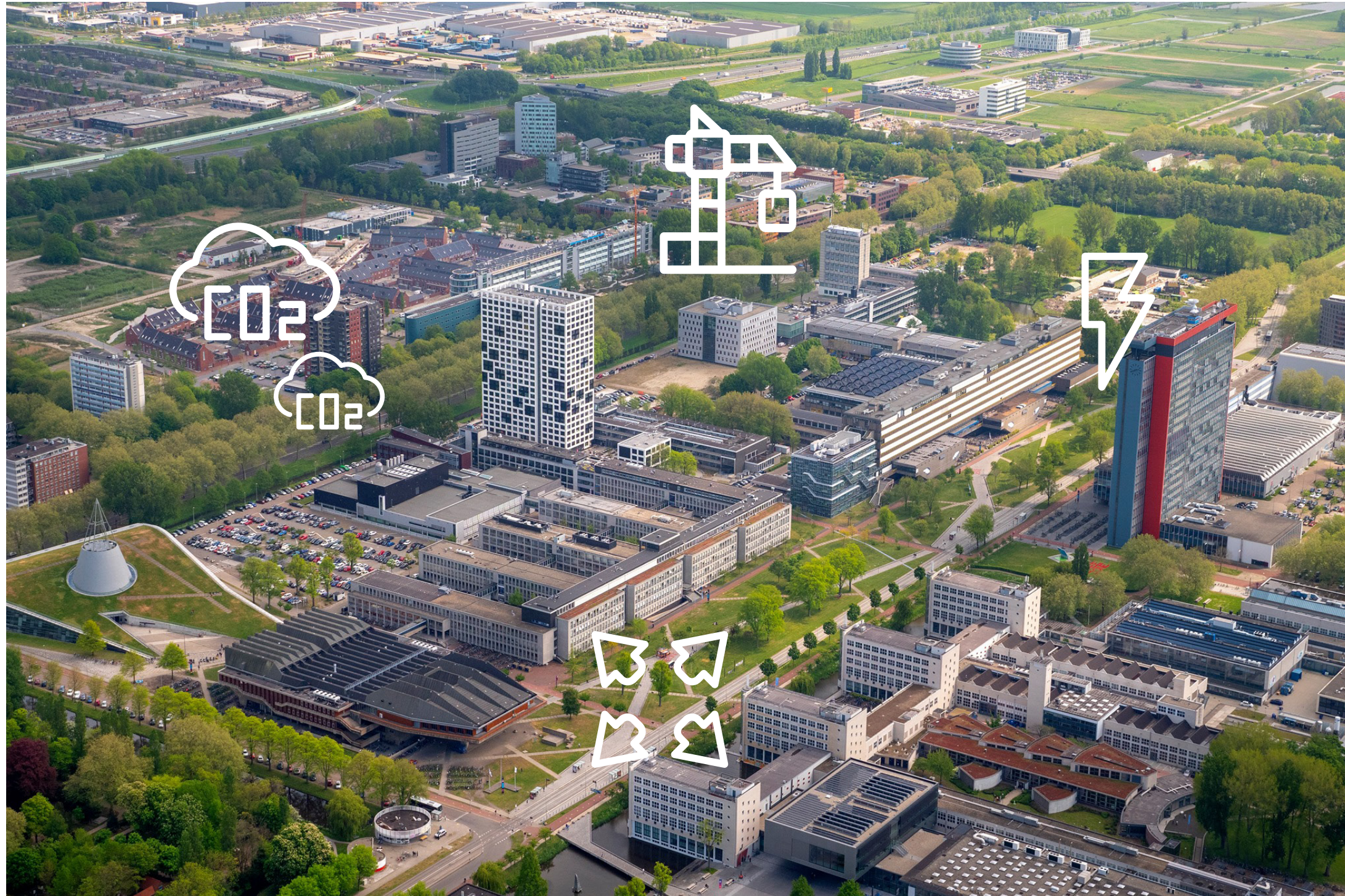


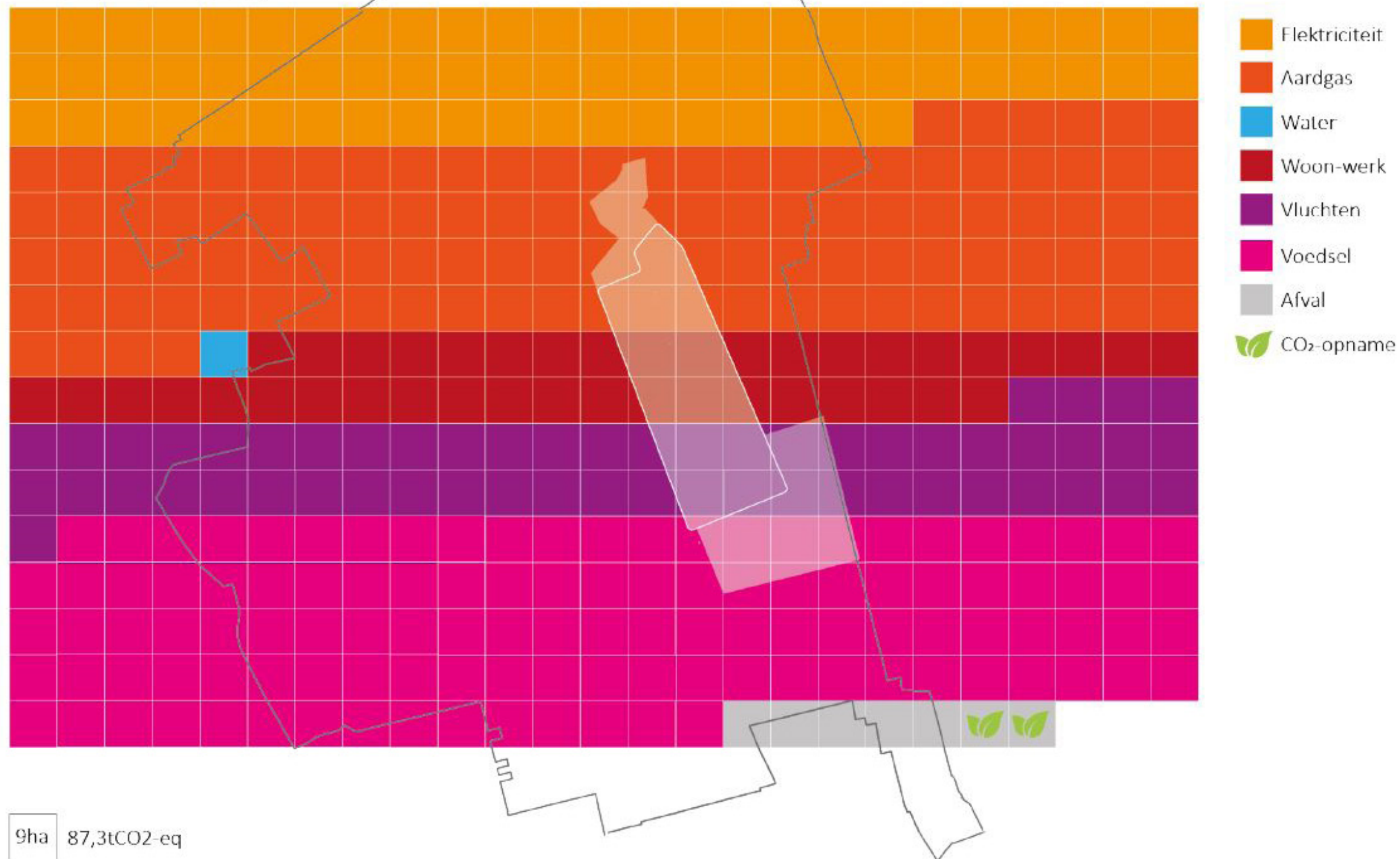
Photo: TU Delft campus life: <https://www.facebook.com/TUDelftCampusLife/photos/p.540351696507032/540351696507032/?type=1&theater>

Campus and Real Estate (CRE):
TU Delft is a CO₂ neutral and circular campus by 2030.

European Green Deal:
“achieve climate neutrality by 2050”

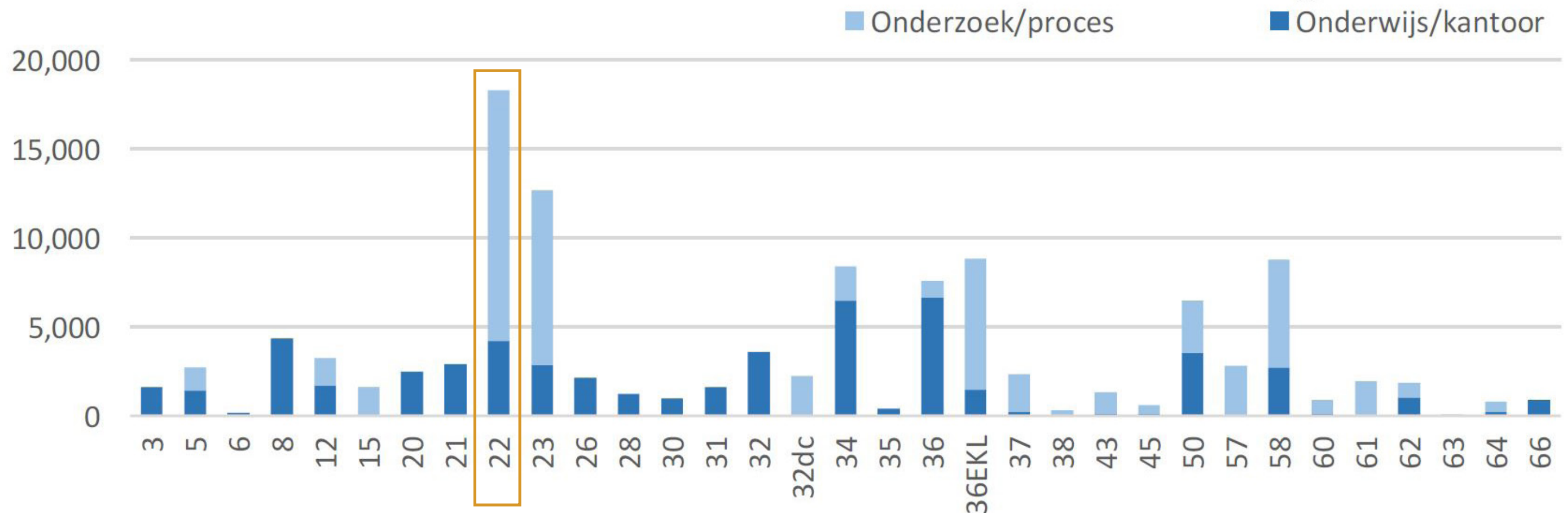
CURRENT STATE - CO₂ EMISSIONS

47.957 tCO₂-eq



CURRENT STATE - ENERGY

Energy consumption MWh
Heat & electricity combined



Building 22 = applied physics

Approximately

5-15 %
circular

Lack of knowledge on the current flows at the TU Delft campus

re-design

re-use exiting materials

renovate



flow research: electricity, heat & materials

OVERALL DESIGN QUESTION

How to design and redevelop building 22 Applied Physics on the TU Delft campus using **circular design techniques**, connecting the **flows** on a local level and **reuse existing materials** to achieve the goals of a fully circular, energy neutral and CO₂ neutral campus?

Techniques

What circular design techniques exist?

How can they be used for the redevelopment of the building?

Flows

How do the flows work?

How can we close the electricity, heat and material loops?

Materials

What materials are present in the building?

What is their re-use potential?

What materials need to be harvested to redevelop the building?

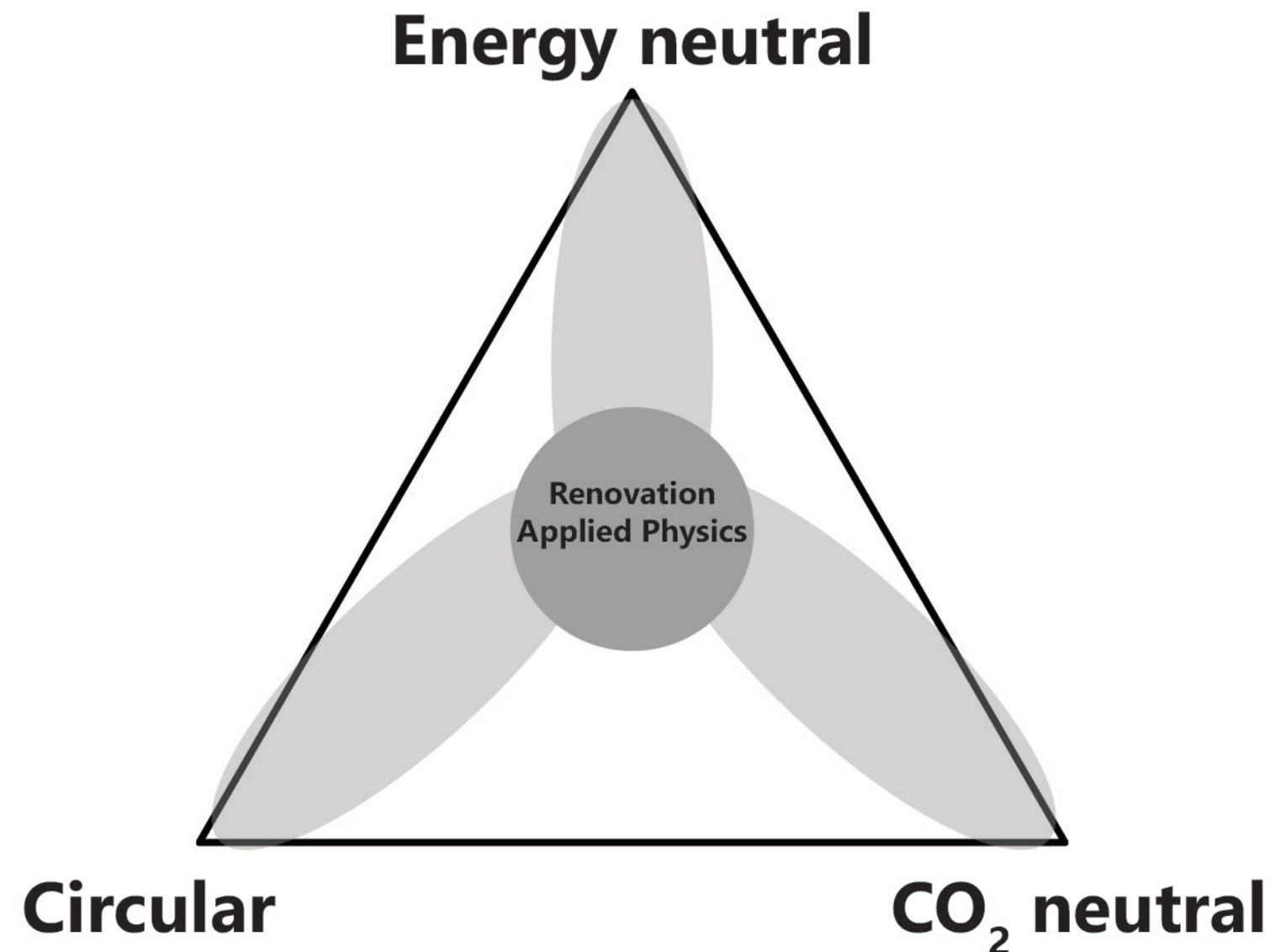
Using local energy and material flows to redevelop the Applied Physics building as part of a circular and CO₂ neutral TU Delft campus

OVERALL DESIGN QUESTION

How to design and redevelop building 22 Applied Physics on the TU Delft campus using circular design techniques, connecting the flows on a local level and reuse existing materials to achieve the goals of **a fully circular, energy neutral and CO₂ neutral campus?**

Goals of CRE for 2030

What interventions are needed to reach these goals?



THEMATIC RESEARCH QUESTION

What interventions are needed in **building 22 Applied Physics** to reduce its current impact by using the available **flows (heat, electricity and materials)** and their potential the redevelop the building into a fully circular, energy neutral and CO₂ neutral building?

The building

What is the current impact of the building on its environment?

How can we reduce this to reach the goals?

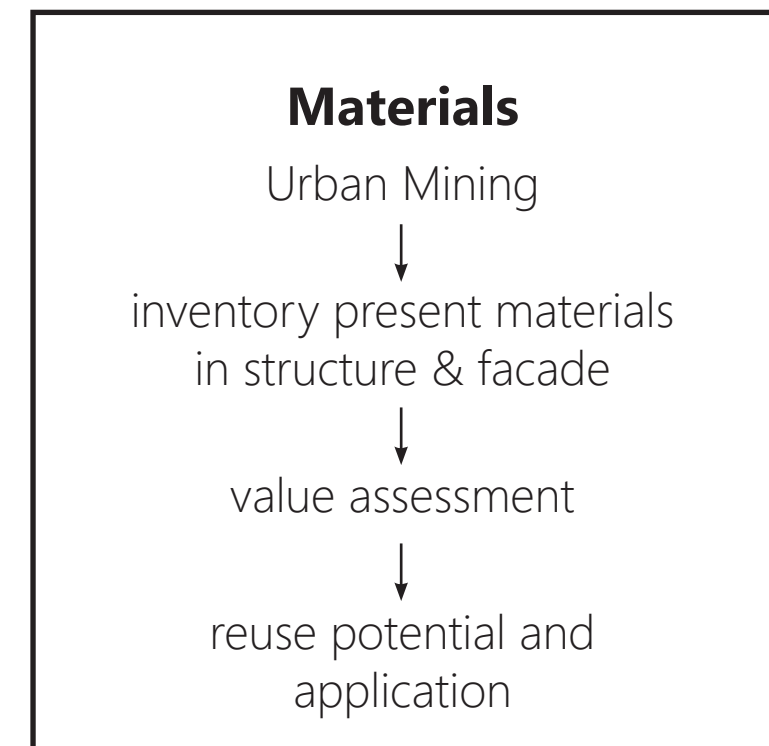
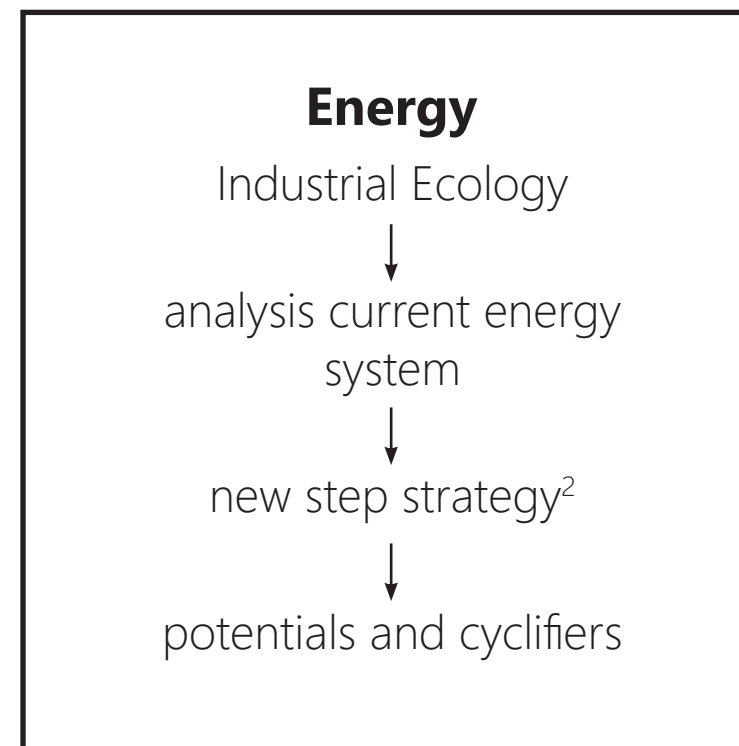
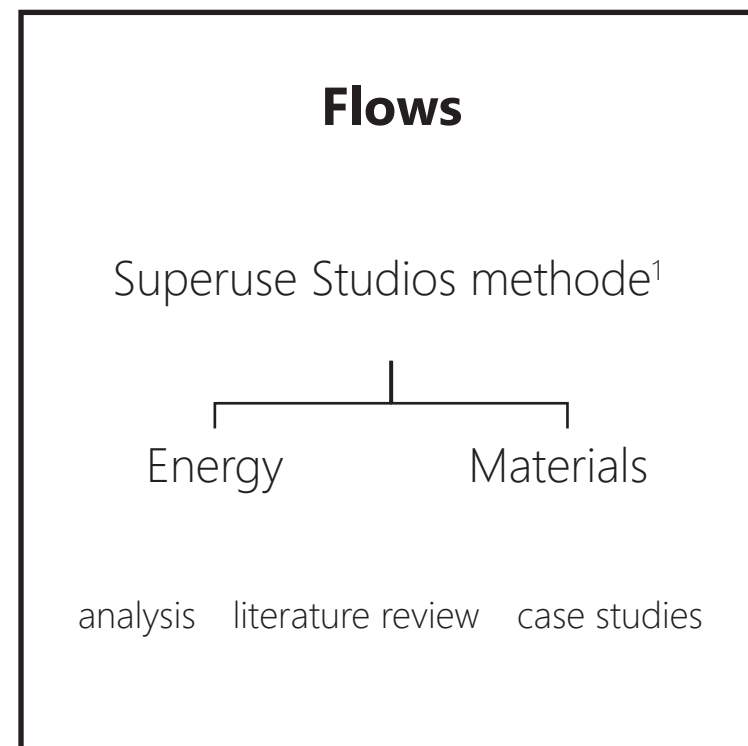
Flows

What is the current situation of these flows?

How can we close the electricity, heat and material loops?

A roadmap with interventions needed redevelop the building as part of a closed loop energy and material system

METHODOLOGY



outcome research: roadmap

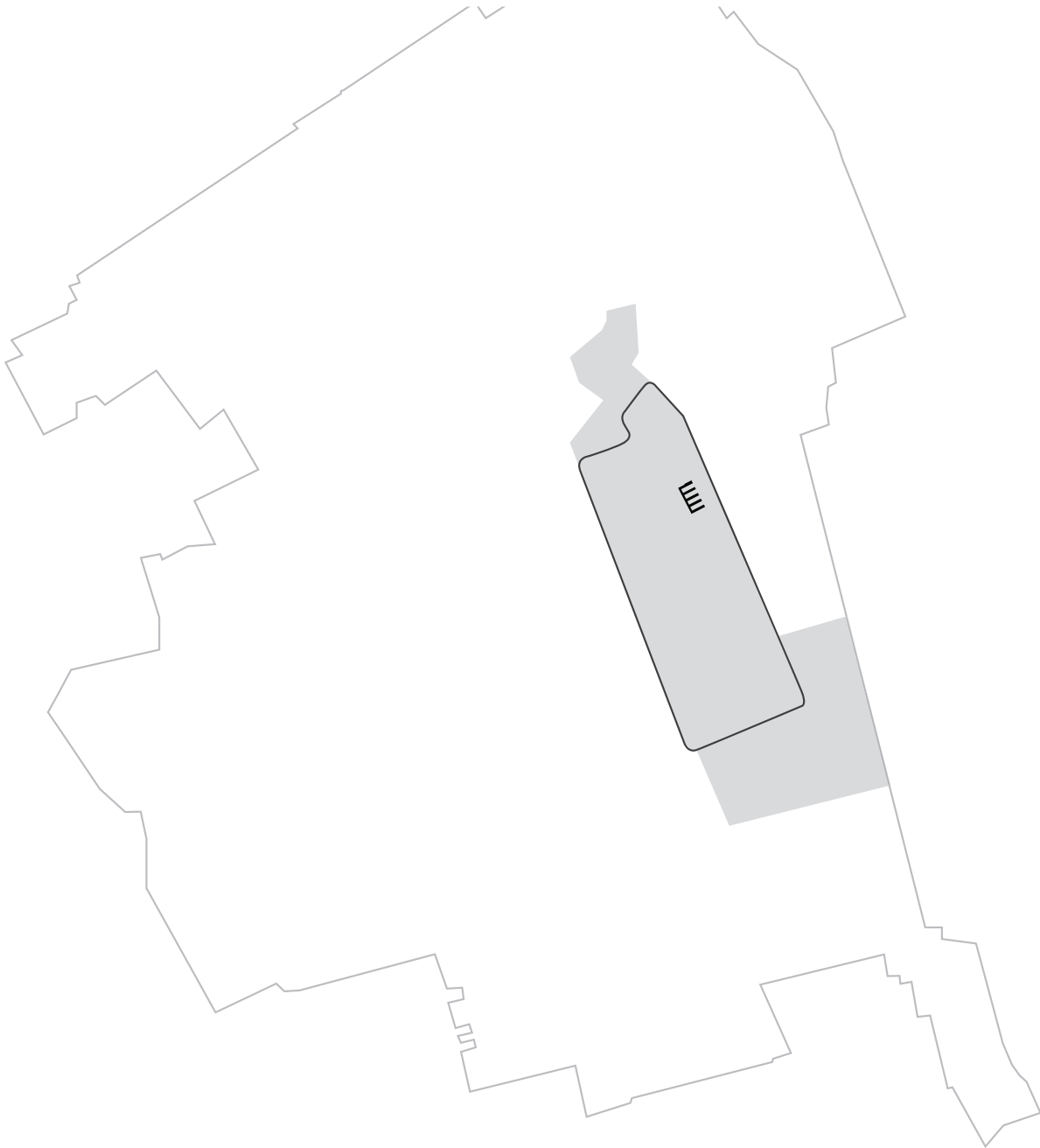
1: Jongert, J. (2014), INSIDEflows research group 2013-2014 reader, 2012 Architecten, & Goossens, F. (2009). Recyclicity: Industrial Ecology applied in the urban environment.
2: 0) research current situation 1) reduce 2) reuse 3) produce sustainably A. van den Dobbelsteen (2008)

context

CONTEXT



The Netherlands



Municipality of Delft

SYSTEM BOUNDARY - CAMPUS TU DELFT

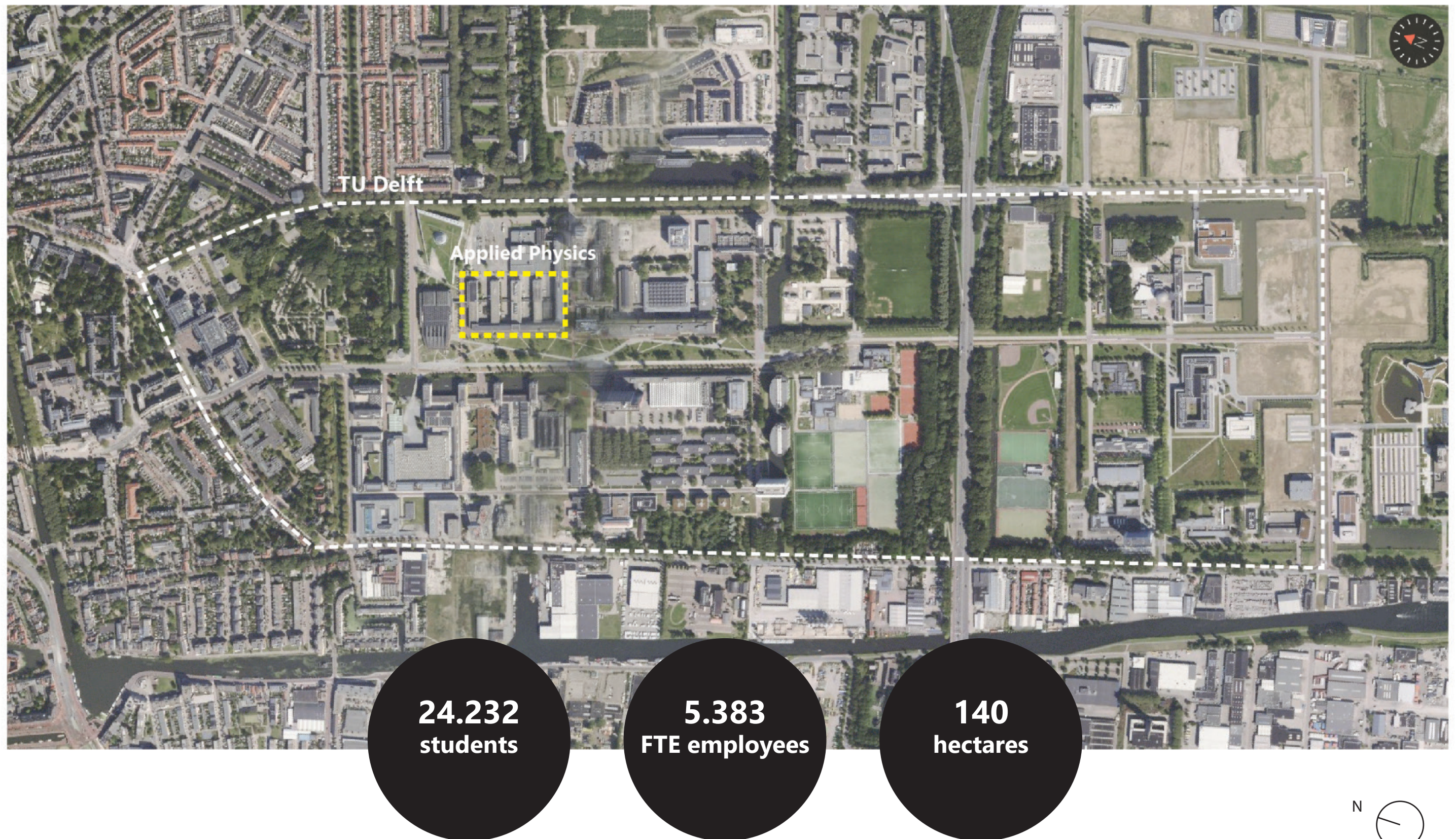


image: apple maps



BUILDING 22 FACTS

**built in
1963**

43100 m²

**Roosenburg,
Verhave and
Luyt architects**

**1270
students**

**1010
FTE employees***

**QuTech &
Microsoft**

* Employees in the Faculty of Applied Sciences where building 22 is part of
TU Delft, Architectenkaart, [online] <https://campusdevelopment.tudelft.nl/wp-content/uploads/2018/05/Architectenkaart-campus-18-04.pdf>
TU Delft (2020), Facts & Figurs 2019-2020, [online] <https://www.tudelft.nl/en/about-tu-delft/facts-and-figures/>



image: Fotografische Dienst TU Delft 1969





image: Nienke Scheenaart



image: Nienke Scheenaart



TU DELFT CAMPUS - SWOT

Strengths

- High-quality facilities (labs, equipment, etc.)
- Strong start-up ecosystem
- Variety of cafe's and food options

Weaknesses

- **Lots of green but of low quality**
- Current buildings are in need of renovation
- **Campus lacks a 'pulsing heart'**
- At night the campus is desolate
- Insufficient bike parking opportunities

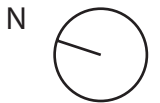
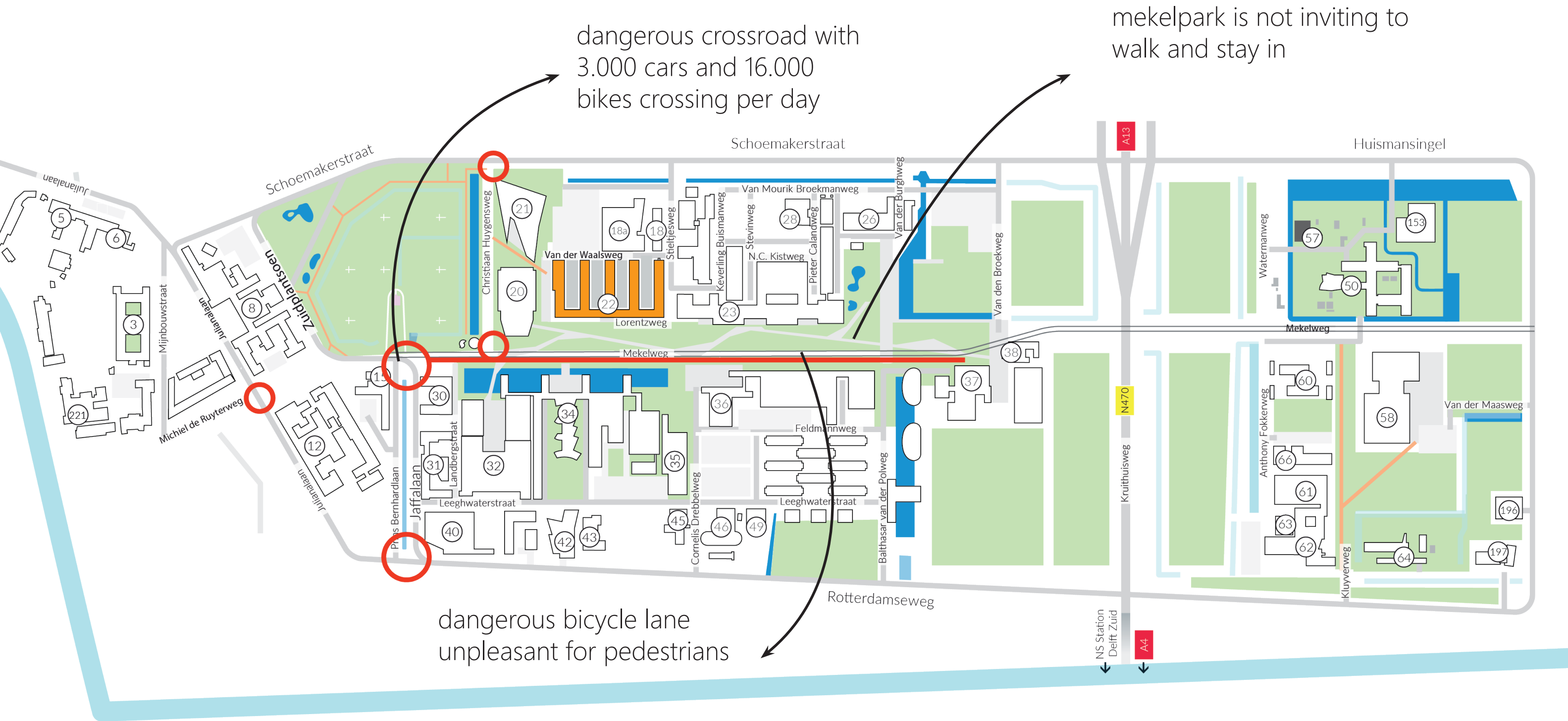
Opportunities

- Re-development campus
- Digitisation
- City-as-campus & Campus-as-city
- Living lab in Mekelpark

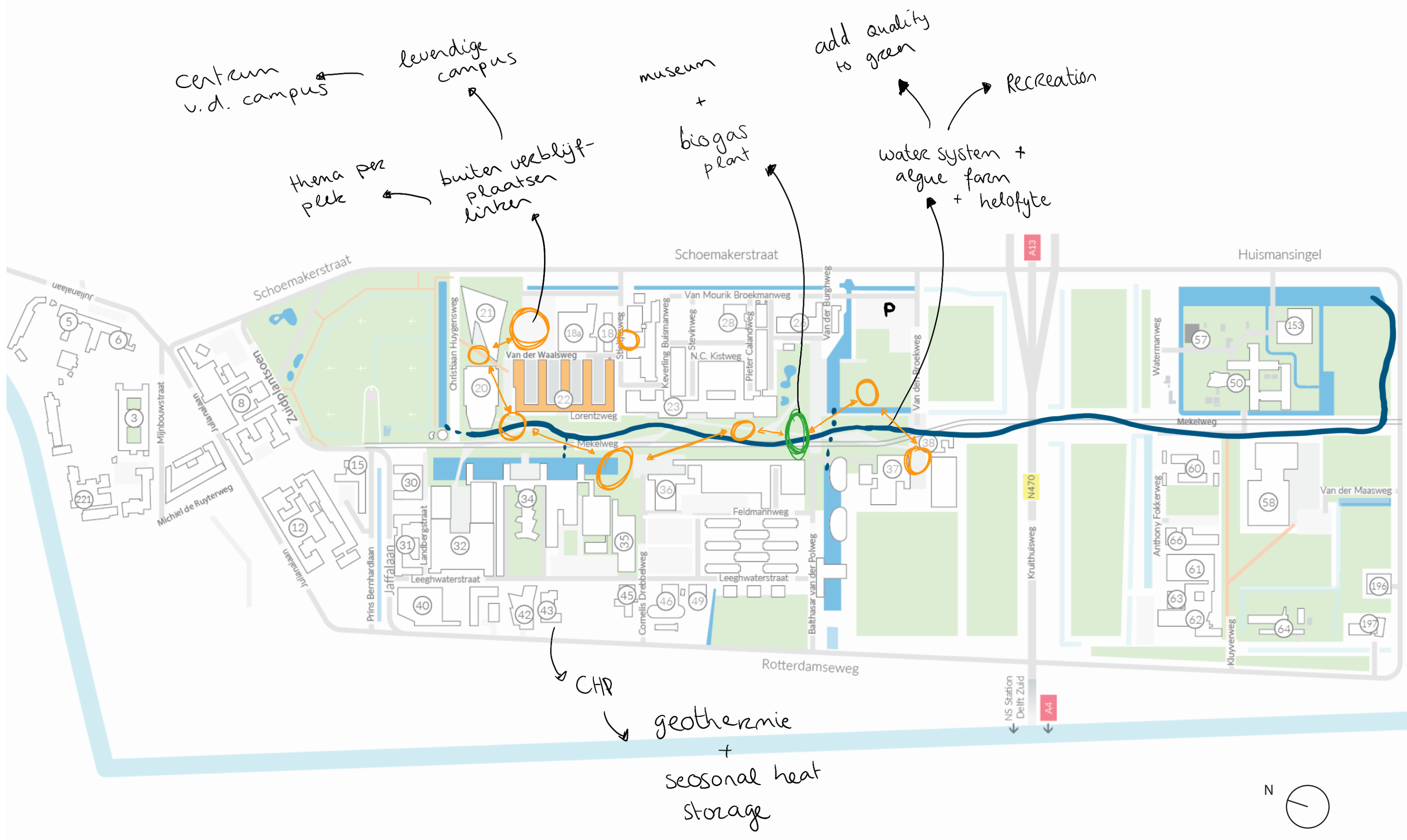
Threats

- **Bikes and car traffic create unsafe situations**
- High maintenance costs for estate
- 'anderhalve-meter-samenleving' results in a (temporary) change of available workspaces

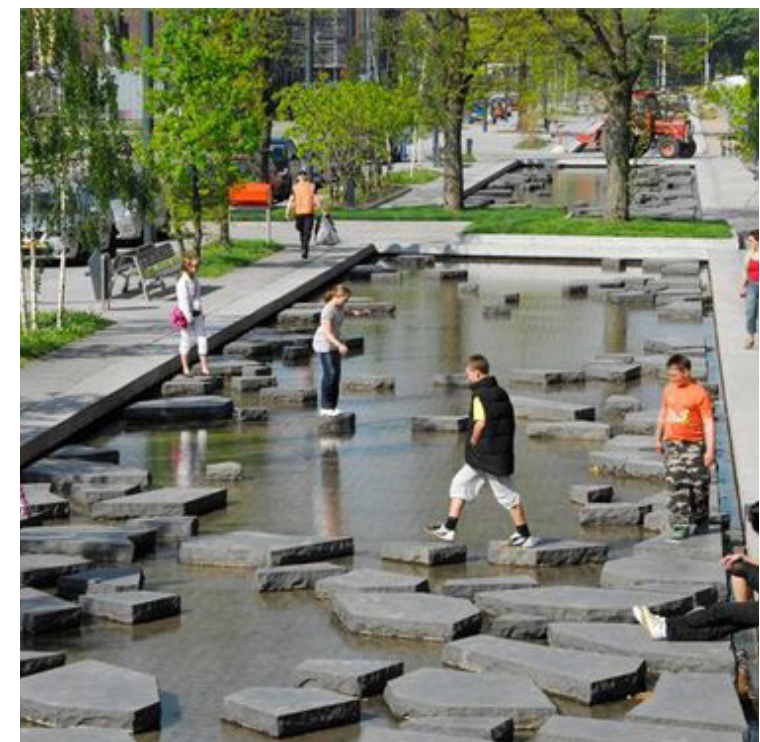
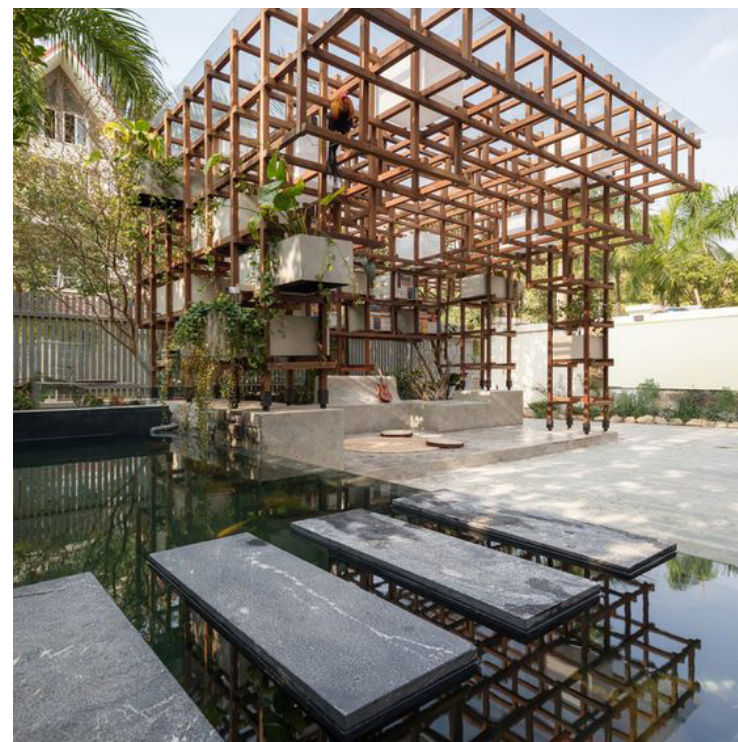
TU DELFT CAMPUS - MOBILITY



NEW VISION TU DELFT CAMPUS

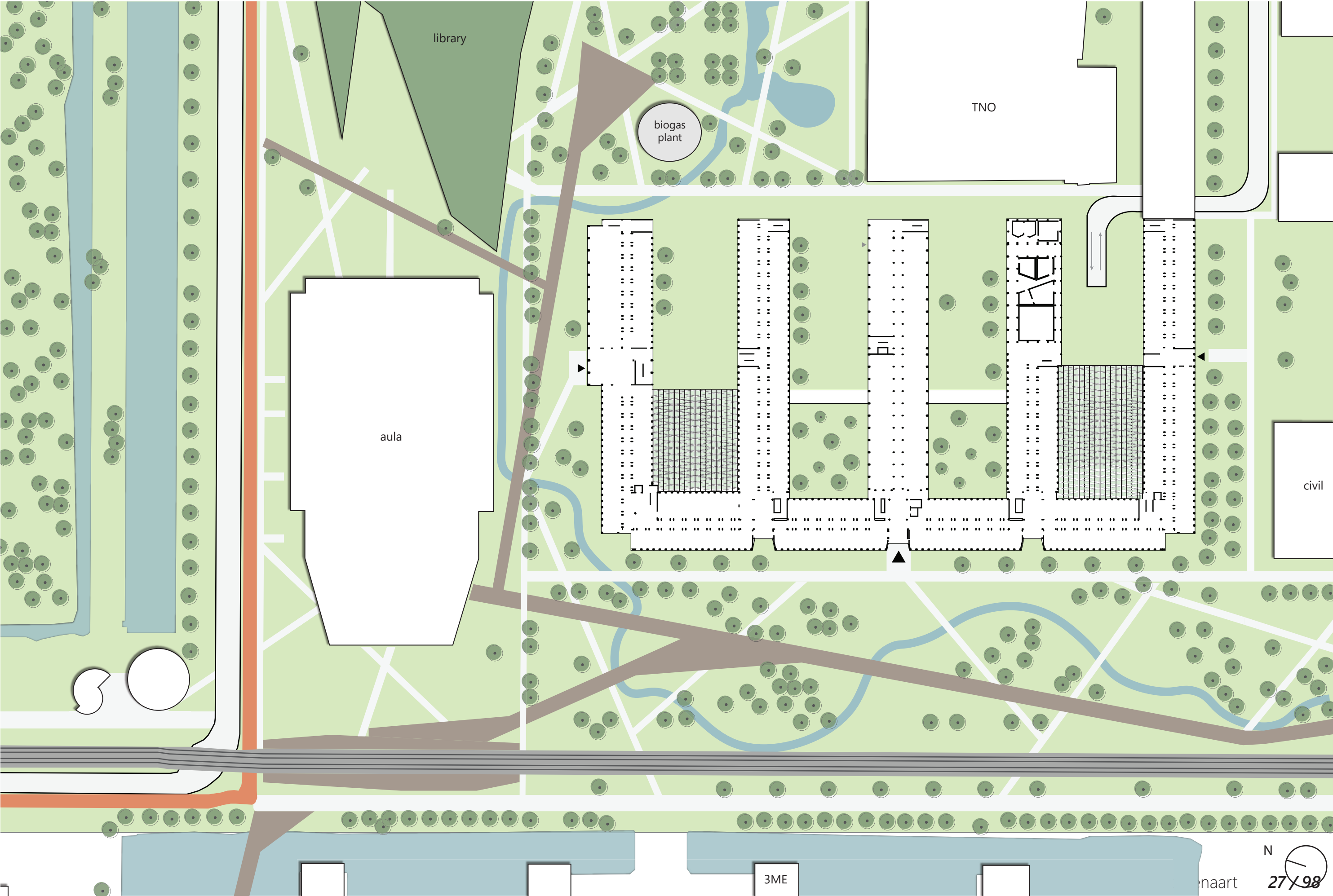


INSPIRATION living lab campus



source: pinterest.com

SITE PLAN 1:1000



FLOWS

Energy - electricity & heat

HEAT GRID

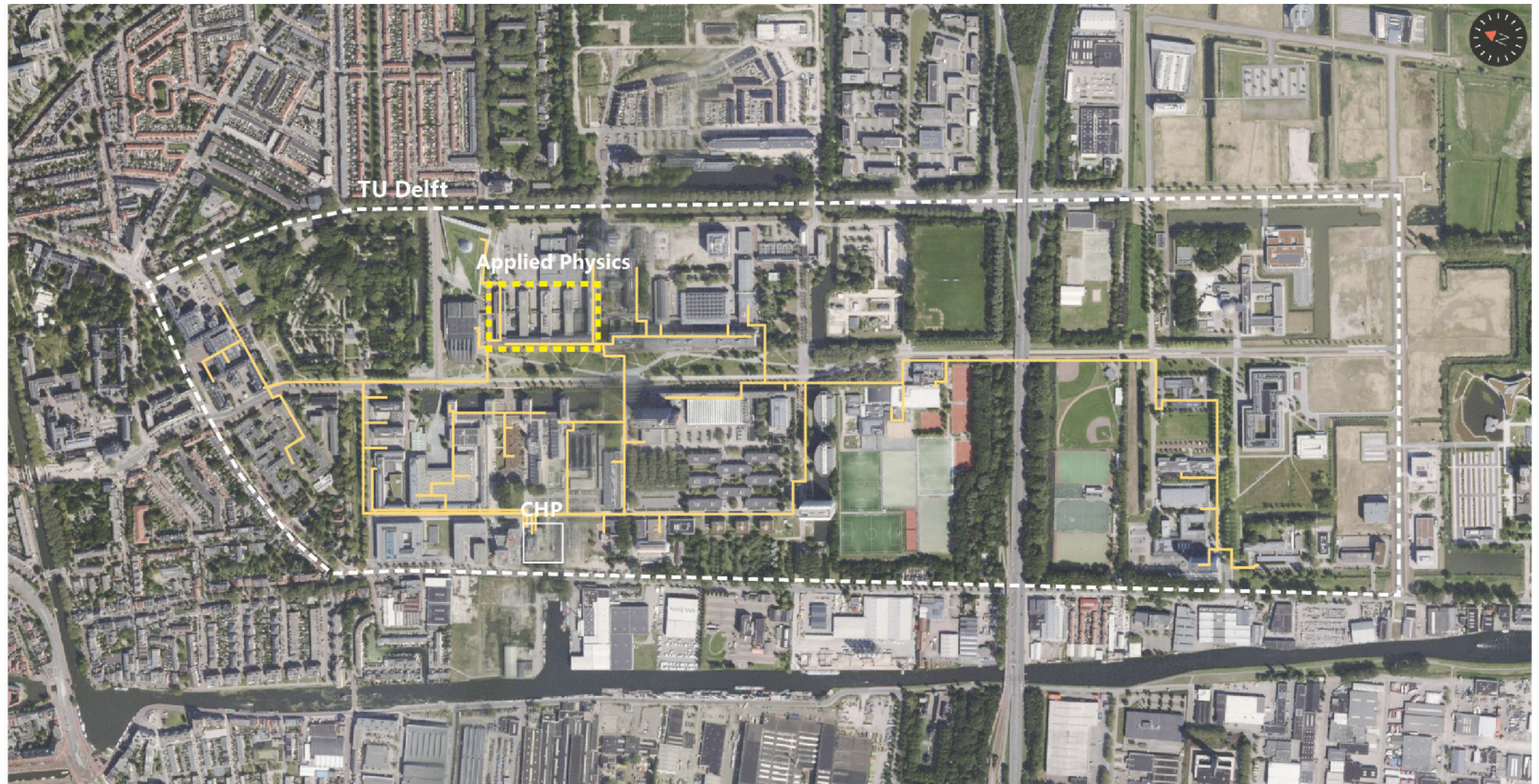
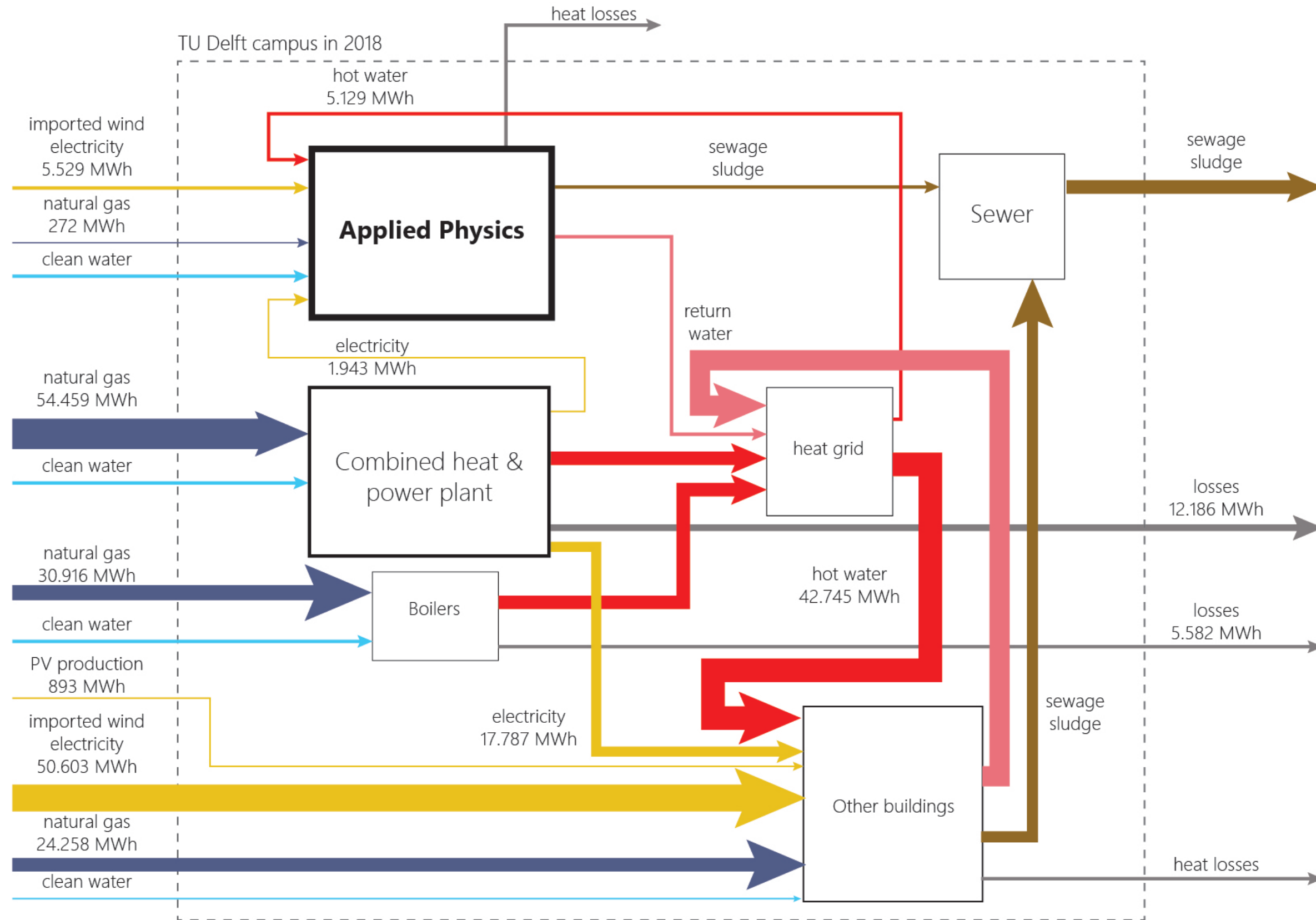


image: apple maps
Blom, T., Dobbelsteen, A. van den, (2019), CO2-roadmap TU Delft

SYSTEM ANALYSIS - ENERGY



CURRENT IMPACT - CO₂ EMISSIONS

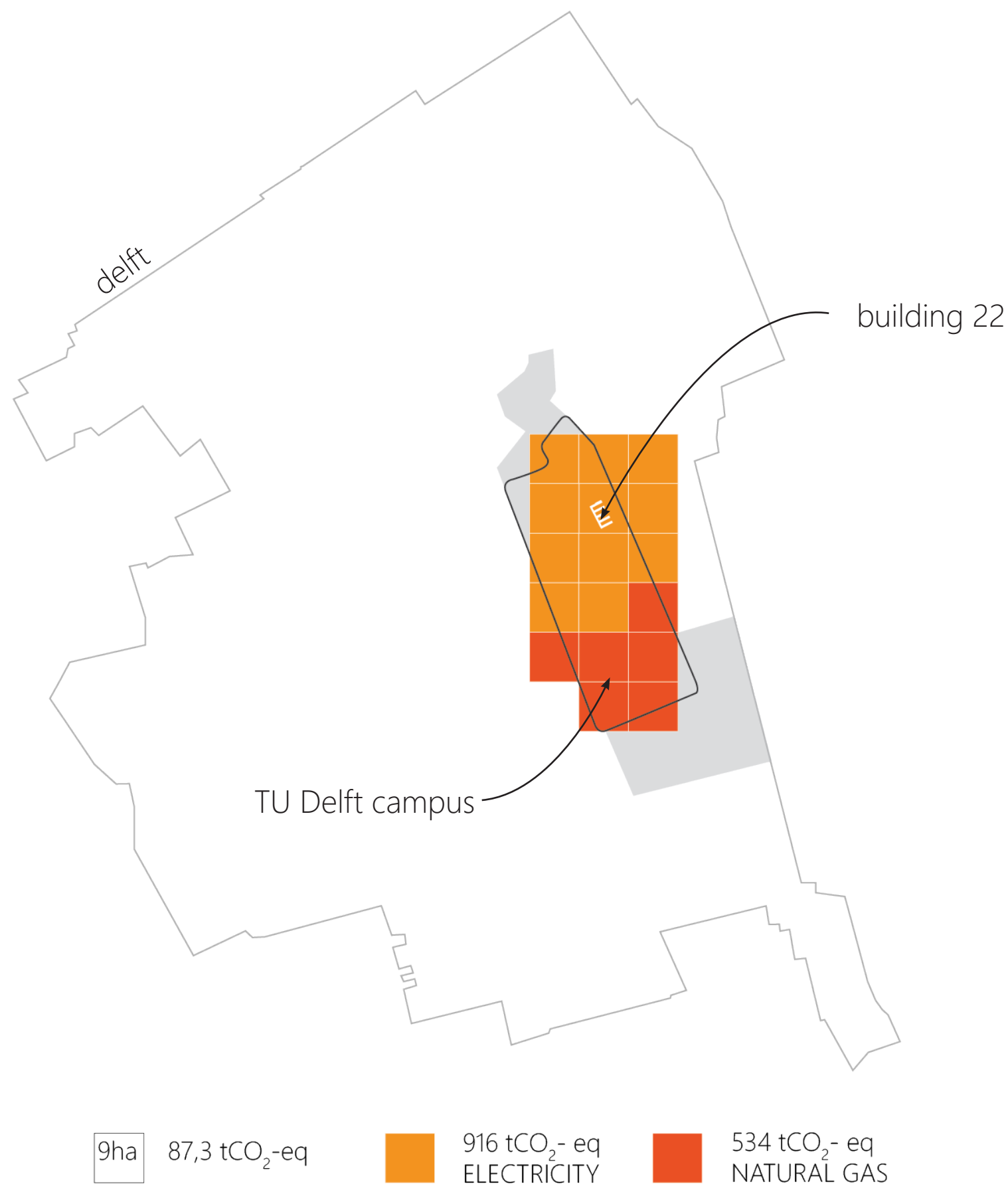
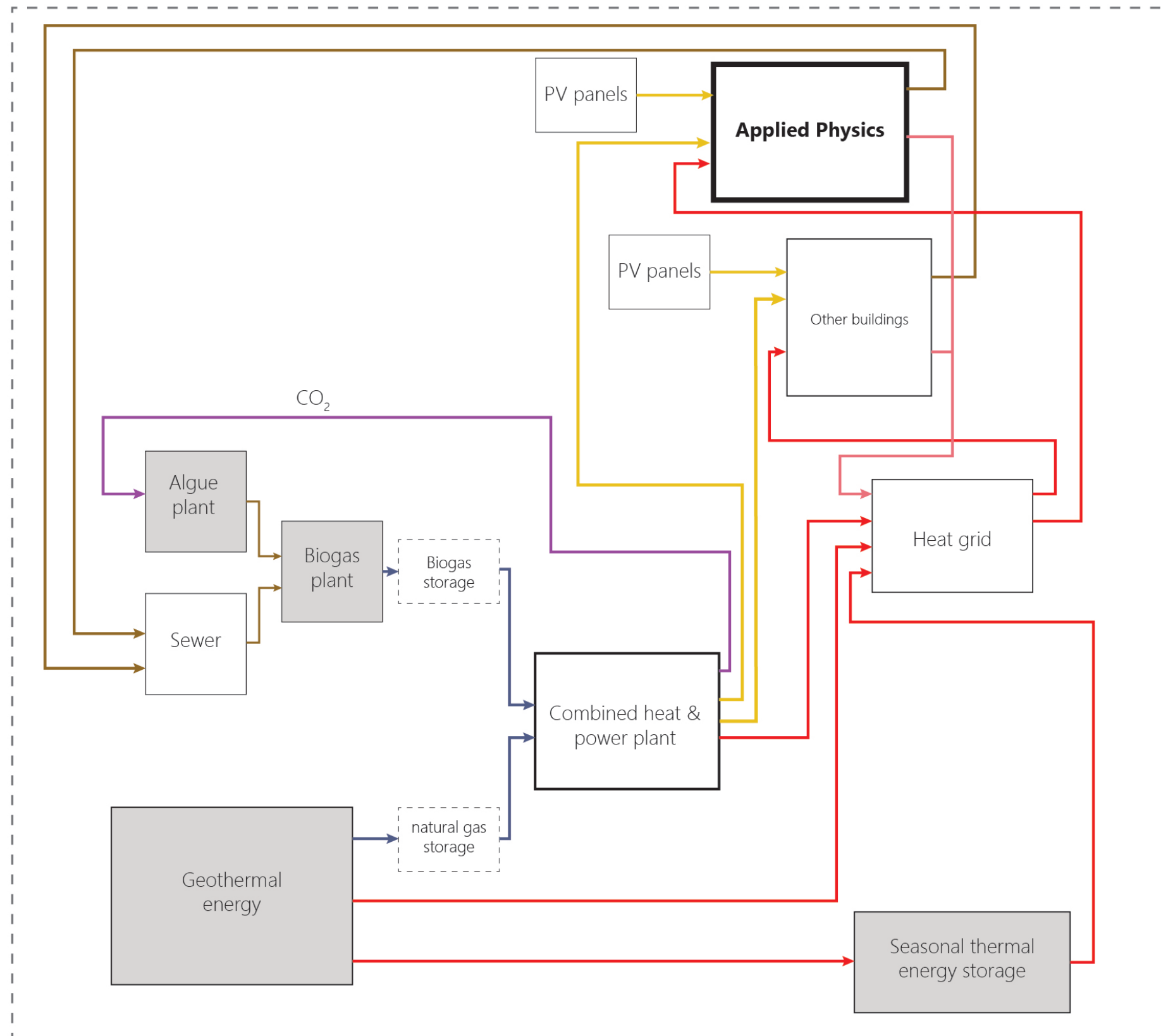


Image by Scheenaart (2020)
Blom, T., Dobbelsteen, A. van den, (2019), CO2-roadmap TU Delft

Applied cyclifiers for a closed loop campus

TU Delft campus closed loop system



FLOWS

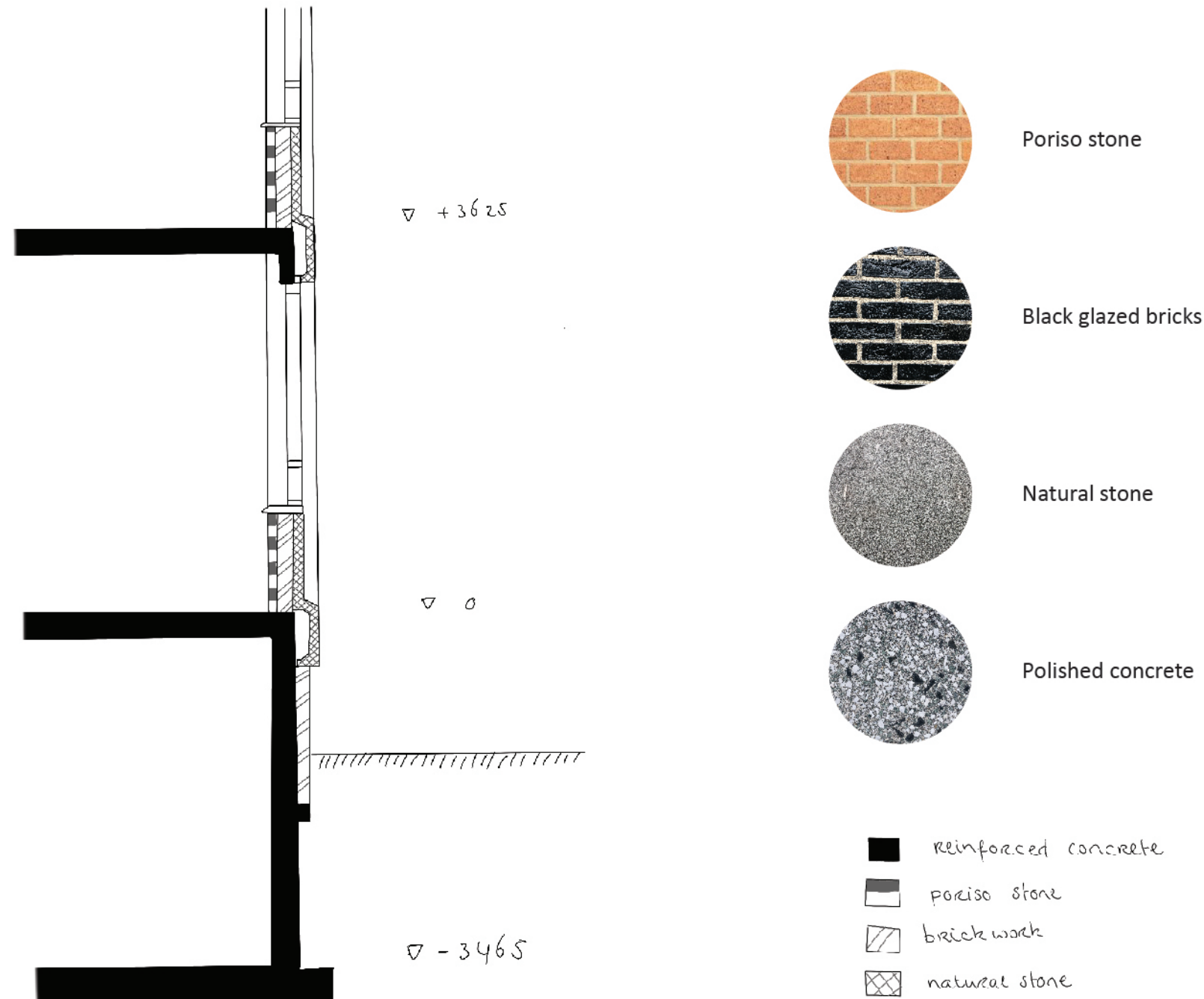
Materials

URBAN MINING

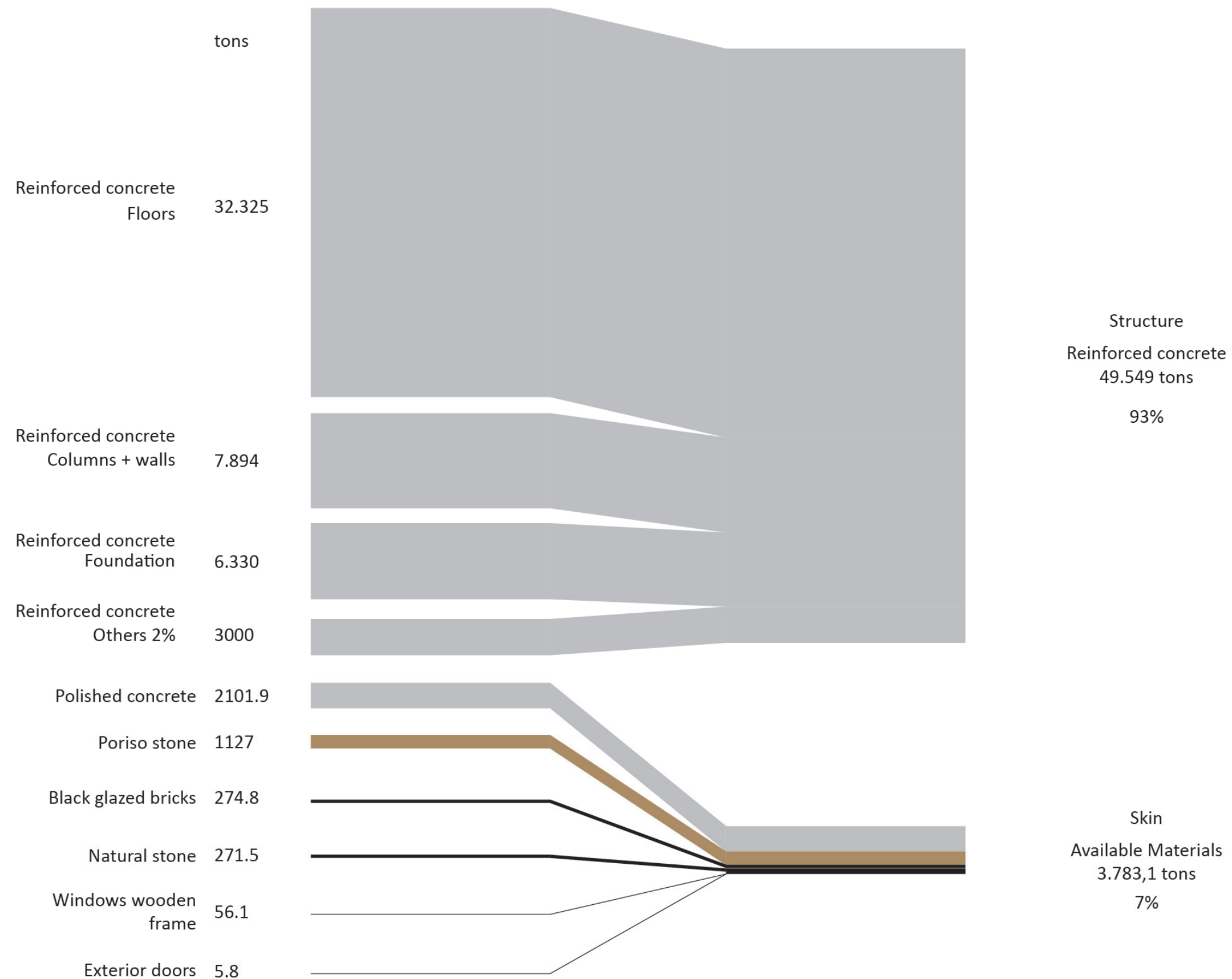
Cities and buildings become potential material mines where materials and energy are recovered for reuse.



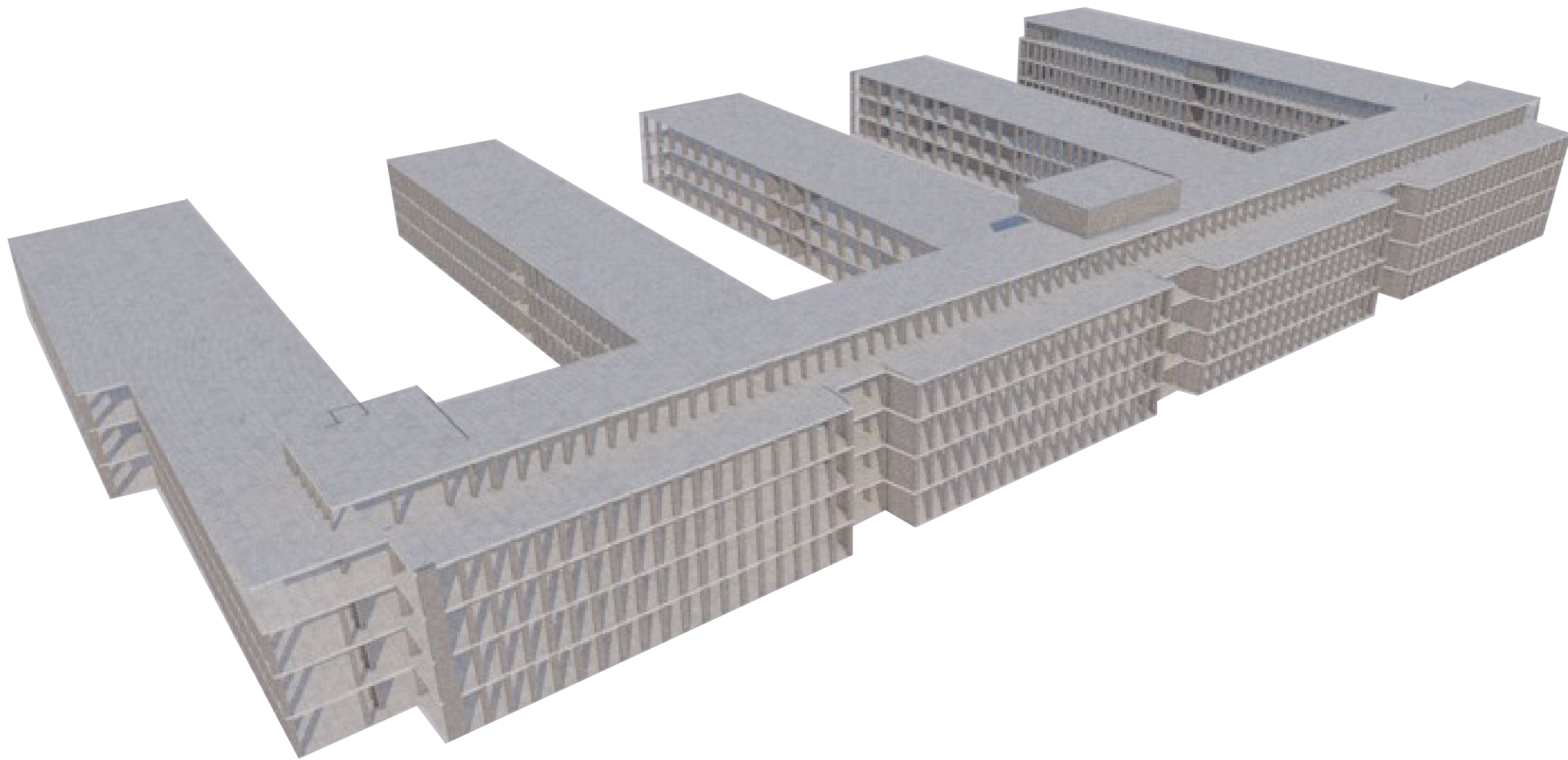
DETAIL FACADE - CURRENT SITUATION



MATERIAL FLOW ANALYSIS



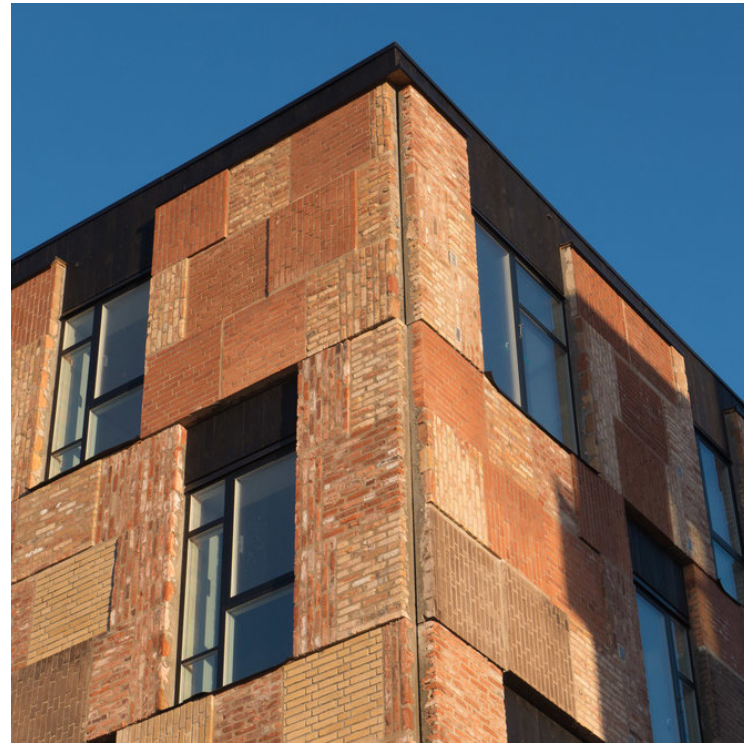
REUSE EXISTING STRUCTURE



VALUE ASSESSMENT MATERIALS

	Viability				Environmental impact			Costs	
	availability	ease of detachment	ease of refurbishment	re-use potential	Embodied energy	CO2 emmissions	Volominous impact	Market value	Production costs
Polished concrete									
Poriso stone									
Black glazed bricks									
Natural stone									
Windows + frames									
Exterior doors									

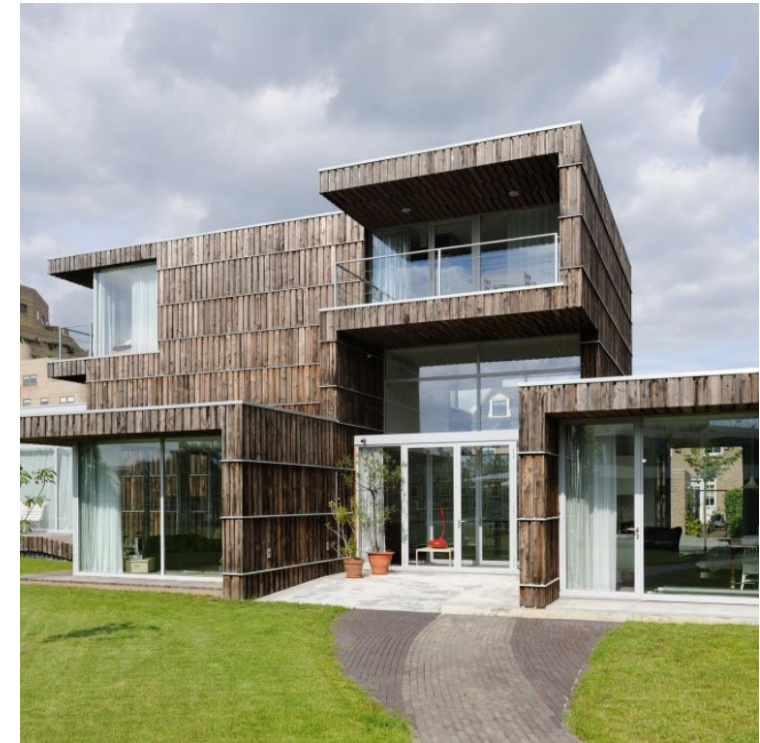
REUSE POTENTIAL & APPLICATION



Recourse Rows - Lendager group



Cubo House - Phooey Architects



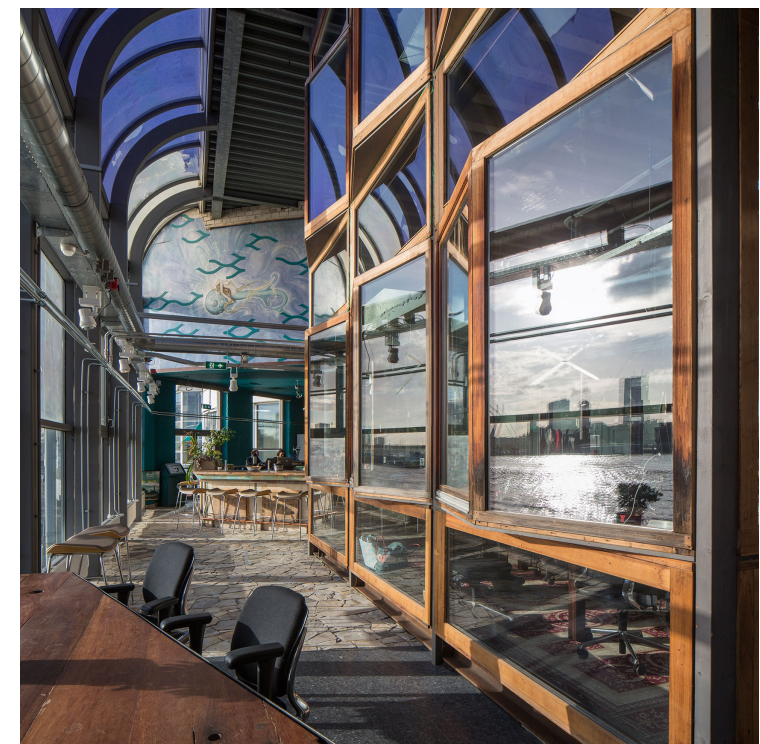
Villa Welpeloo - Superuse Studios



Circle House - 3XN

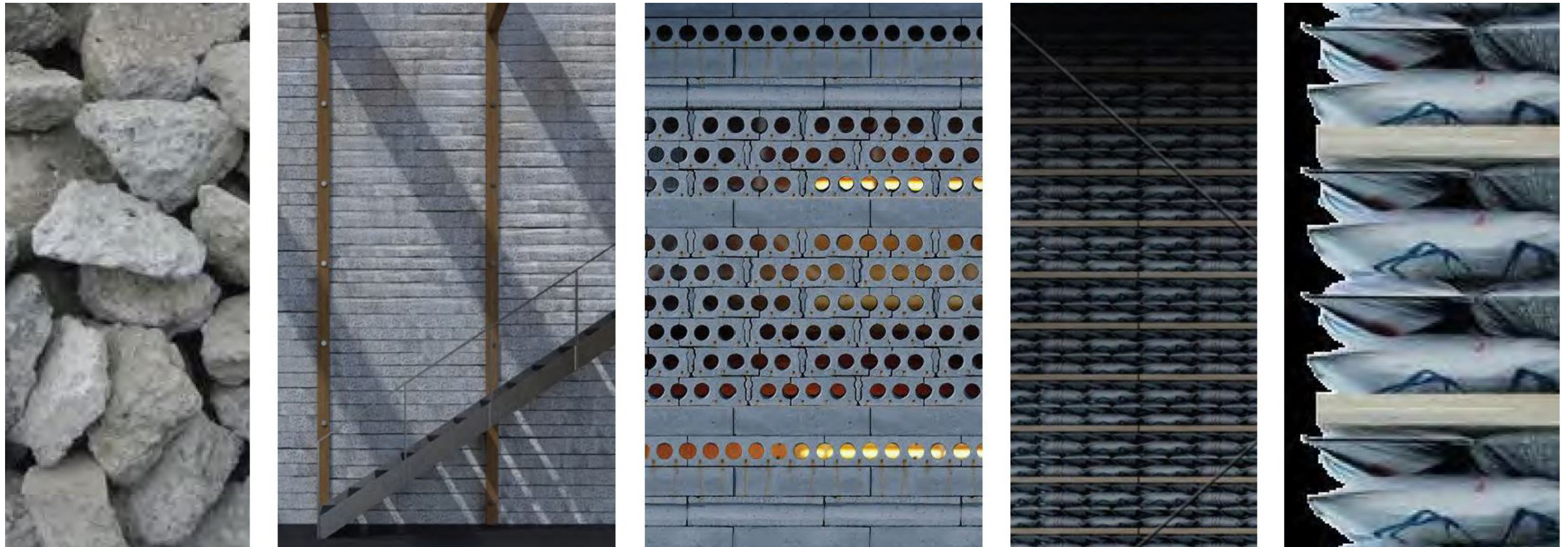


HAKA Rotterdam - DoepelStrijkers



BlueCity - Superuse Studios

REUSE POTENTIAL & APPLICATION

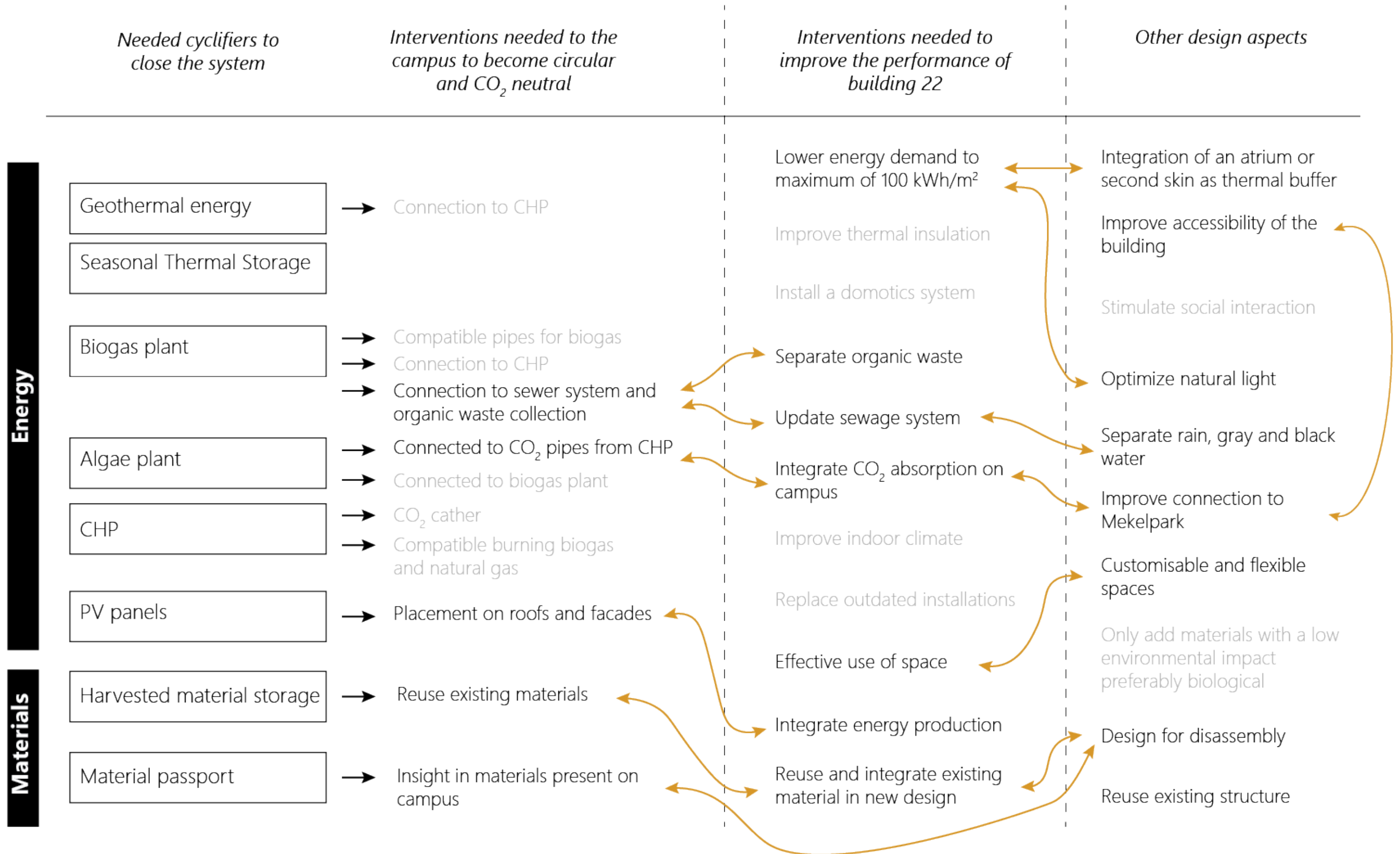


roadmap

	<i>Needed cyclifiers to close the system</i>	<i>Interventions needed to the campus to become circular and CO₂ neutral</i>	<i>Interventions needed to improve the performance of building 22</i>	<i>Other design aspects</i>
Energy	Geothermal energy	→ Connection to CHP	Lower energy demand to maximum of 100 kWh/m ²	Integration of an atrium as thermal buffer
	Seasonal Thermal Storage		Improve thermal insulation	Improve accessibility of the building
	Biogas plant	→ Compatible pipes for biogas → Connection to CHP → Connection to sewer system and organic waste collection	Install a domotics system	Stimulate social interaction
	Algae plant	→ Connected to CO ₂ pipes from CHP → Connected to biogas plant	Separate organic waste	Optimize natural light
	CHP	→ CO ₂ cather → Compatible burning biogas and natural gas	Update sewage system	Separate rain, gray and black water
	PV panels	→ Placement on roofs and facades	Integrate CO ₂ absorption on campus	Improve connection to Mekelpark
Materials			Improve indoor climate	Customisable and flexible spaces
			Replace outdated installations	Only add materials with a low environmental impact preferably biological
	Harvested material storage	→ Reuse existing materials	Effective use of space	
	Material passport	→ Insight in materials present on campus	Integrate energy production	Design for disassembly
			Reuse and integrate existing material in new design	Reuse existing structure

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			Reuse and integrate existing material in new design	

	<i>Needed cyclifiers to close the system</i>	<i>Interventions needed to the campus to become circular and CO₂ neutral</i>	<i>Interventions needed to improve the performance of building 22</i>	<i>Other design aspects</i>
Energy	Geothermal energy	→ Connection to CHP	Lower energy demand to maximum of 100 kWh/m ²	Integration of an atrium or second skin as thermal buffer
	Seasonal Thermal Storage		Improve thermal insulation	Improve accessibility of the building
	Biogas plant	→ Compatible pipes for biogas → Connection to CHP → Connection to sewer system and organic waste collection	Install a domotics system	Stimulate social interaction
	Algae plant	→ Connected to CO ₂ pipes from CHP → Connected to biogas plant	Separate organic waste	Optimize natural light
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design goals

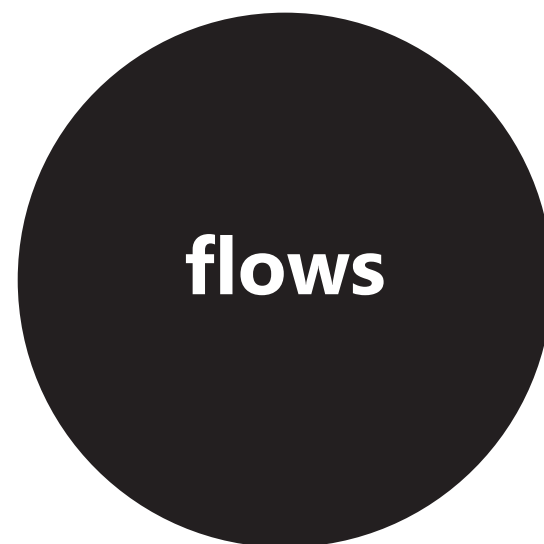
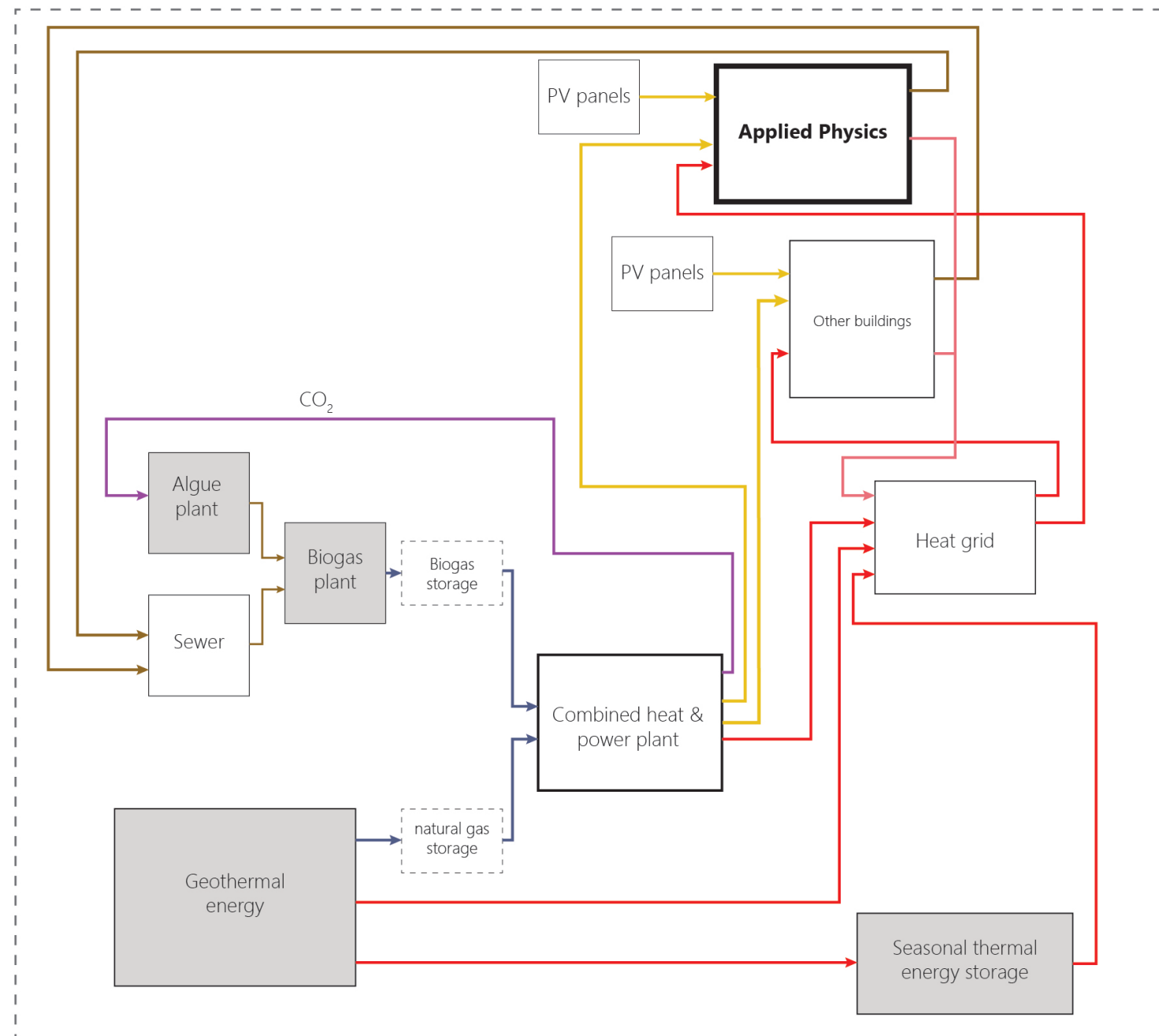
flows

circularity

**energy
neutral**

CO₂ neutral

program



close local energy & material flows

intergrate energy production into urban design & architecture of the building

local reuse of existing materials

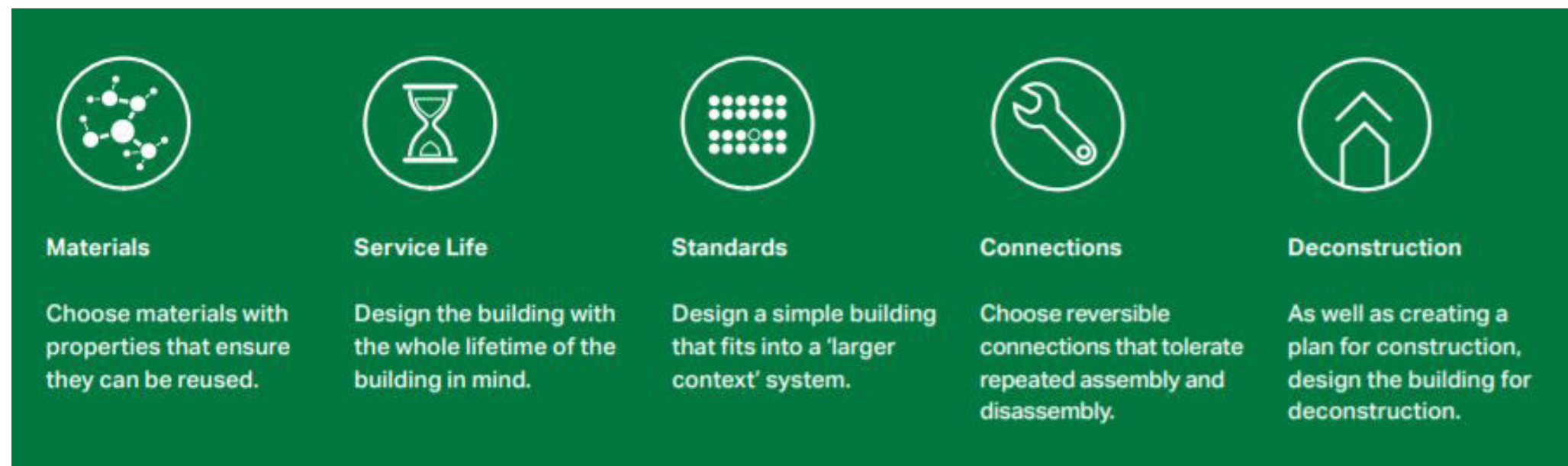
circularity



design for disassembly

use as many reused or biological materials

flexible and adaptable spaces



**energy
neutral**

reduce the energy demand

increase Rc-value to 4,5 - 7 m²K/W

produce energy with a renewable source

smartly organise the program to create synergy

reuse existing structure and materials

stop using natural gas

incorporate CO₂ absorption

when adding new materials choose ones with little
CO₂ emissions

**CO₂
neutral**

case studies

Atlas TU Eindhoven

Total Engineering Team

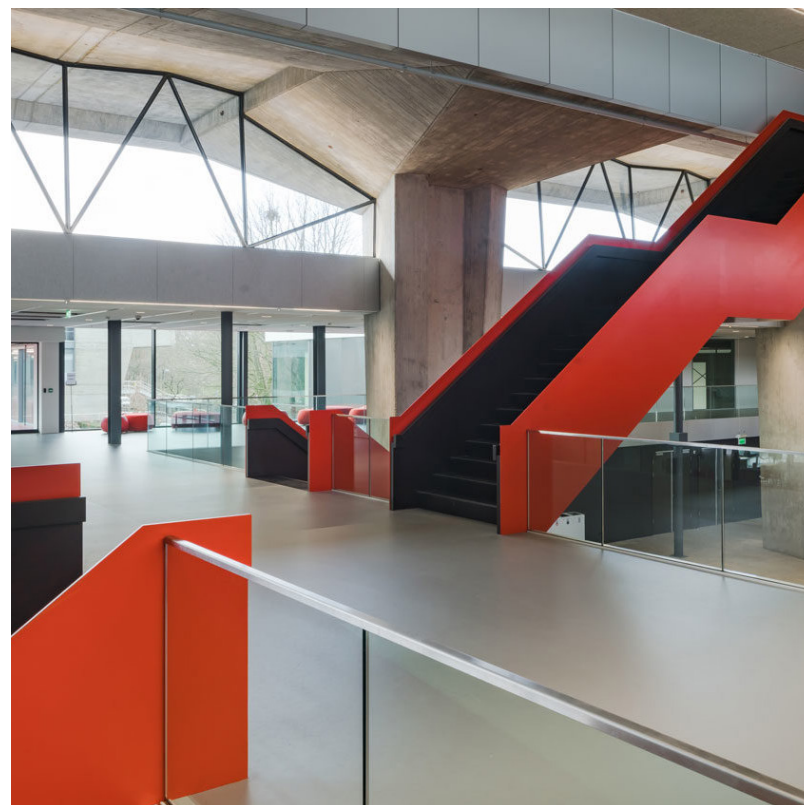
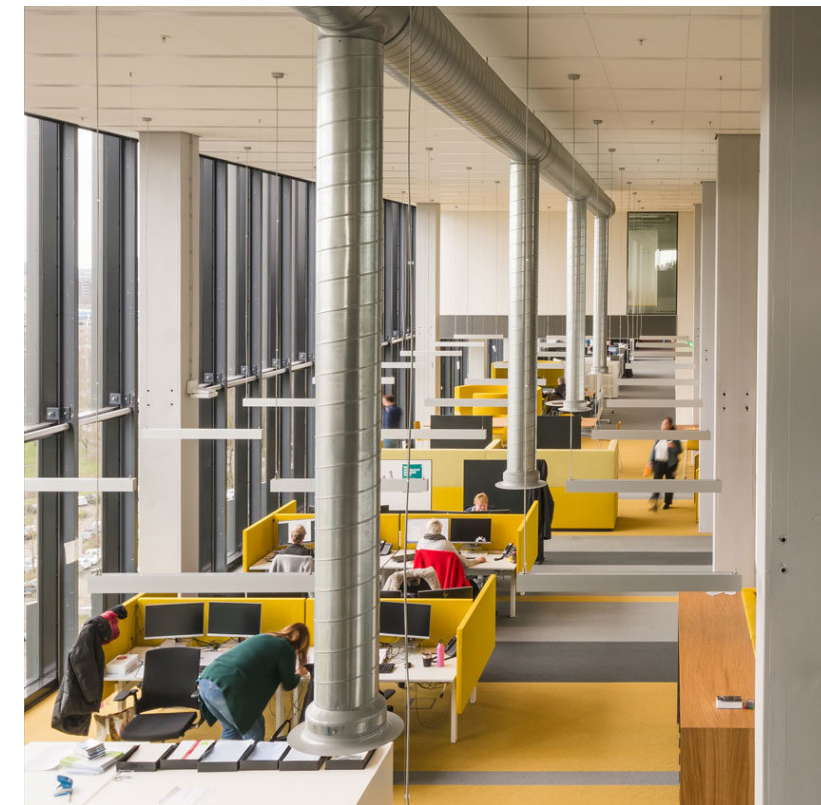
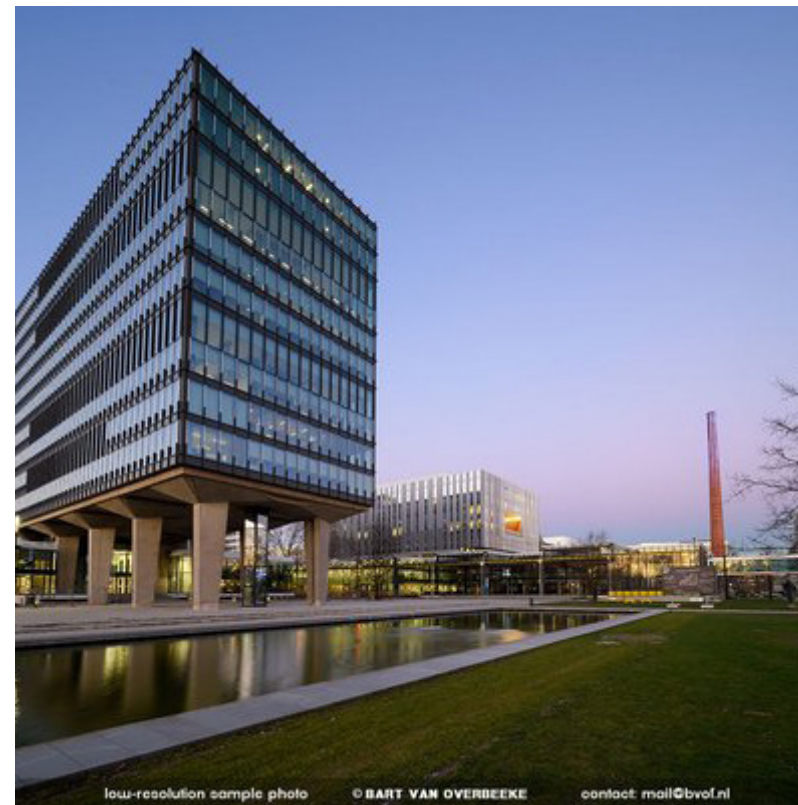
RSVP

Educational

2019

44.000 m²

Eindhoven, The Netherlands



most sustainable education buildings in the world according to BREEAM

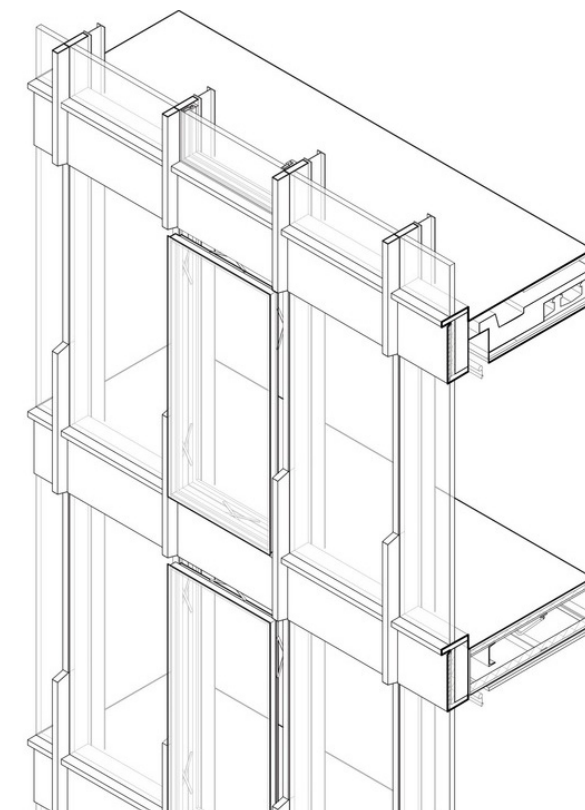
CO₂ emissions have been reduced by around 80 percent while the number of users has more than doubled

campus-wide aquifer thermal energy storage system

retaining the steel facade construction

Smart Energy saving Lighting

Night cooling via automatic windows





Pulse TU Delft

Ector Hoogstad

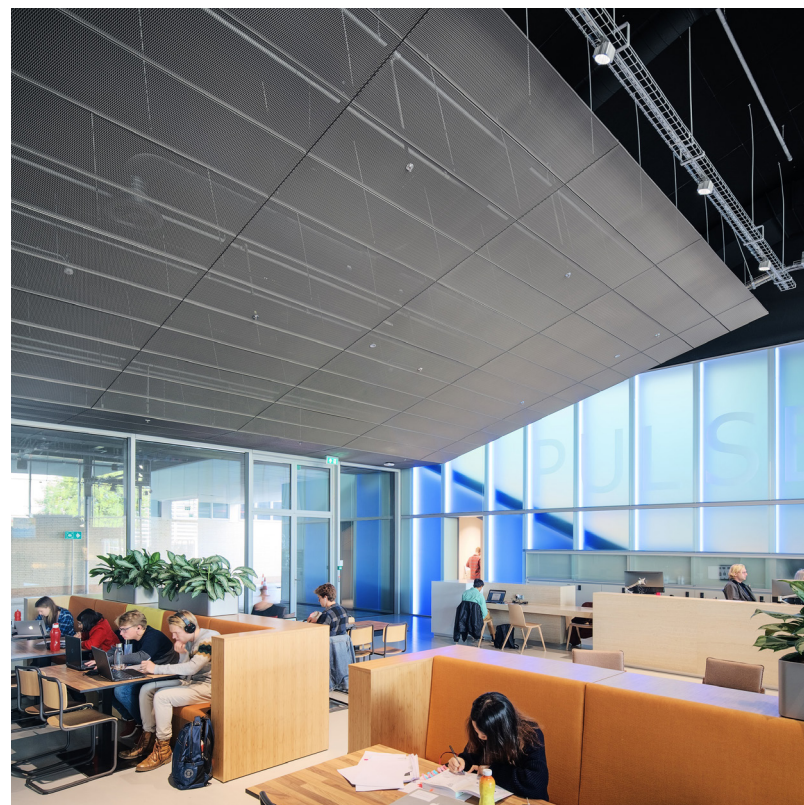
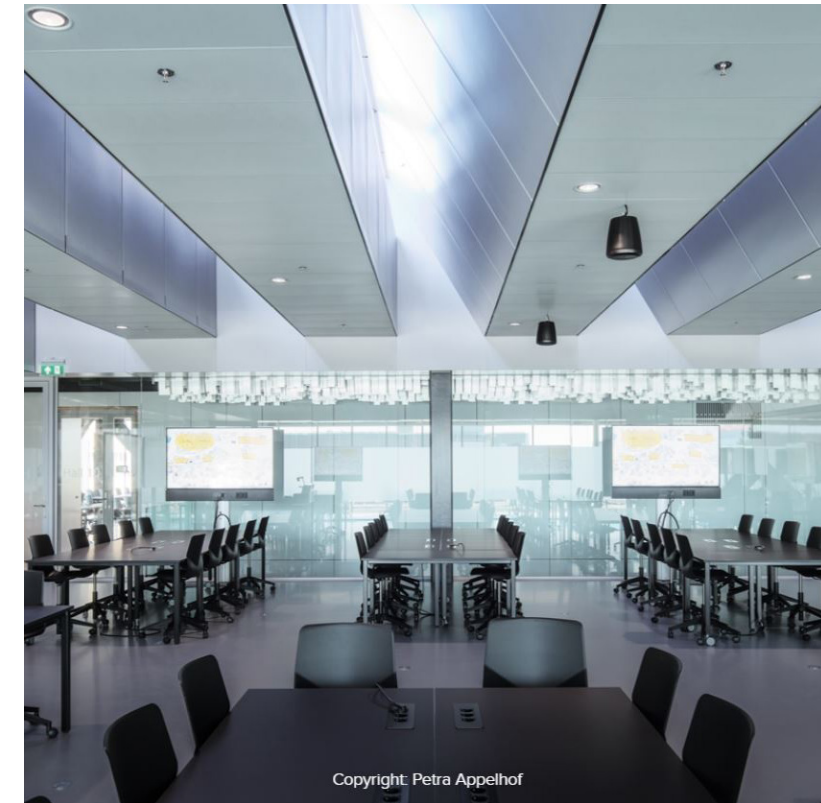
Architecten

Educational

2018

4.700 m²

Delft, The Netherlands



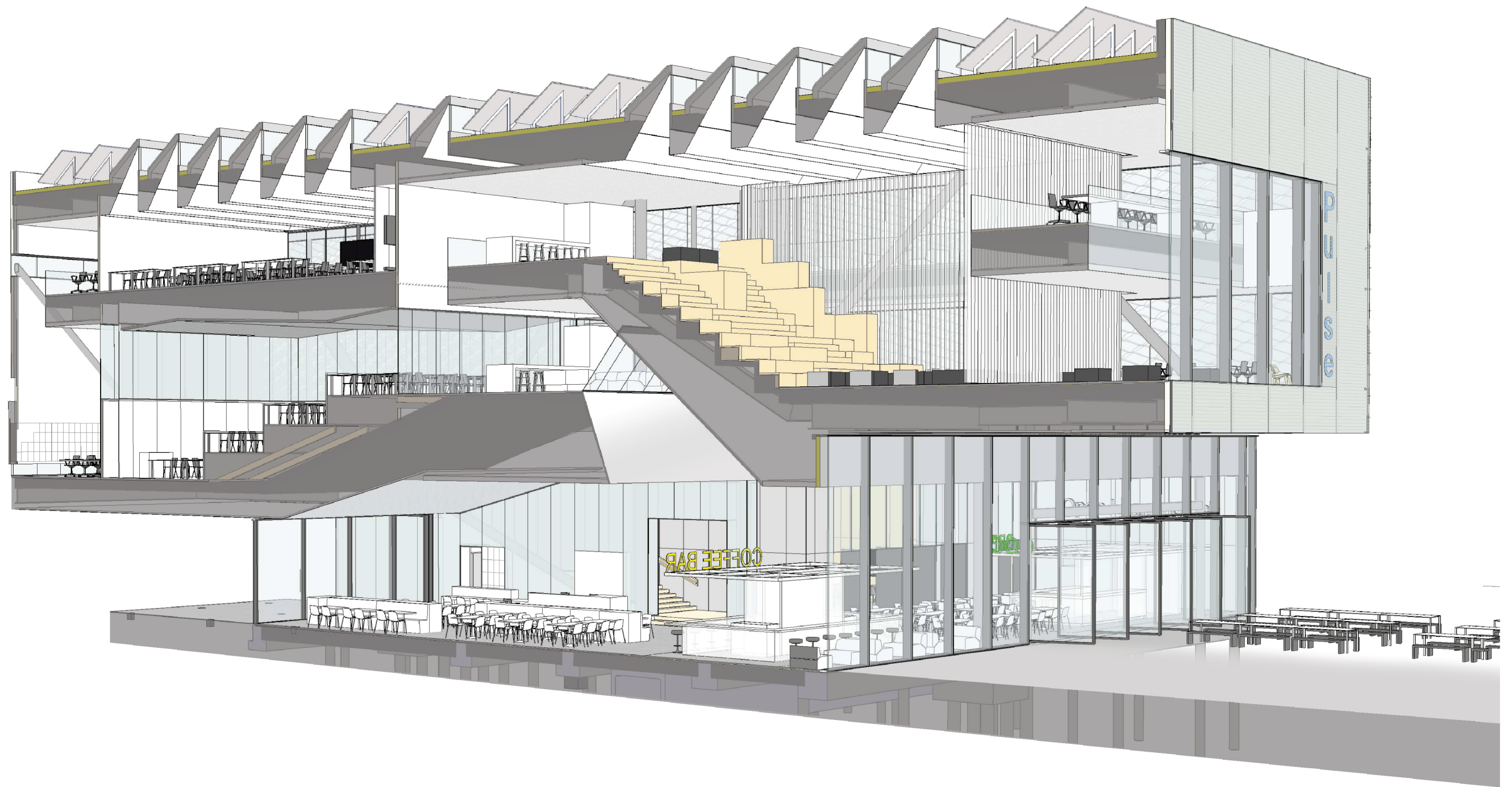
Pulse – Practise, Unite, Learn, Share & Explore - 1.020 education spaces, 10 rooms for 60 - 125 people, 3 themed rooms, 160 study spaces

zero energy building A+++++. With an annual output of 150,000 kWh, the 490 solar panels (750m²). BREEAM-score Excellent

underground thermal energy storage and features high-performance insulating glass.

intelligent building management system controls the ventilation, lighting, cooling and heating

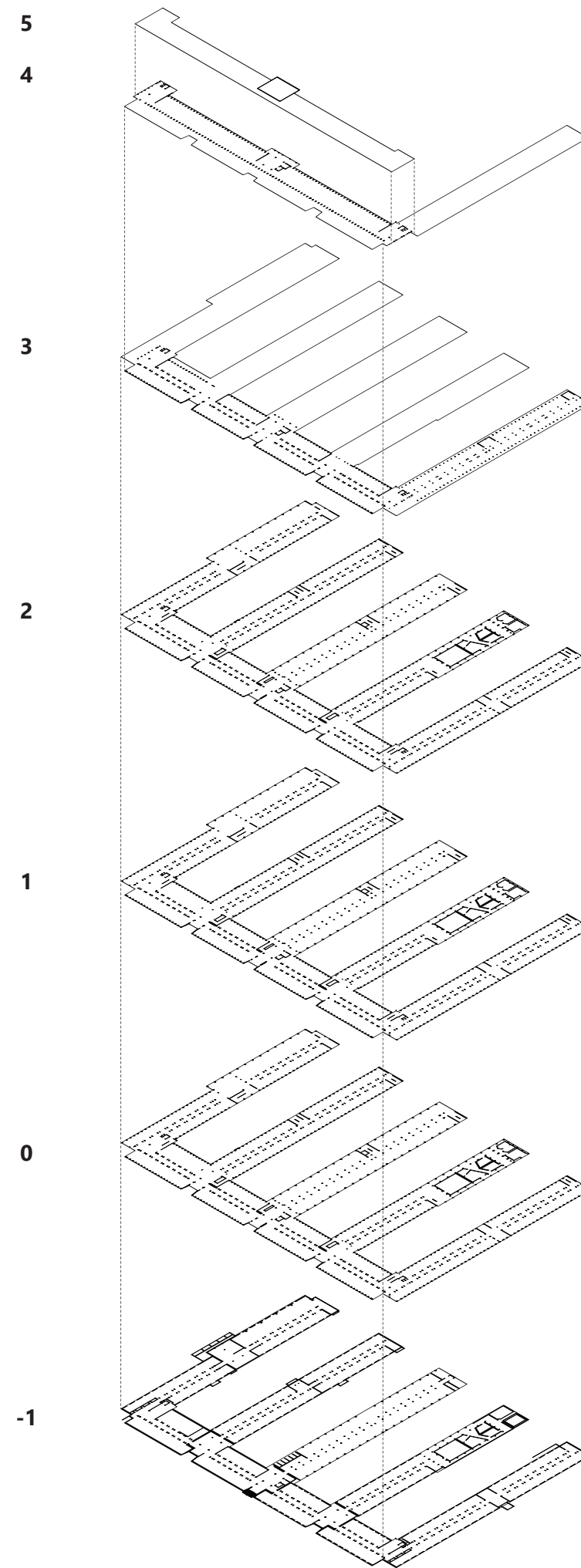




program

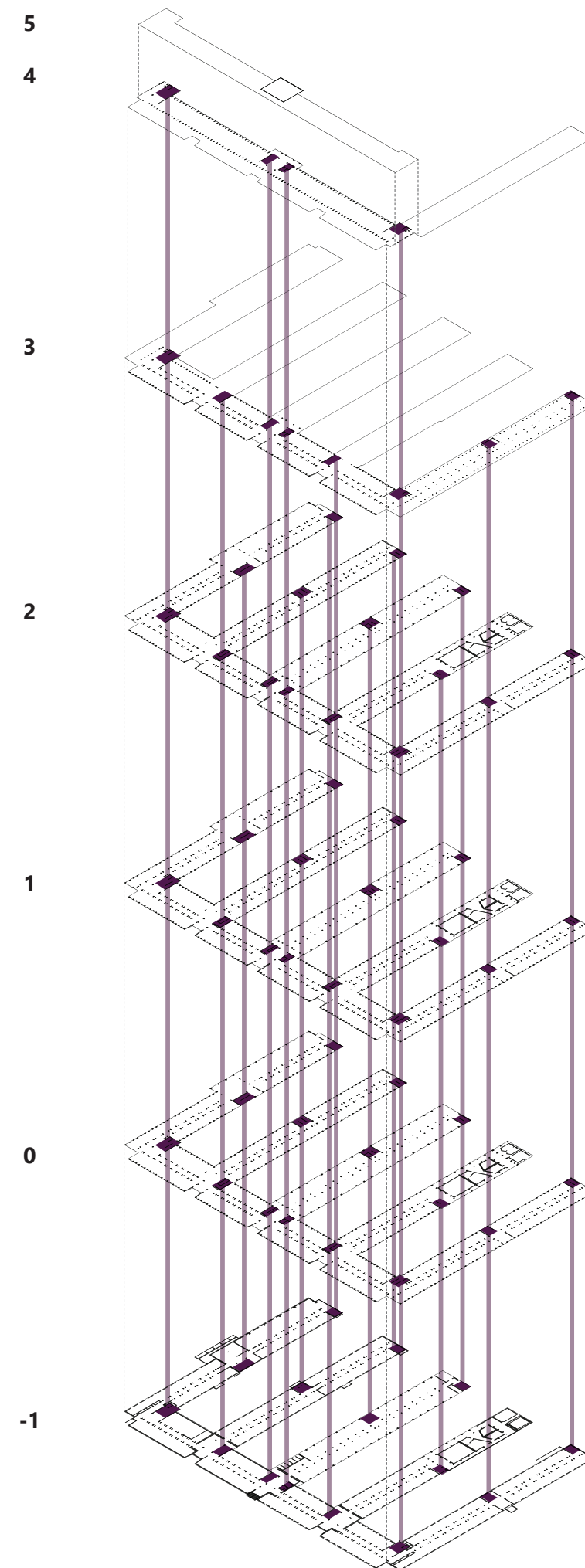


0 meting



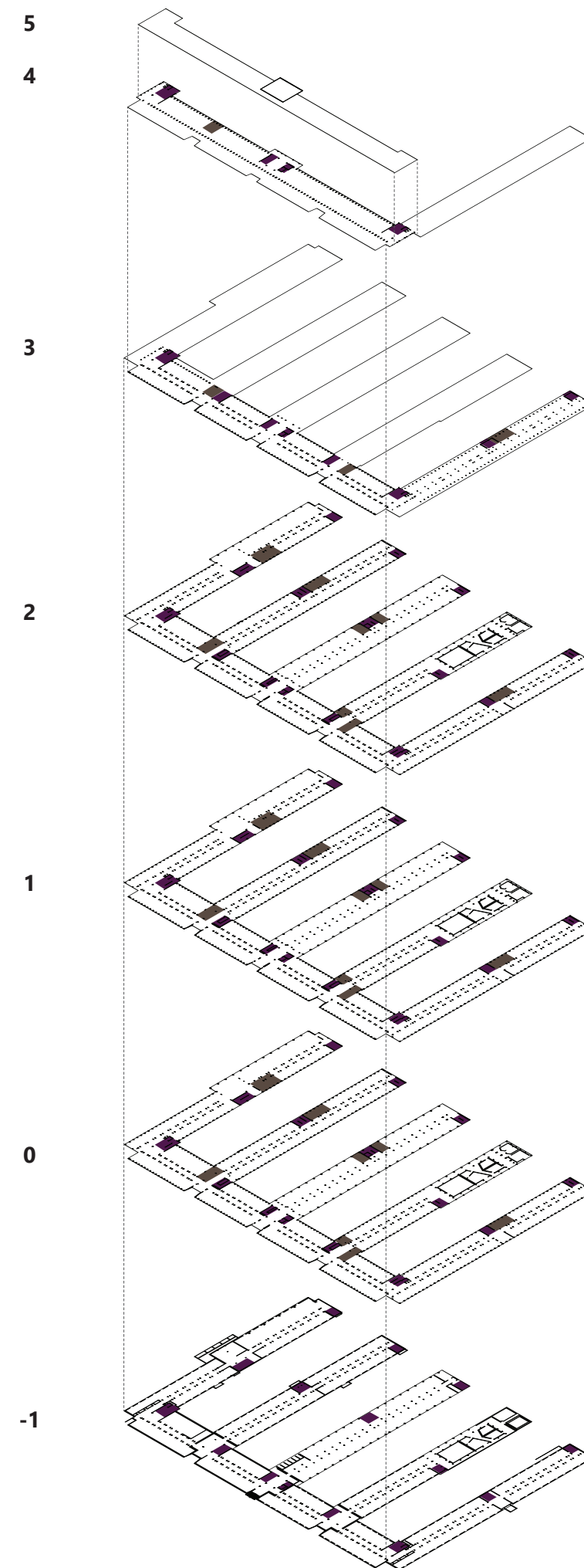


stairs



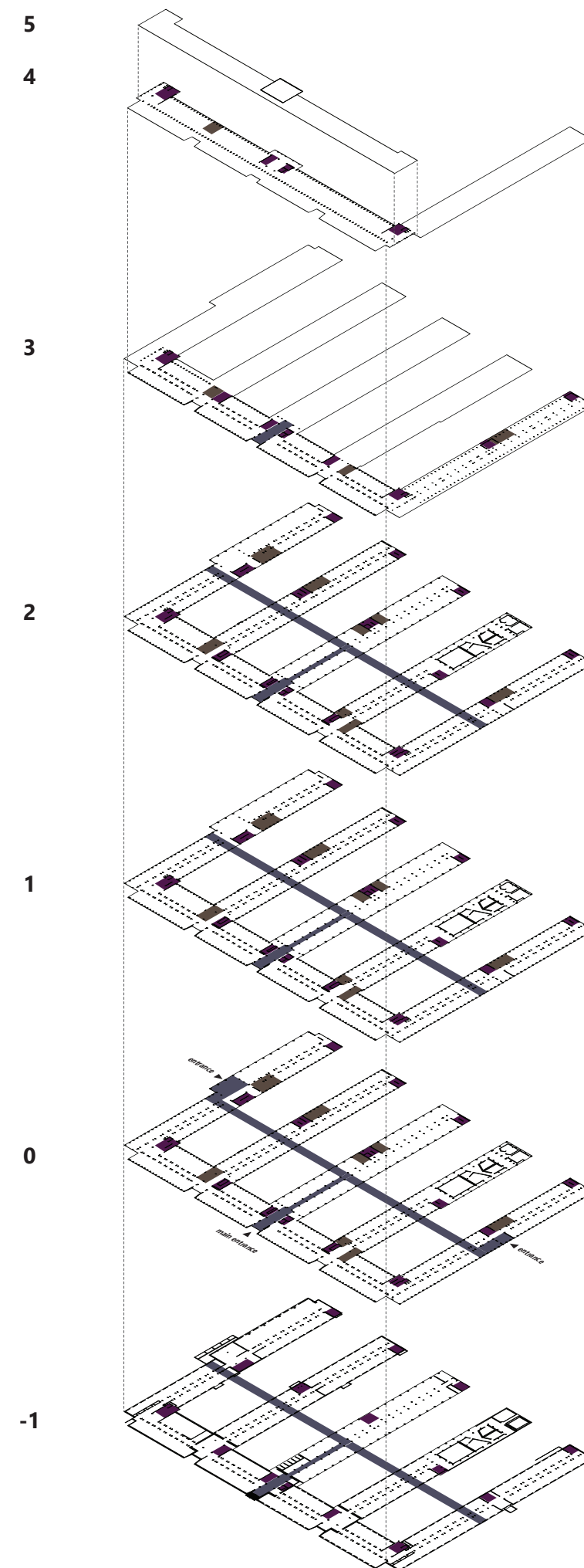


toilets & shafts





main routing

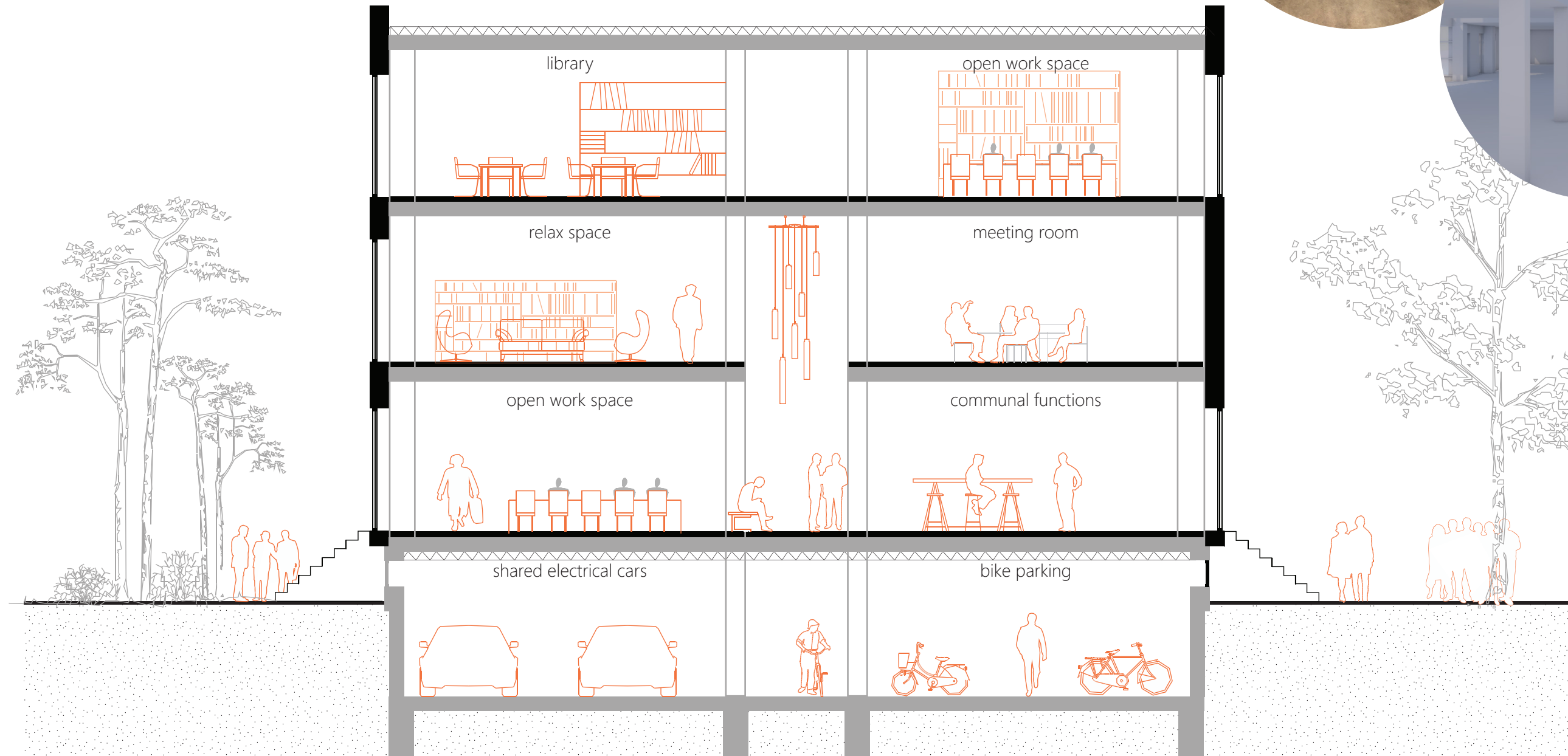


MAIN STREET

before



after



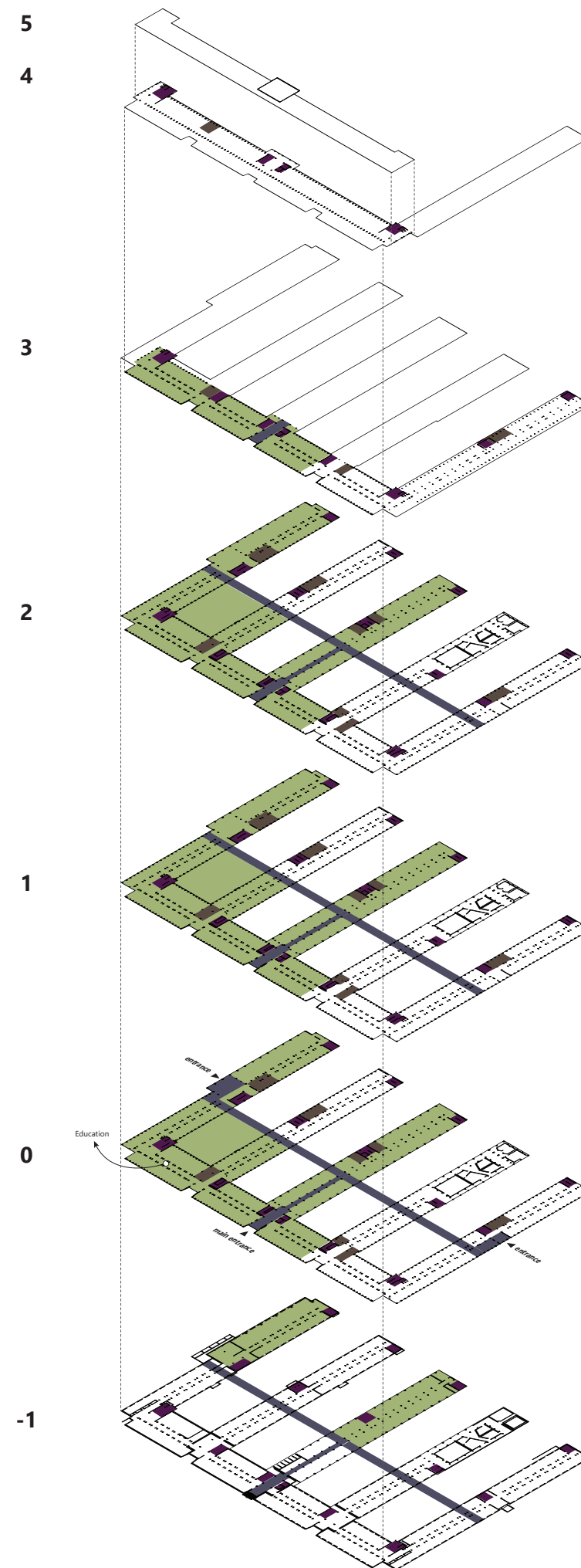
program education



students



teachers & professors





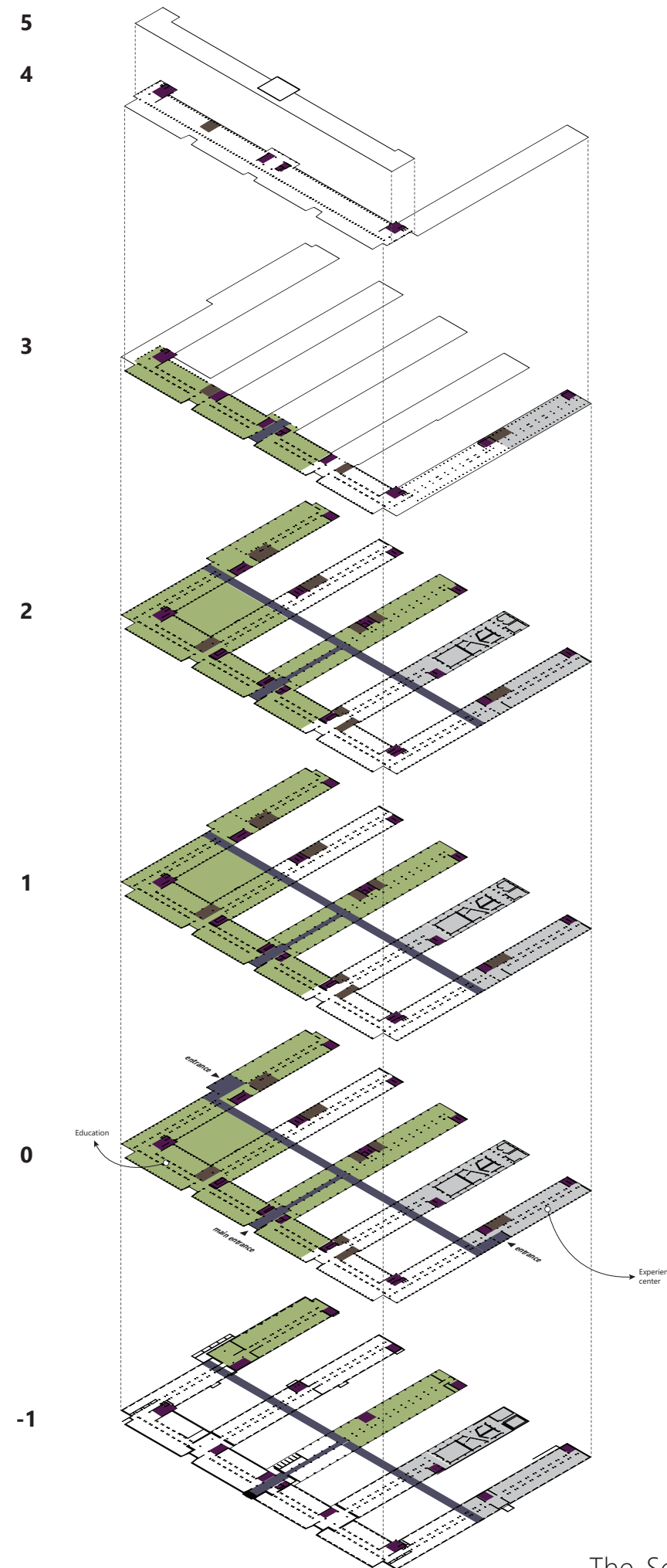
experience center



students



teachers & professors



kids & teenagers



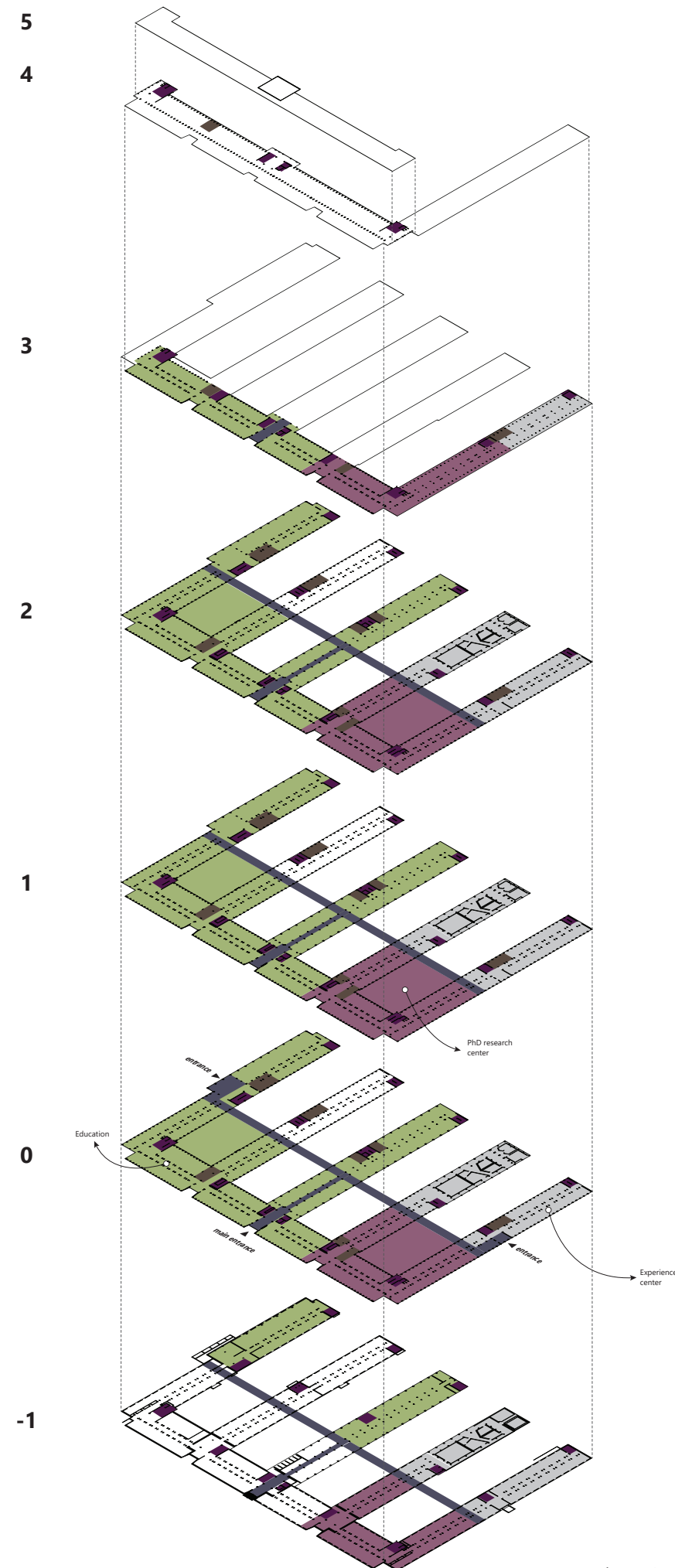
PhD research center



students



teachers & professors



kids & teenagers



PhD researcher



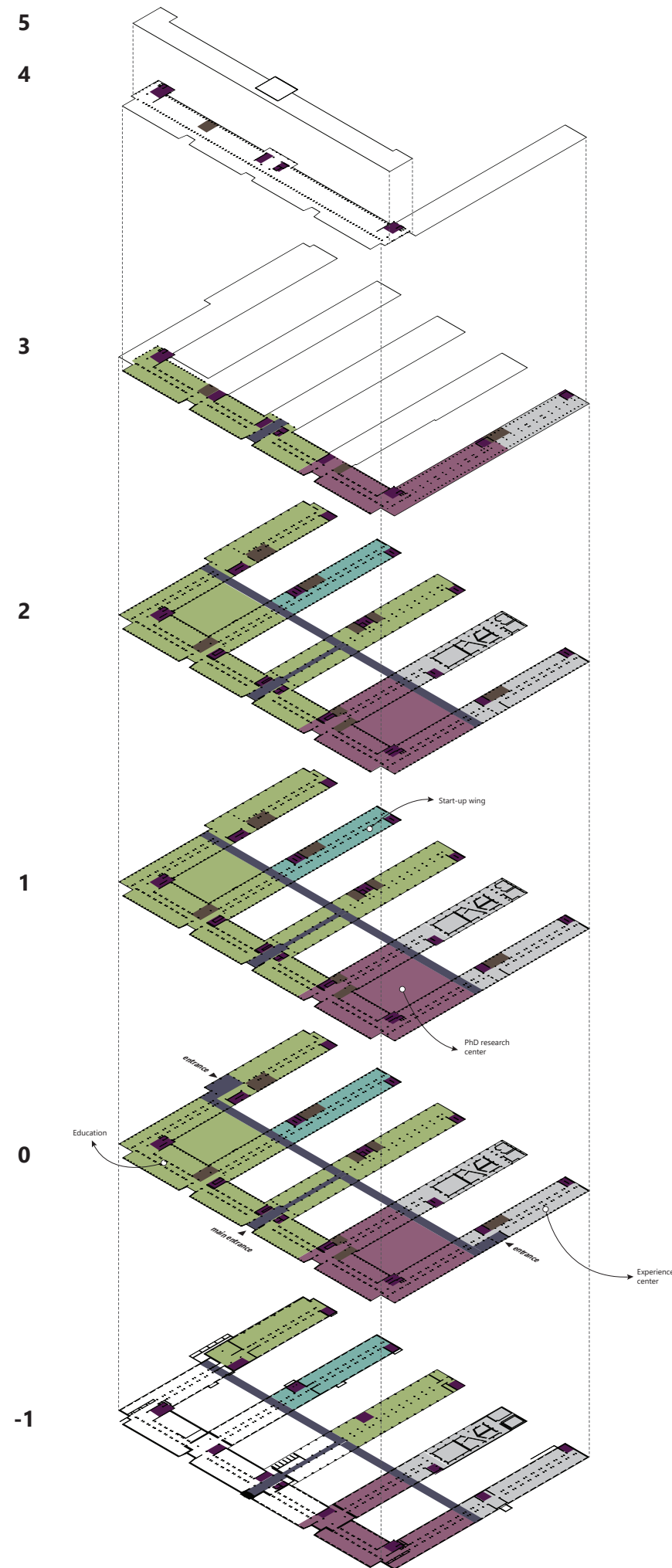
start-up wing



students



teachers & professors



young professionals



kids & teenagers



PhD researcher



communal social space



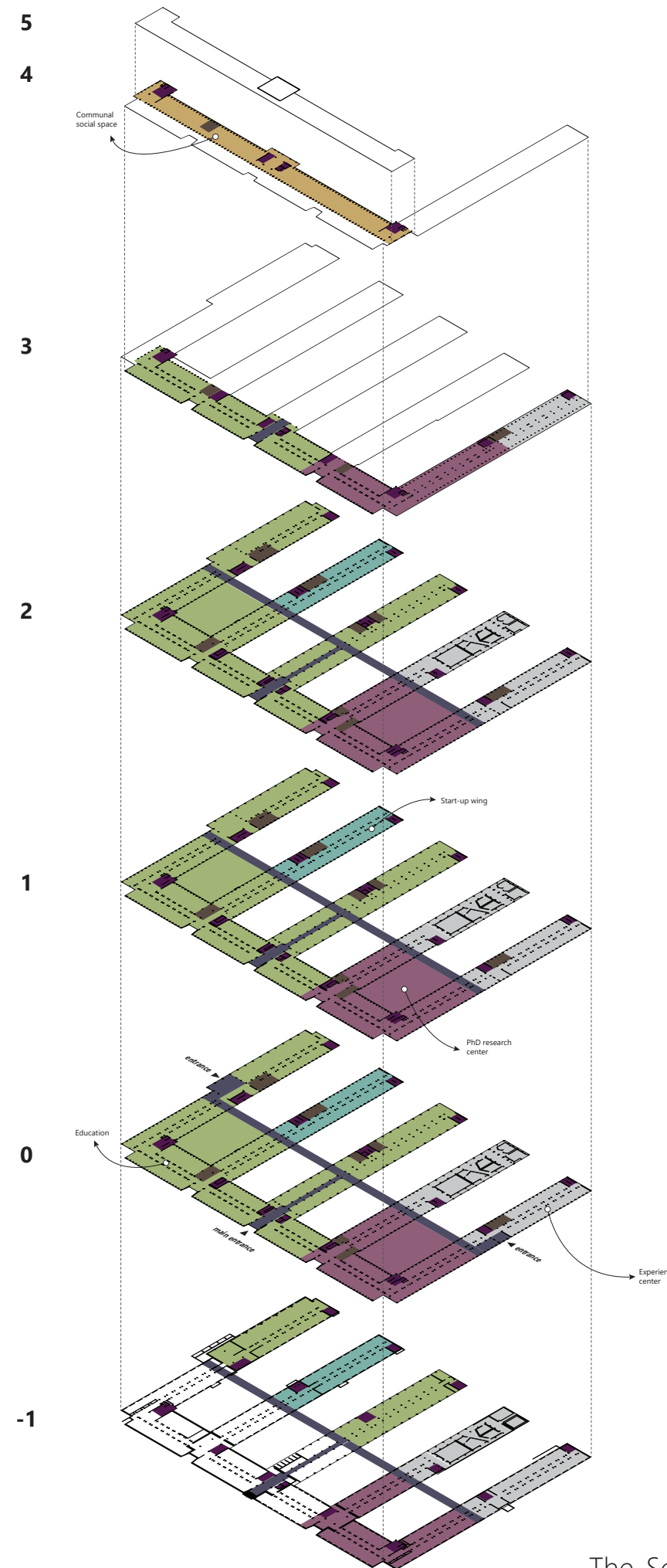
visitors



students



teachers & professors



young professionals



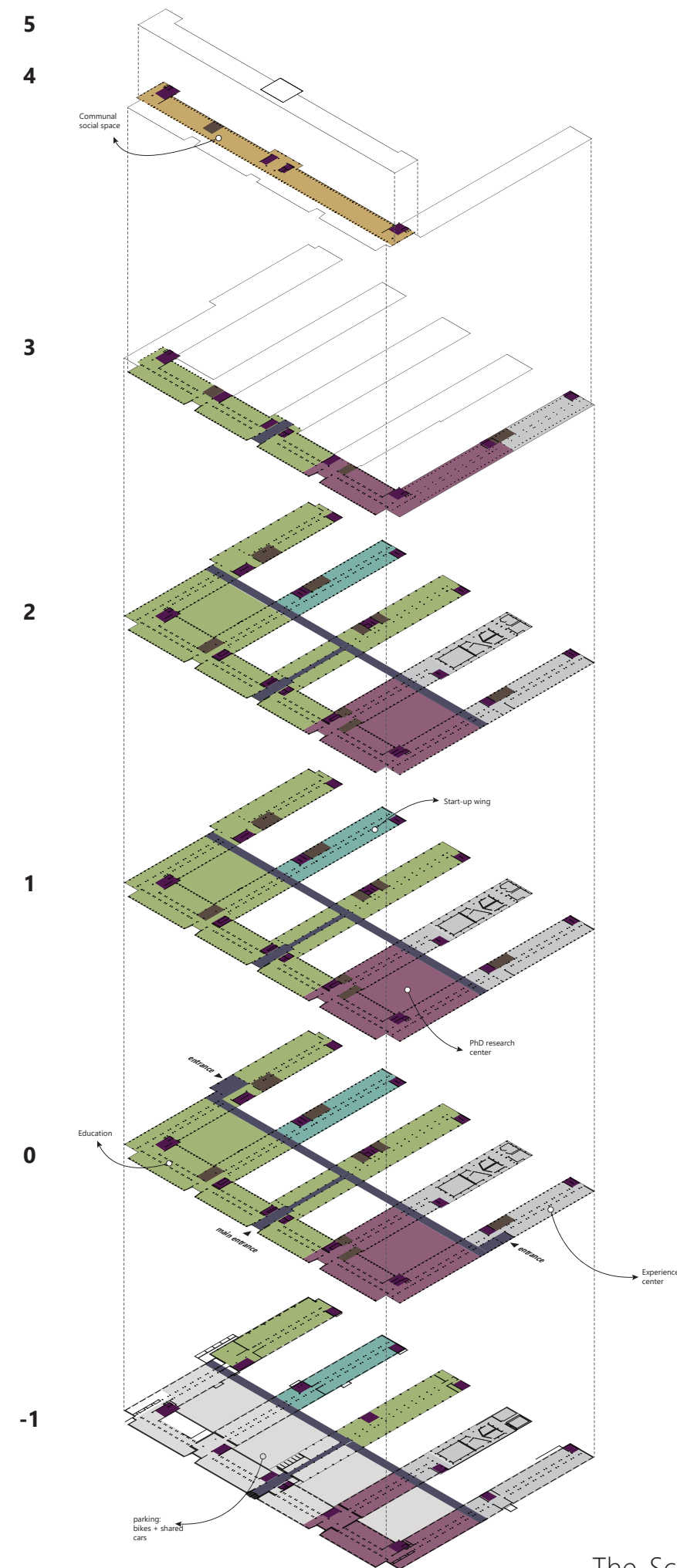
kids & teenagers



PhD researcher

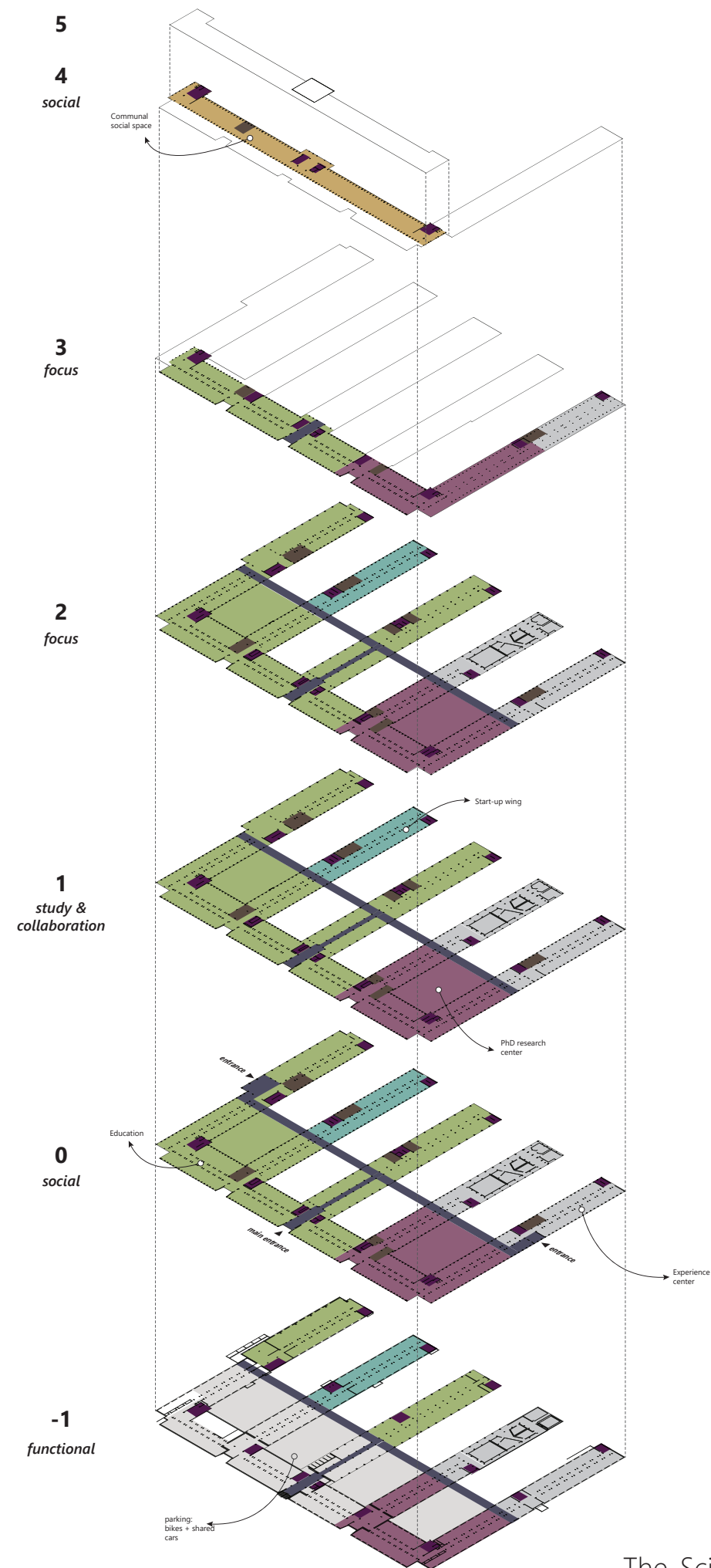


shared parking





themes



program

key spaces



rooftop terras



library



open work spaces



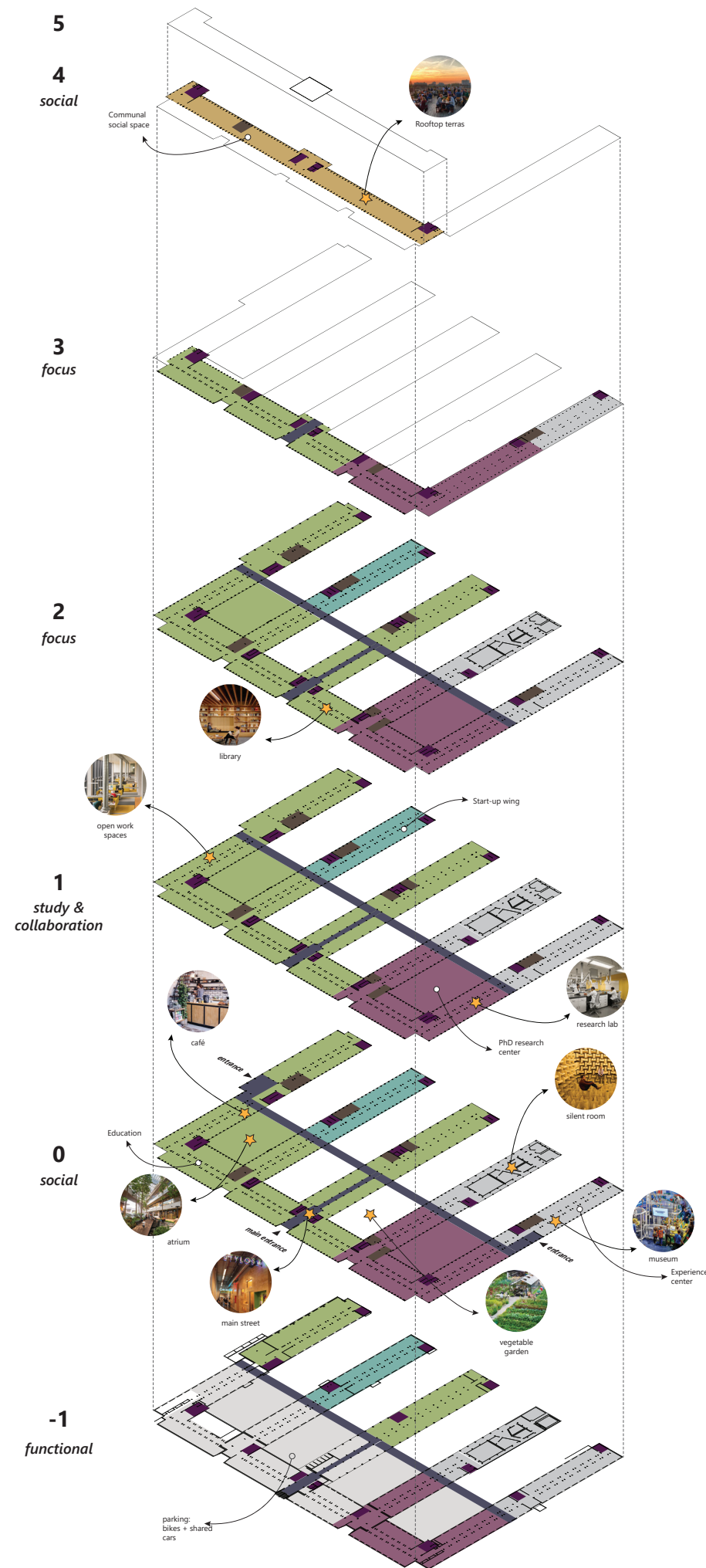
atrium



café



main street



research lab



silent room



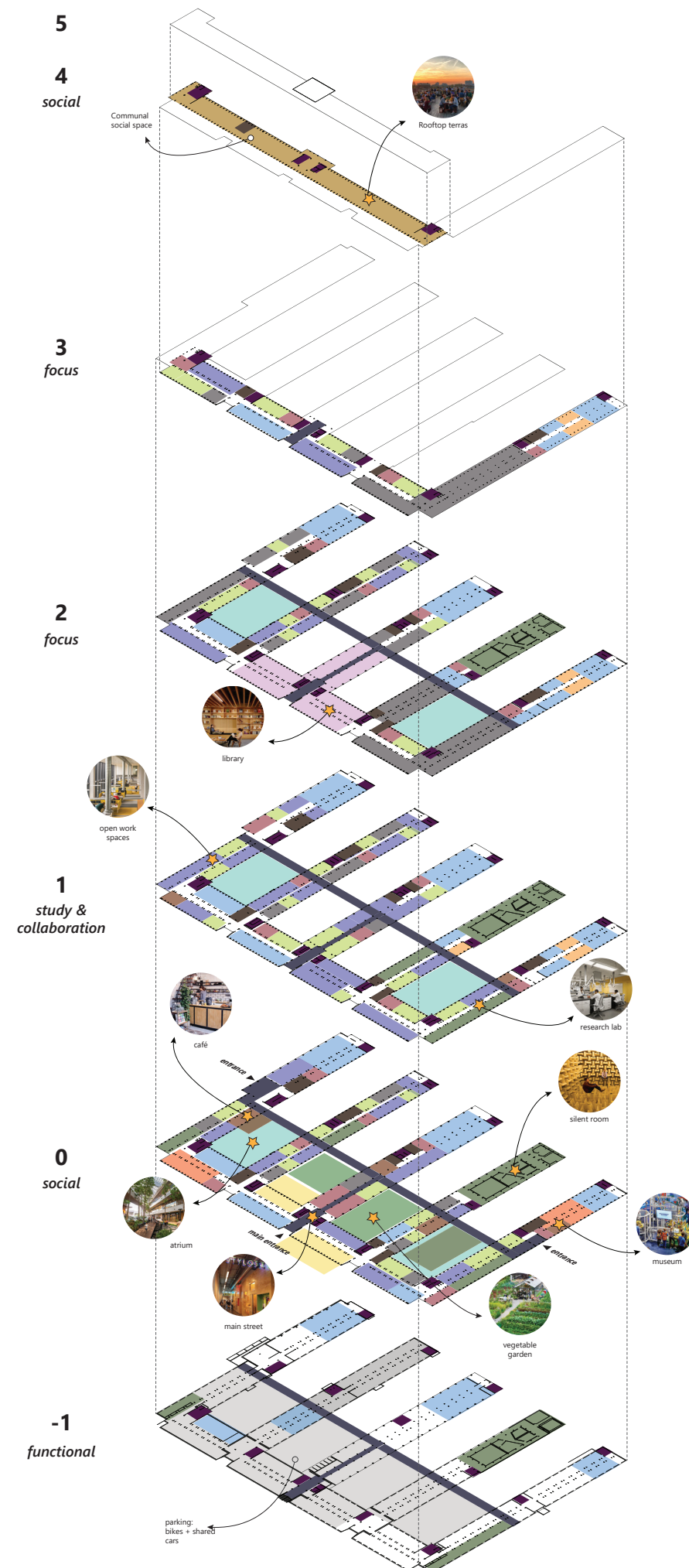
museum



vegetable garden



specific functions

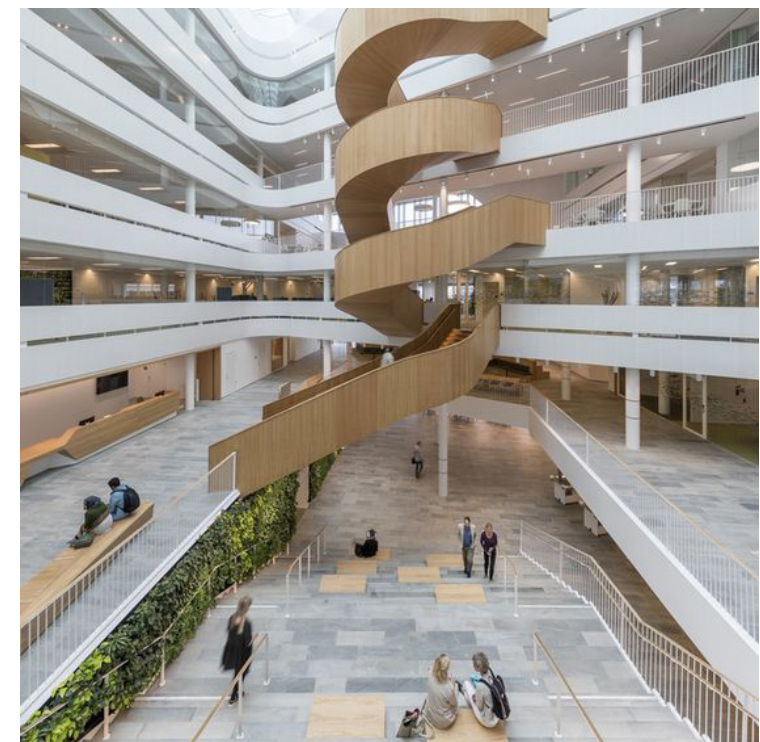
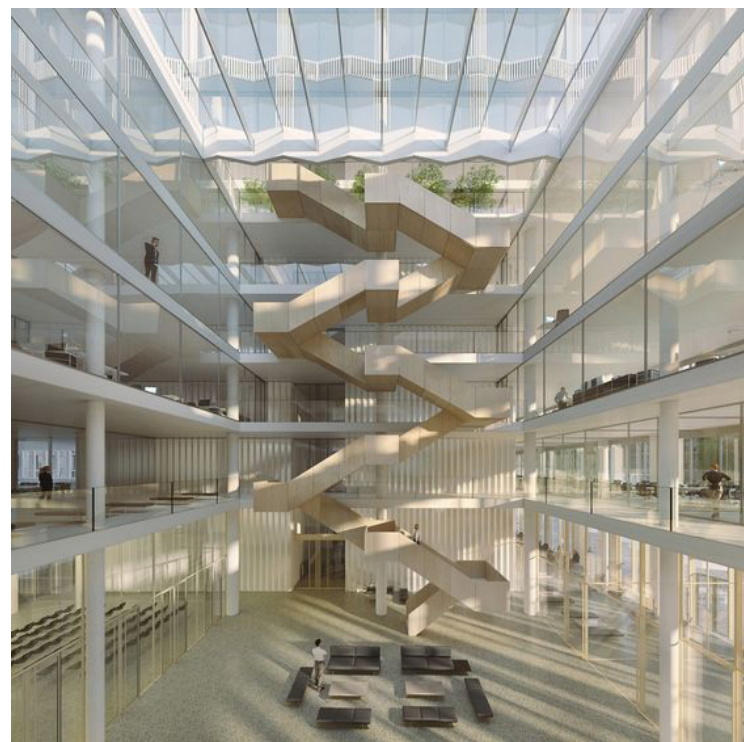
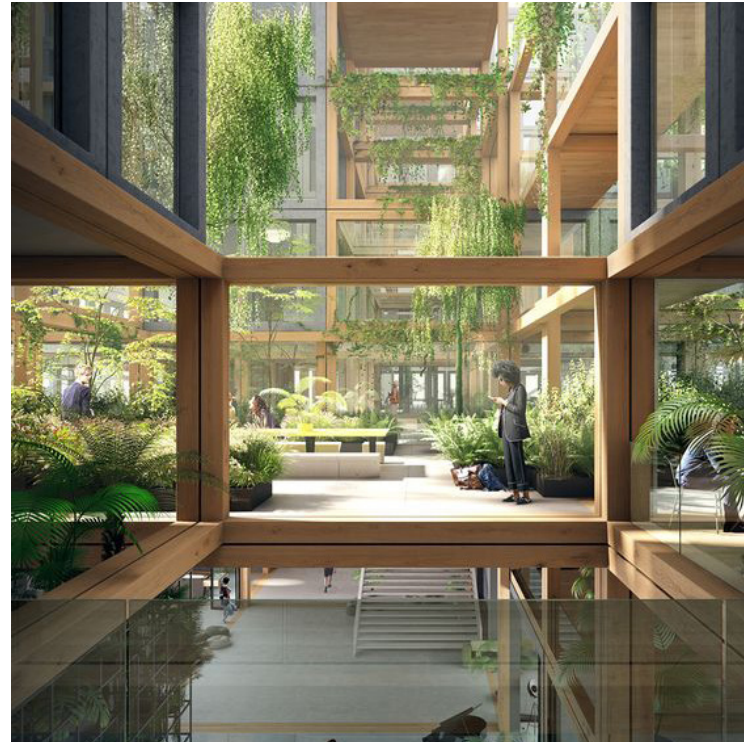


- Green garden/ courtyard
- Expo
- Event space
- Atrium
- Horeca
- Lecture/teaching room
- Lab
- Open work spaces
- Private offices
- Meeting rooms
- Relax spaces
- Coffee corner

1:200 PLAN GROUND FLOOR

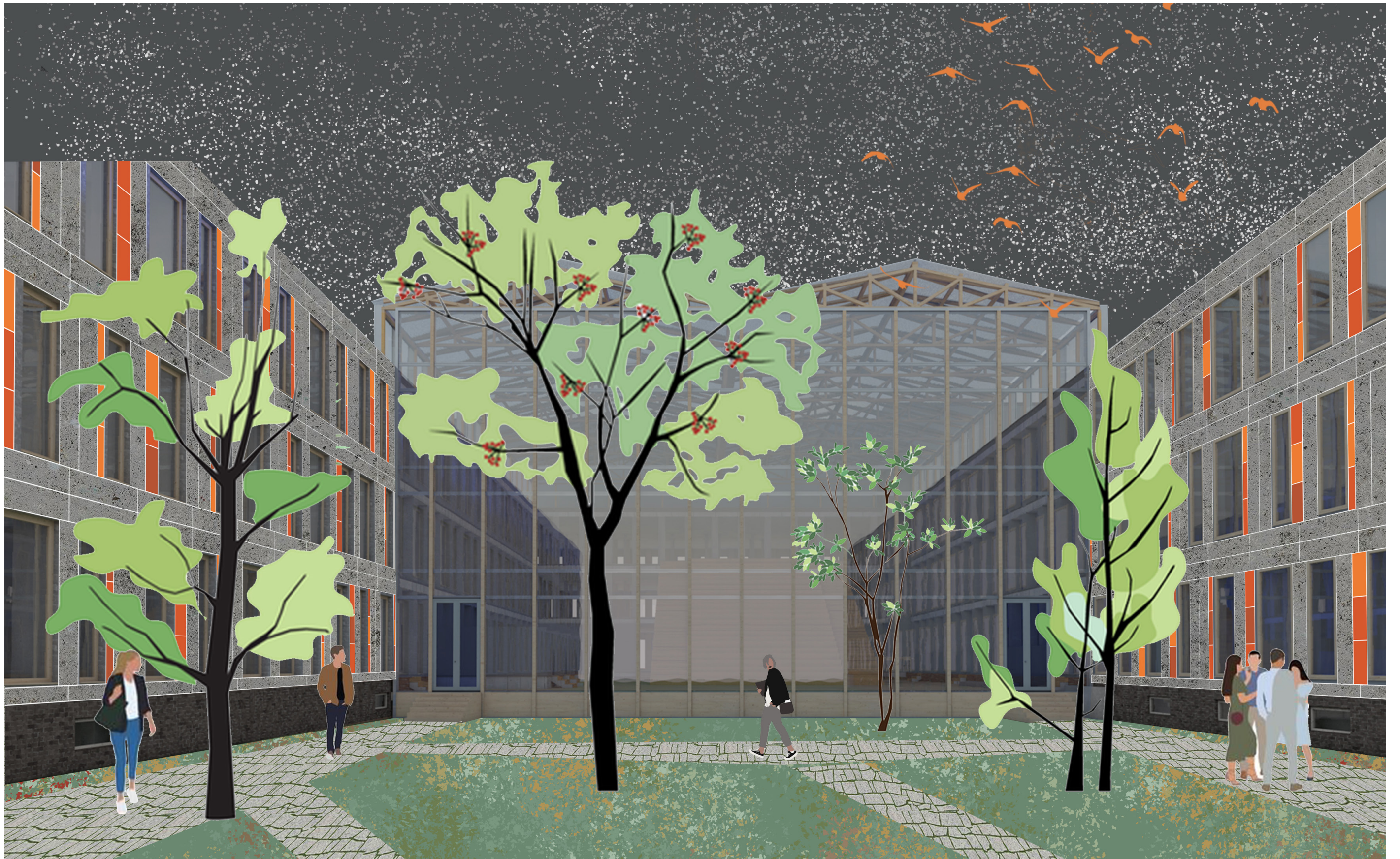


INSPIRATION ATRIUM

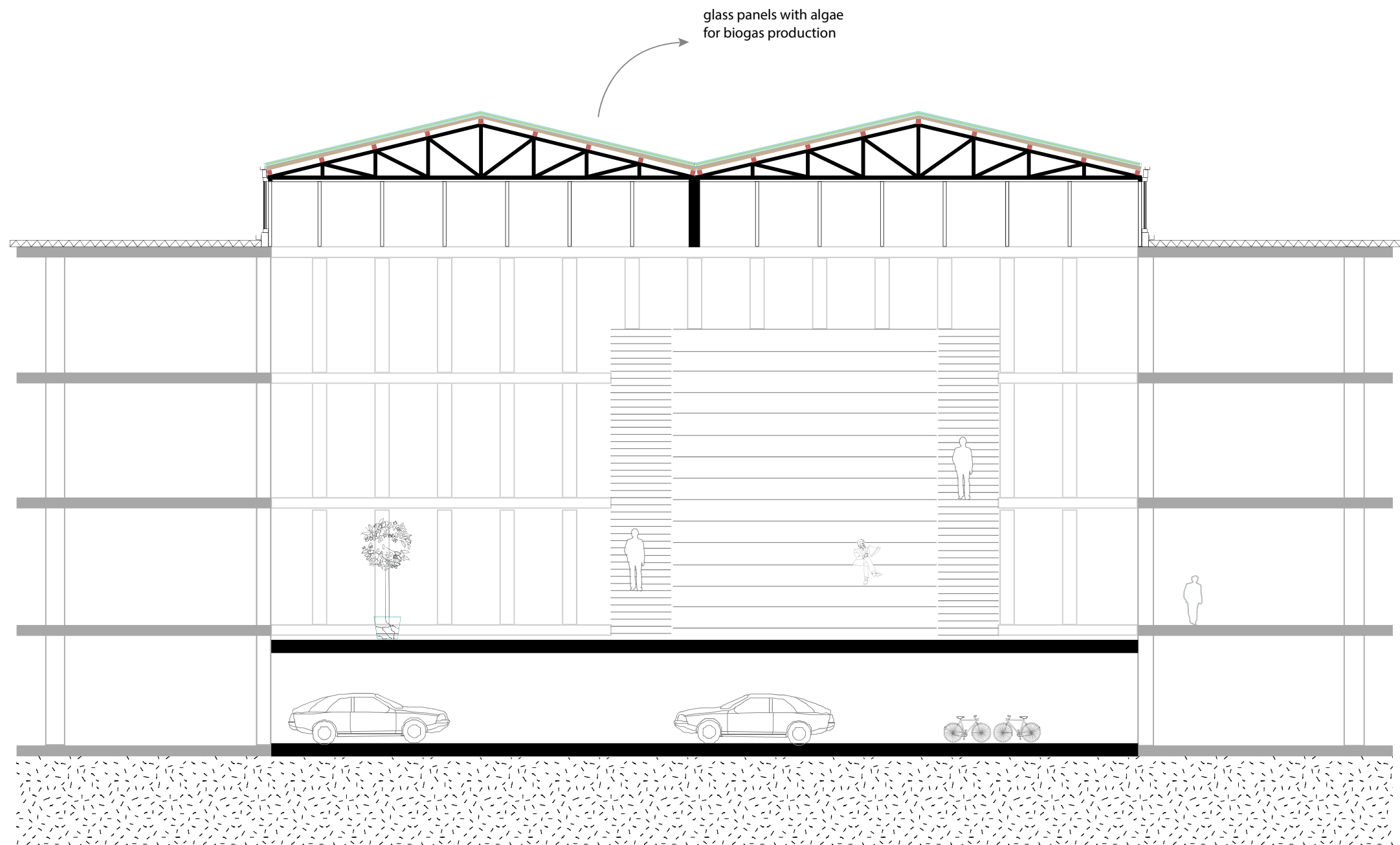


source: pinterest.com

ATRIUM



ATRIUM



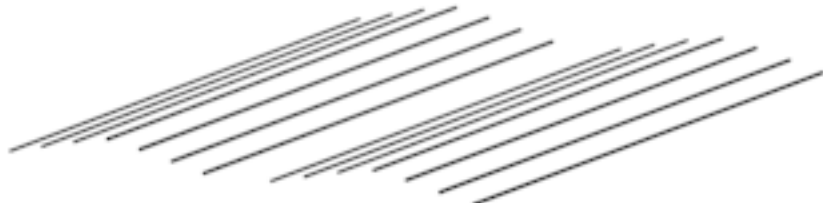
ROOF STRUCTURE ATRIUM



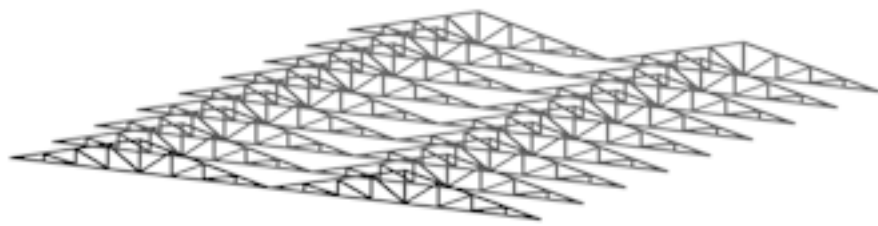
algae panels



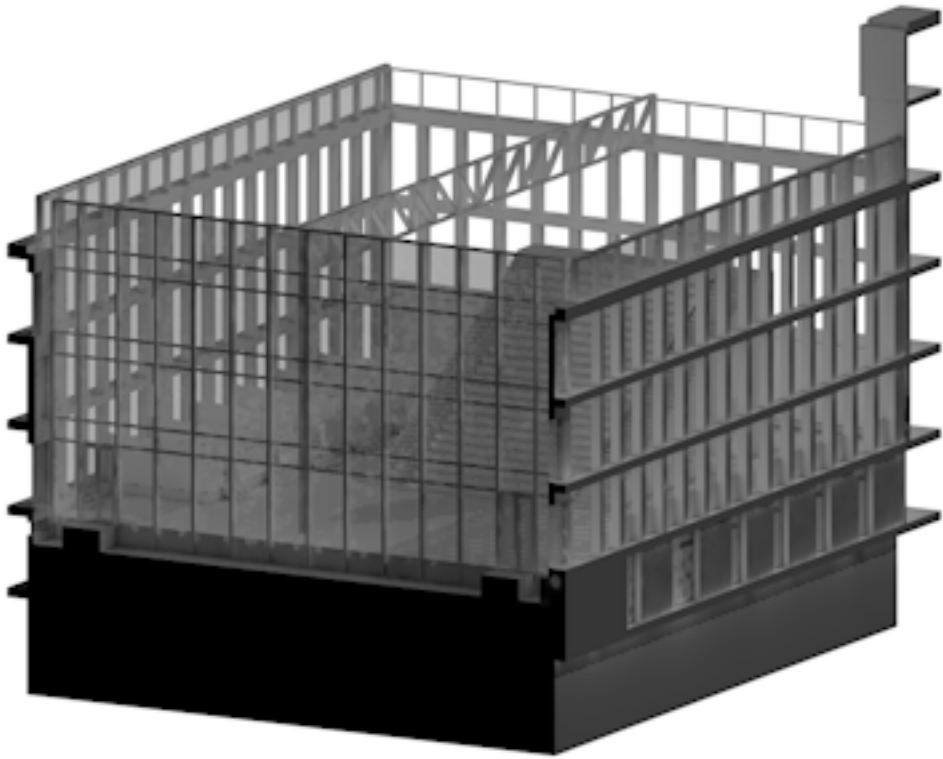
wooden frames for algae panels, wind stability



wooden purlins

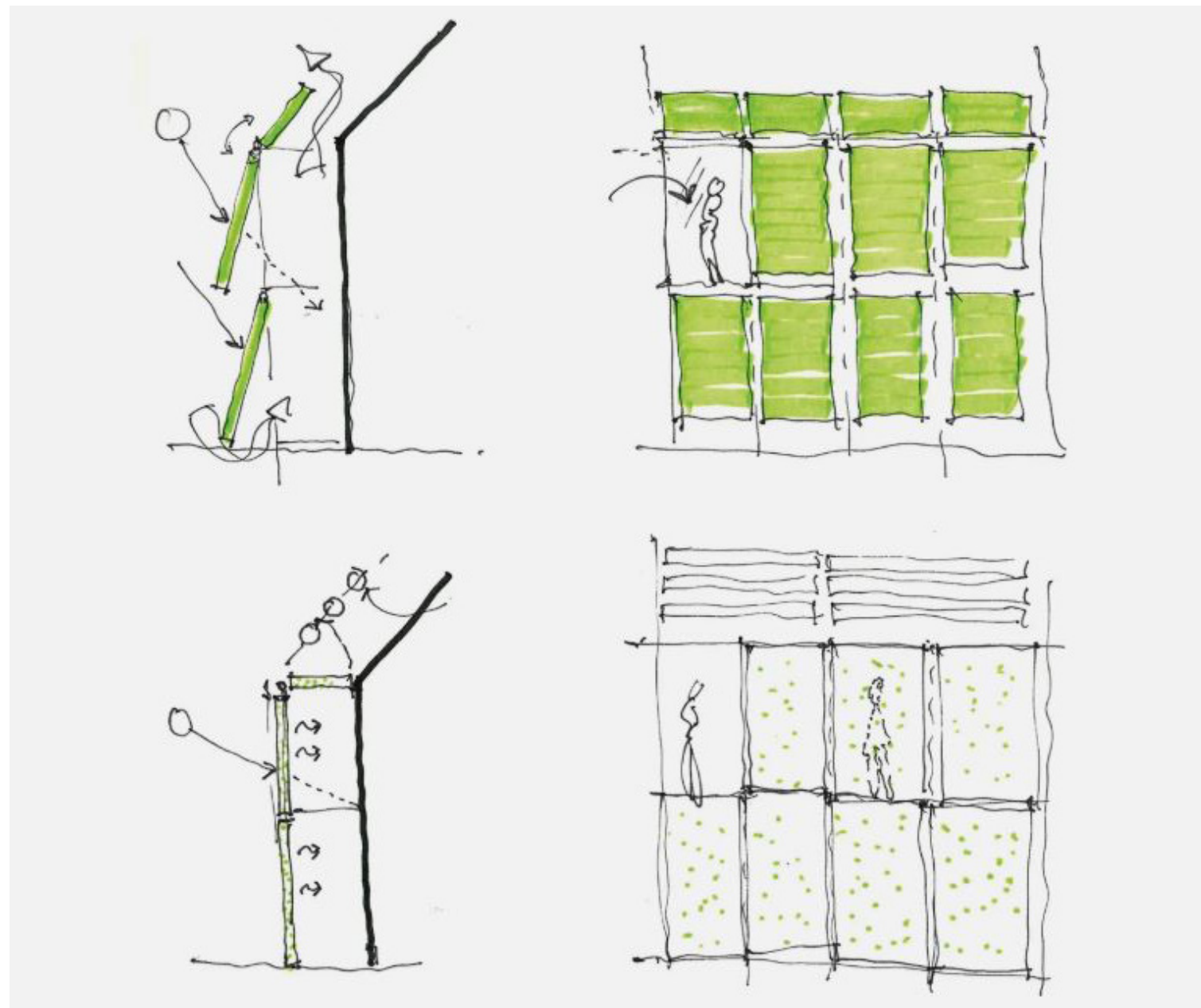


wooden trusses



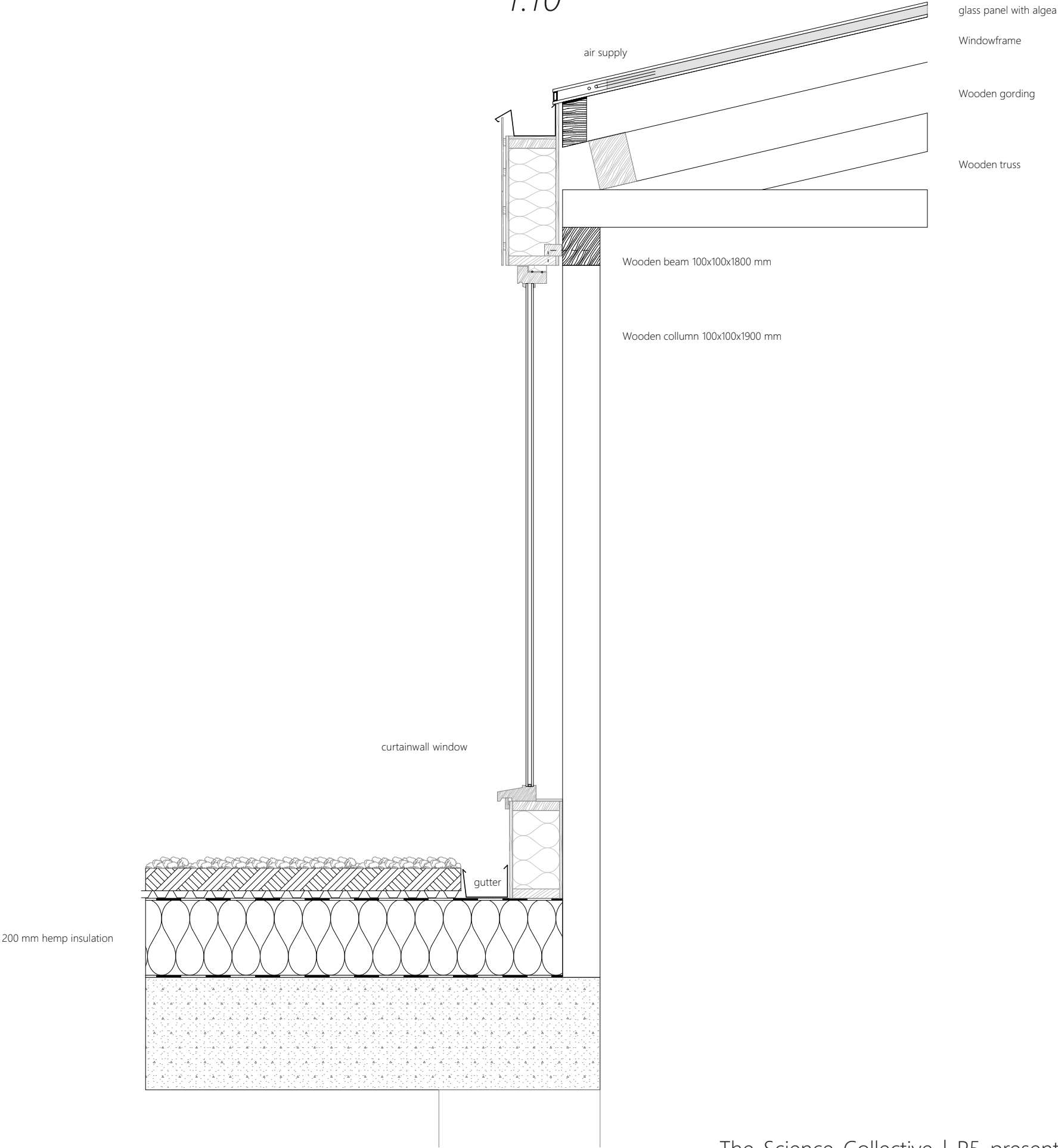
main structure added to existing building

CONCEPT ALGAE FACADE ARUP

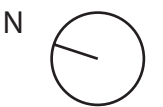
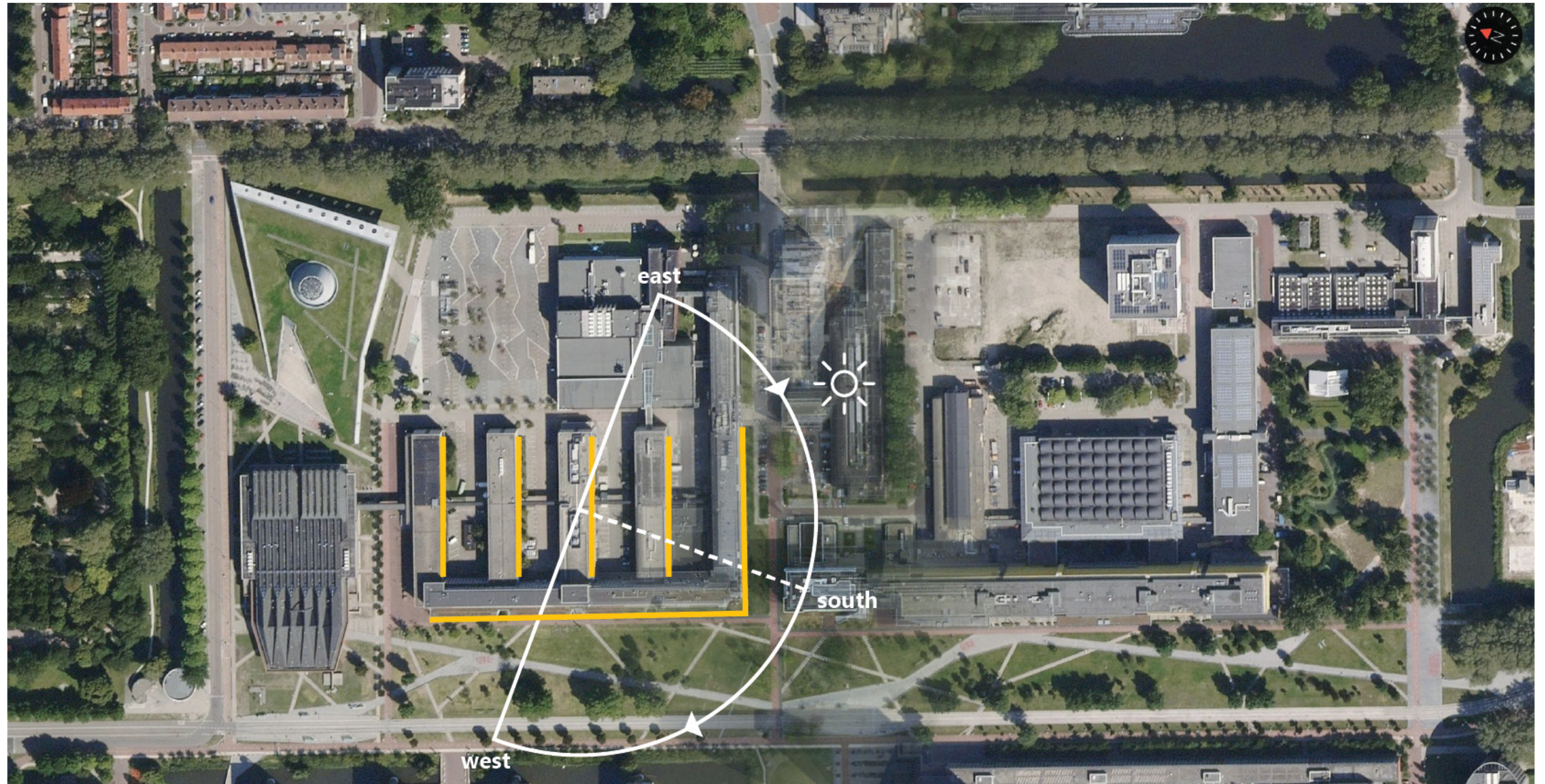


CONNECTION OF ATRIUM TO EXISTING BUILDING

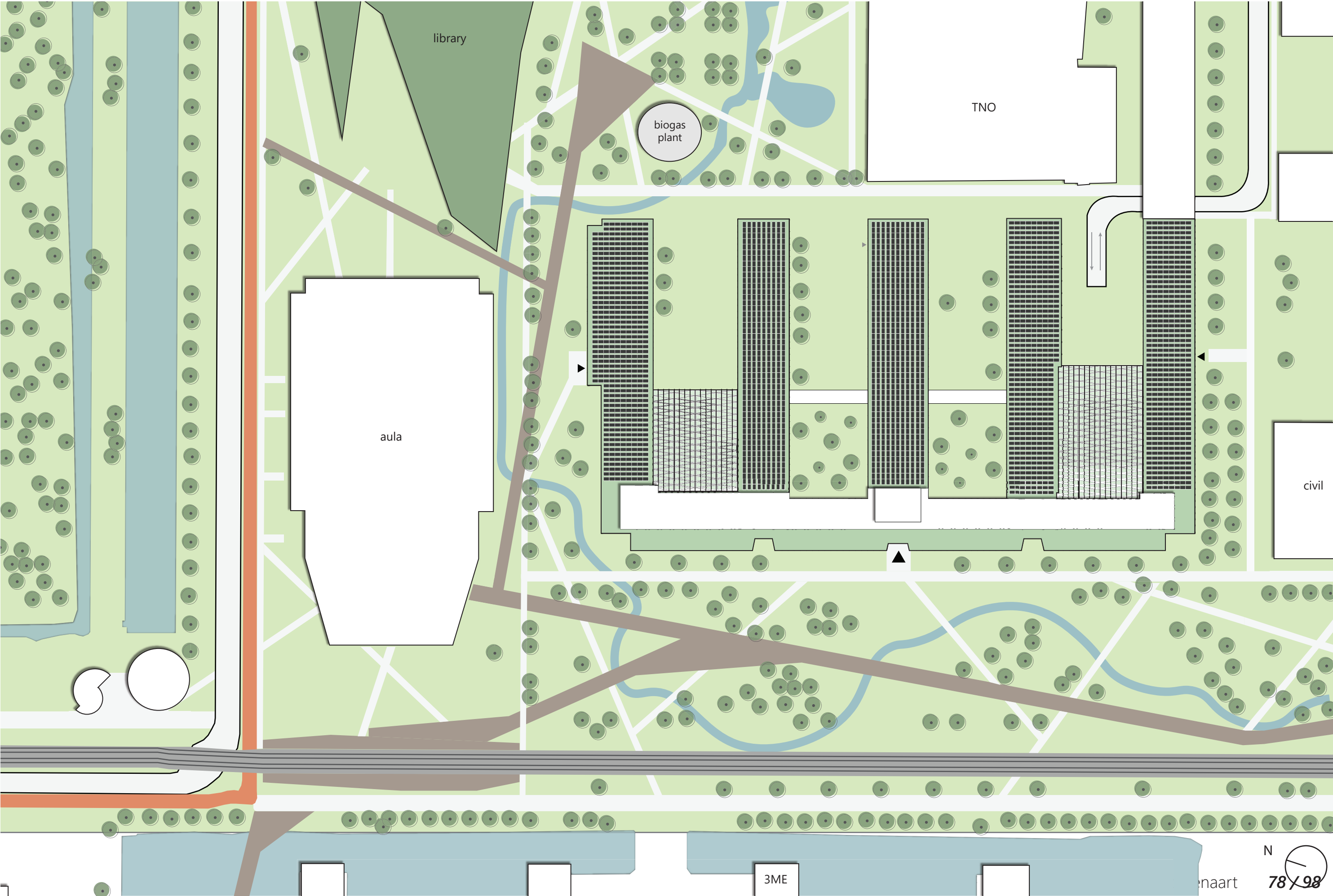
1:10



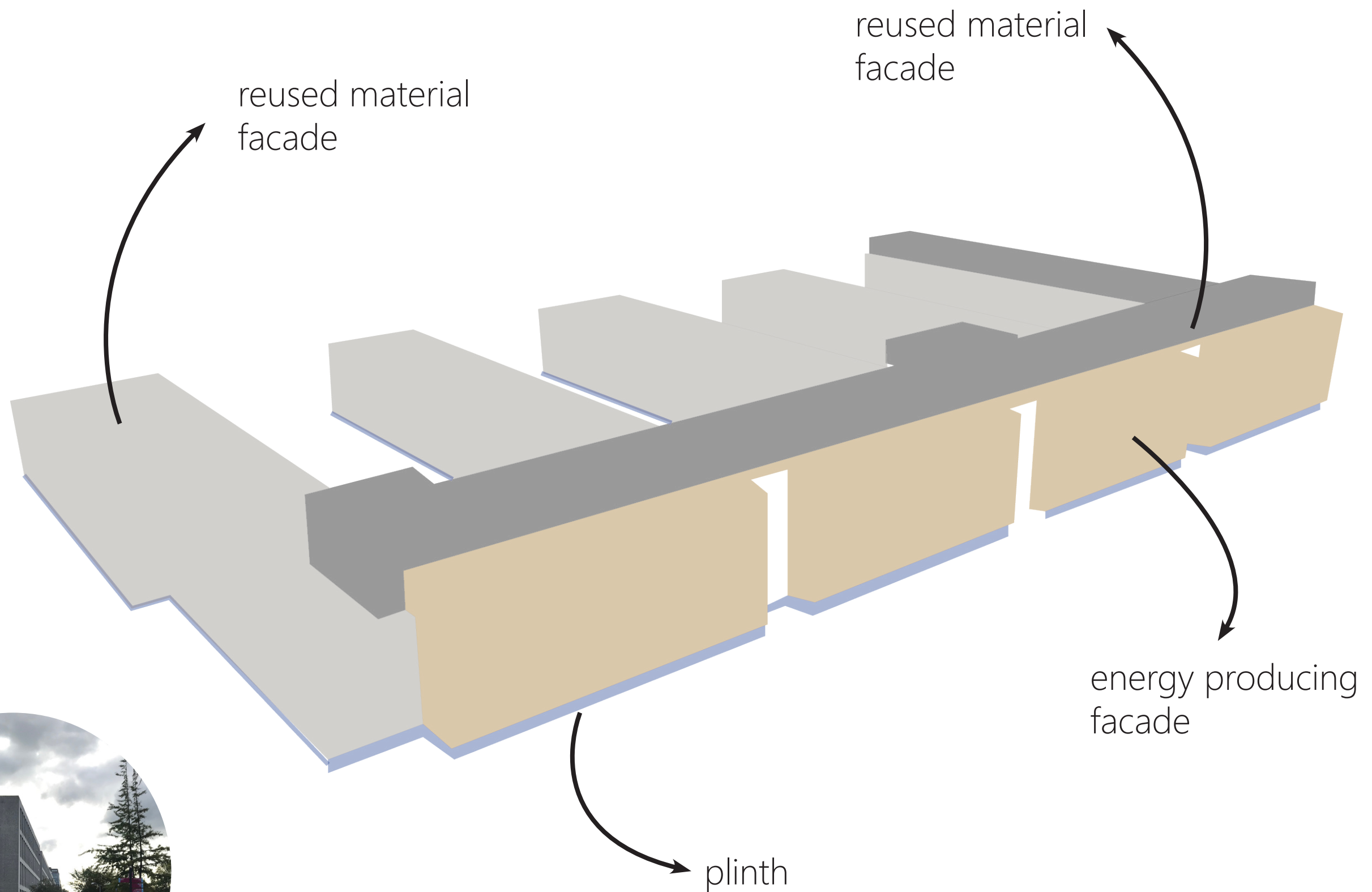
SITE - SUN PATH



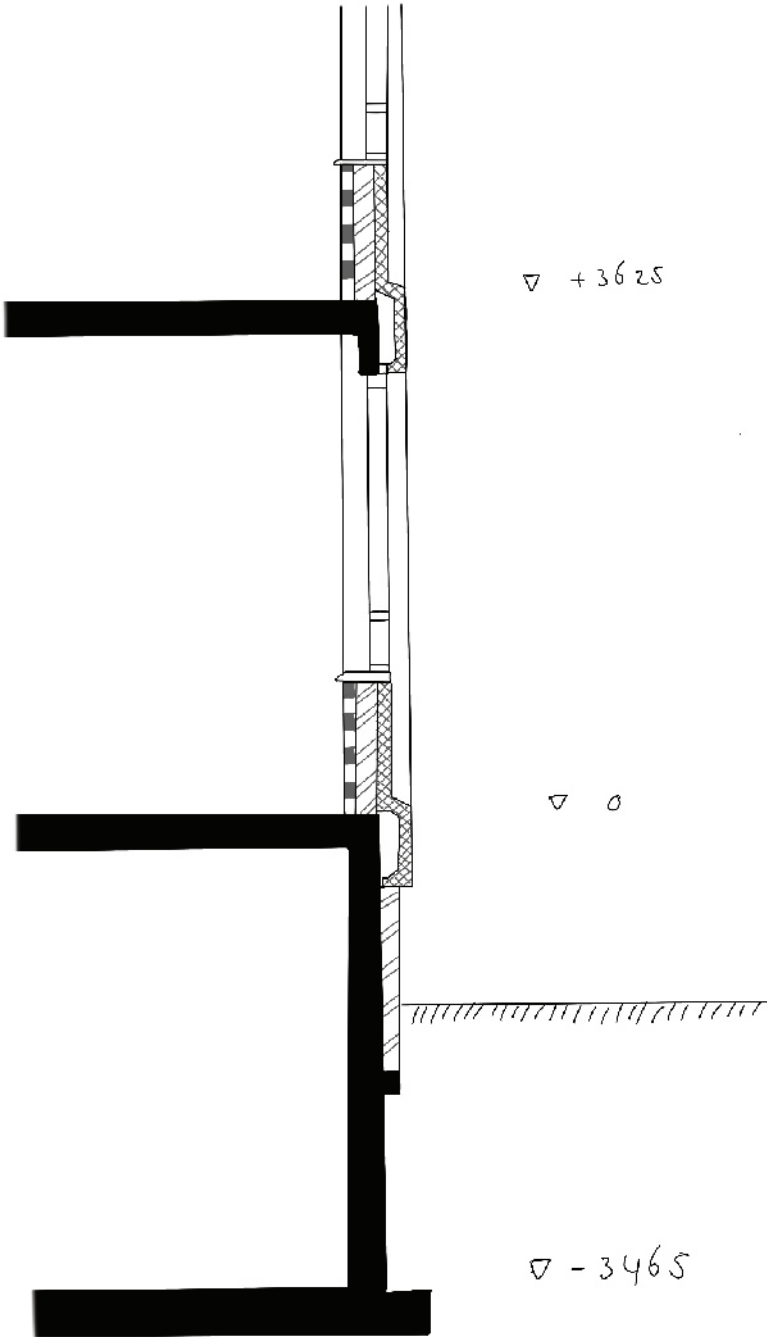
SITUATION ROOF PLAN 1:1000



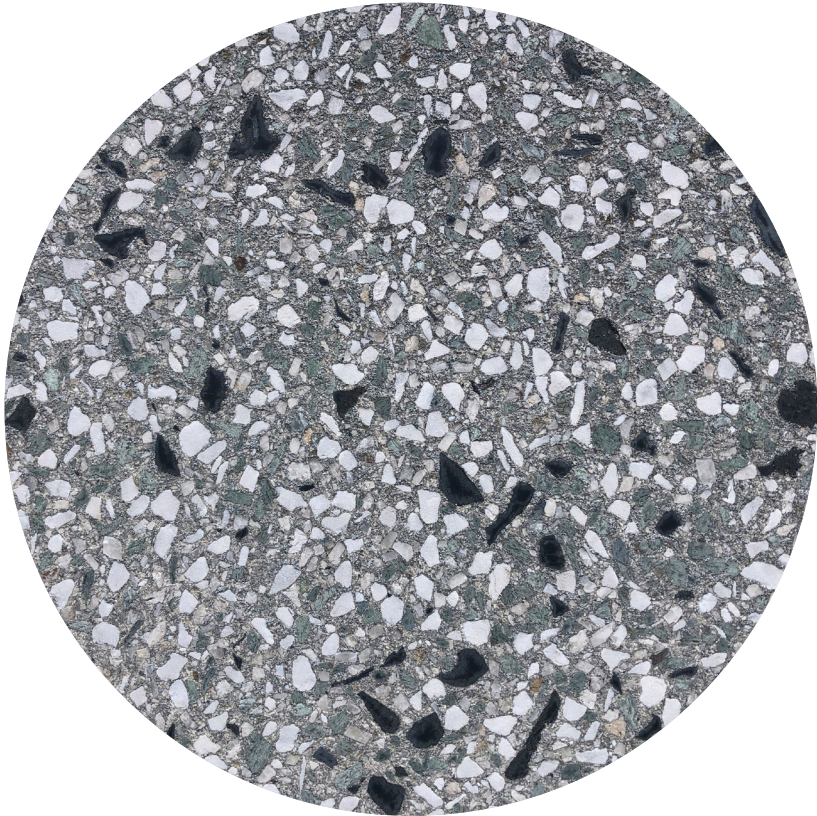
VOLUMES FACADE



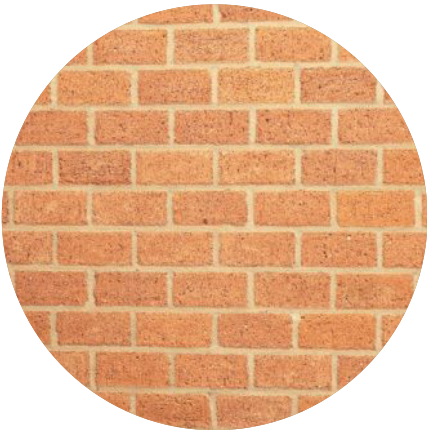
REUSE EXISTING FACADE MATERIALS



- reinforced concrete
- poriso stone
- brickwork
- natural stone



Polished concrete
876 m3
2101.9 tons
54.8% of façade



Poriso stone
835 m3
1127 tons
29.4% of façade



Black glazed bricks
189,4 m3
274.8 tons
7.2% of façade



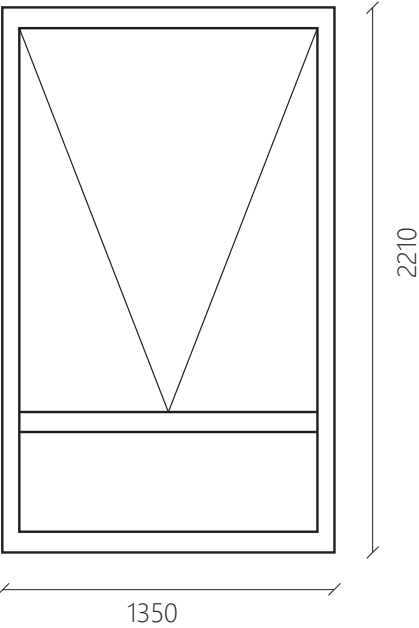
Natural stone
106 m3
271.5 tons
7.1% of façade



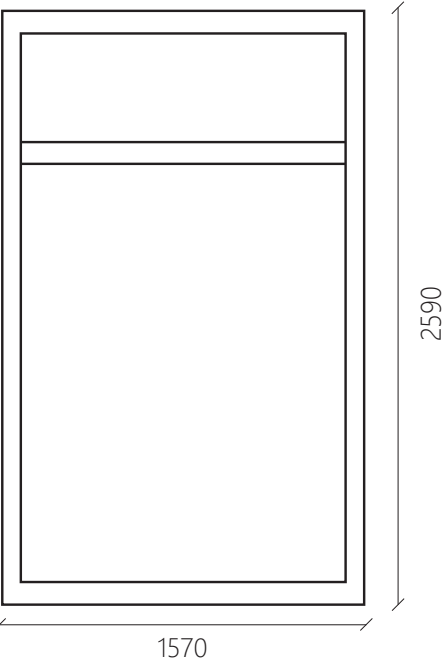
Windows
6126.5 m2
56.1 tons
1856 pieces
11 types

REUSE EXISTING FACADE MATERIALS

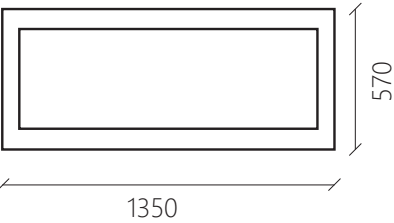
Type A
amount: 1330



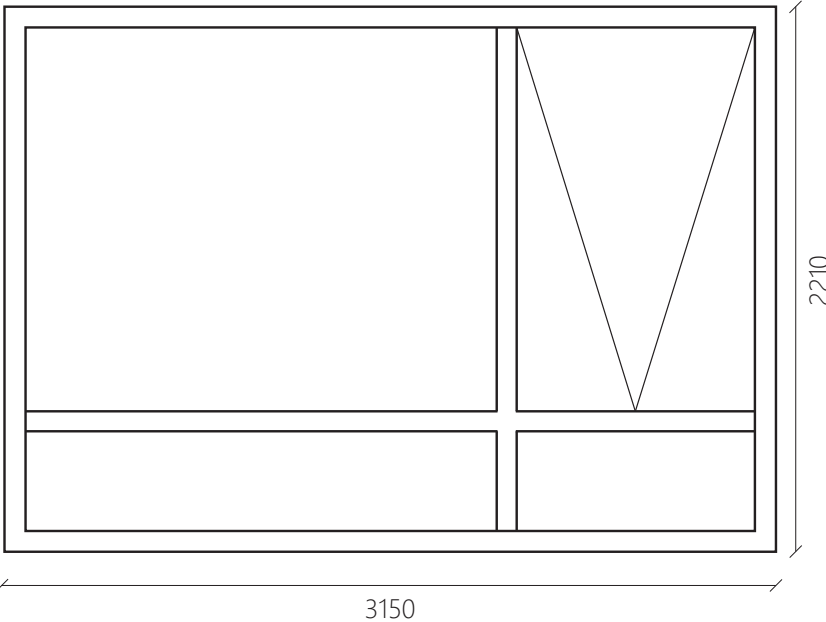
Type B
amount: 141



Type G
amount: 117

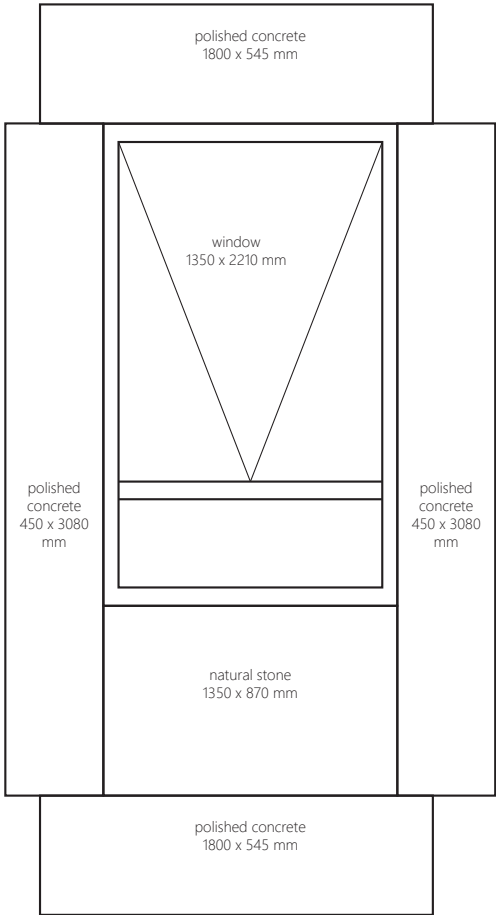


Type J
amount: 140

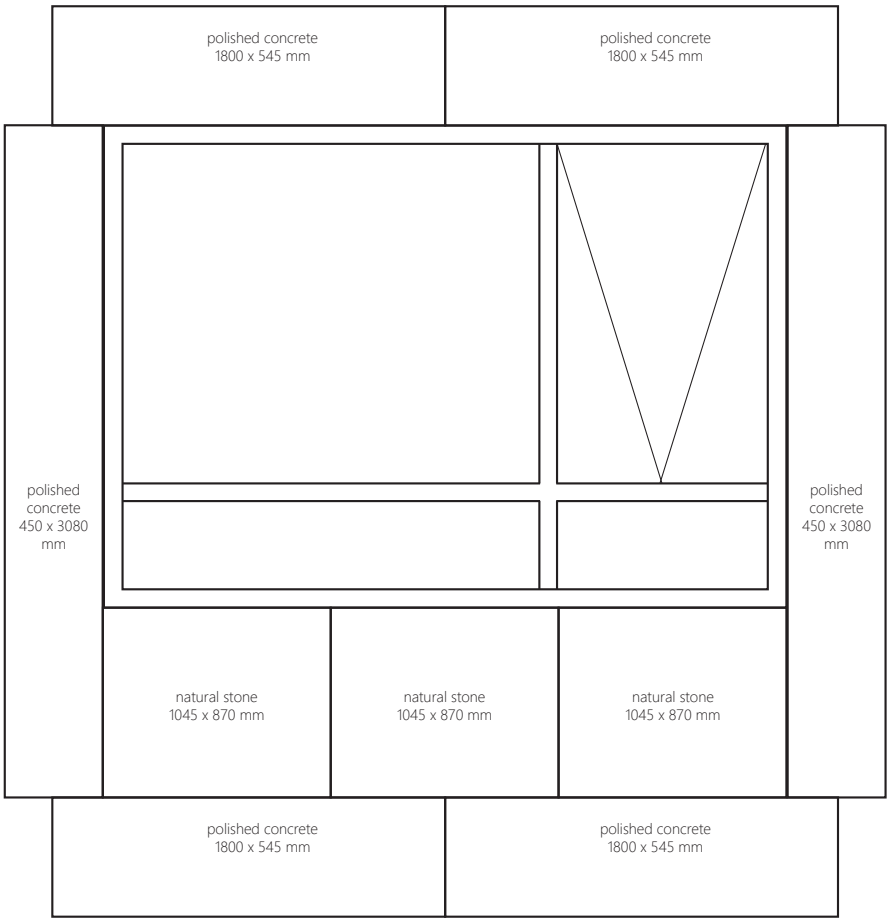


REUSE EXISTING FACADE MATERIALS

Type A
amount: 1330

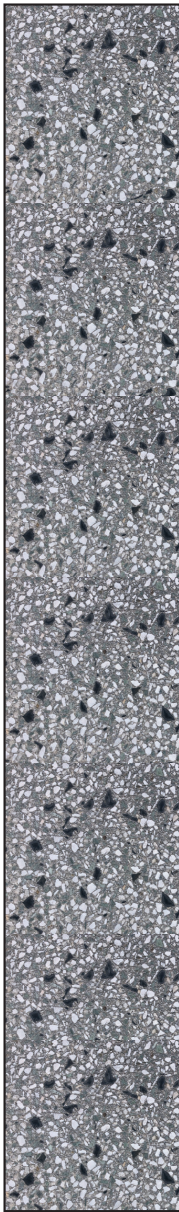


Type J
amount: 140



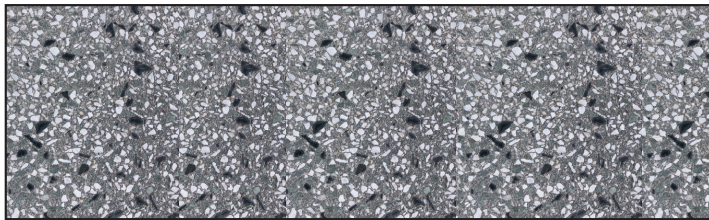
REUSE EXISTING FACADE MATERIALS

amount: 1470



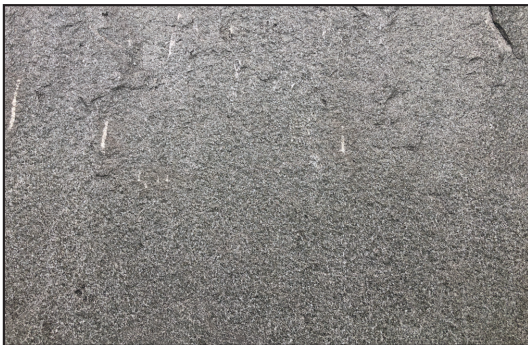
polished concrete
450 x 3080 x 100 mm

amount: 1950



polished concrete
1800 x 545 x 100 mm

amount: 1330



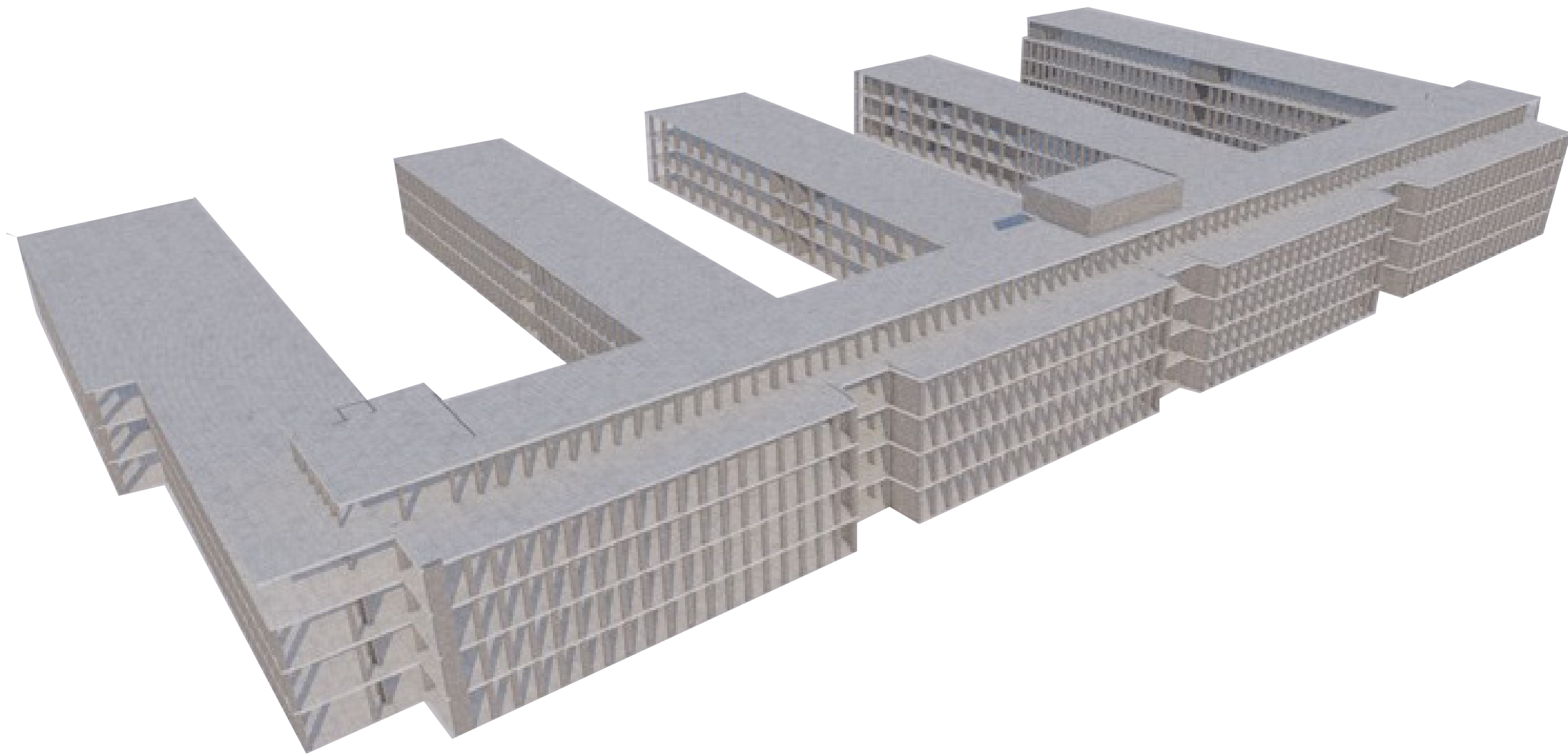
natural stone
1350 x 870 x 50 mm

amount: 420

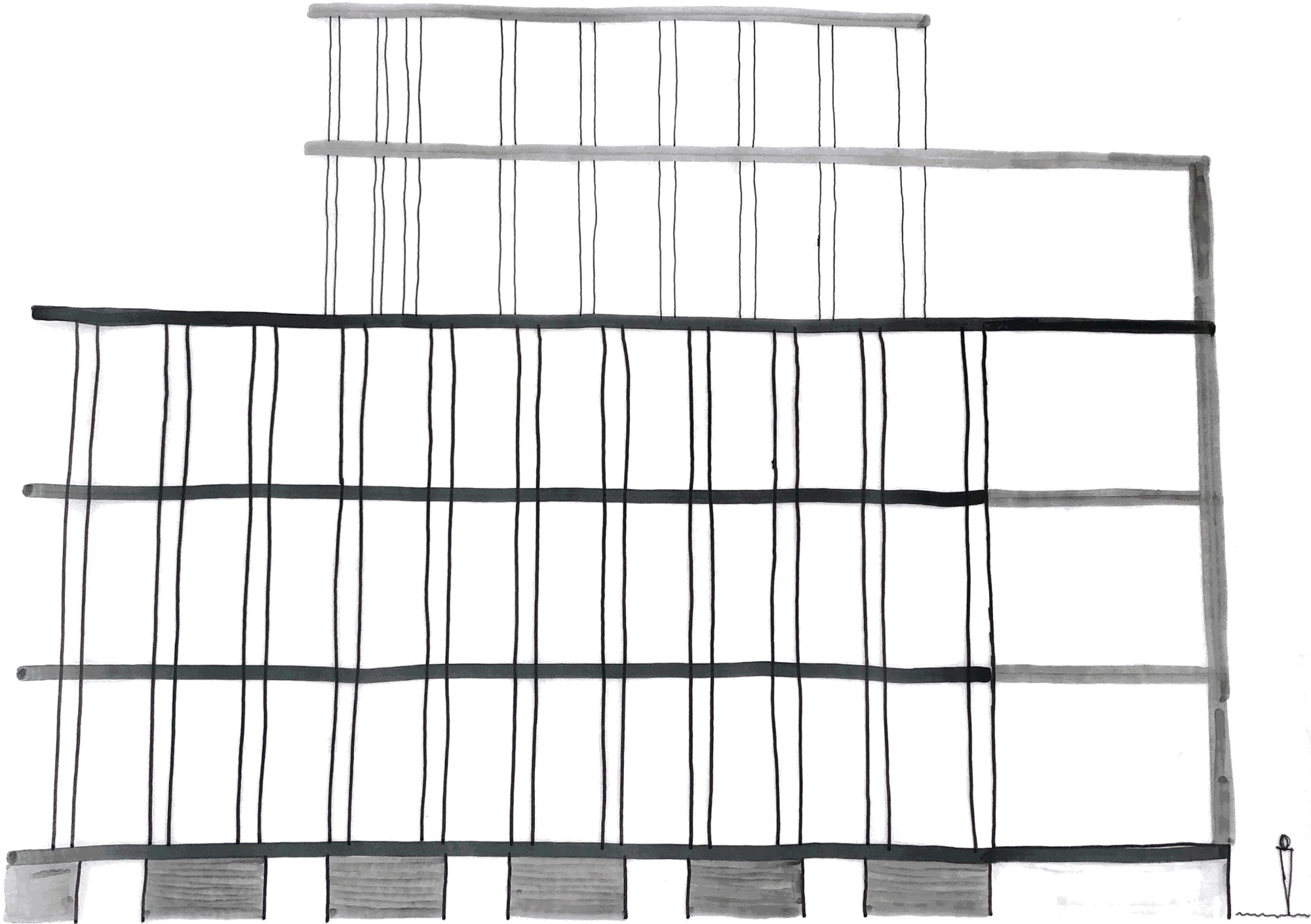


natural stone
1045 x 870 x 50 mm

REUSE EXISTING STRUCTURE



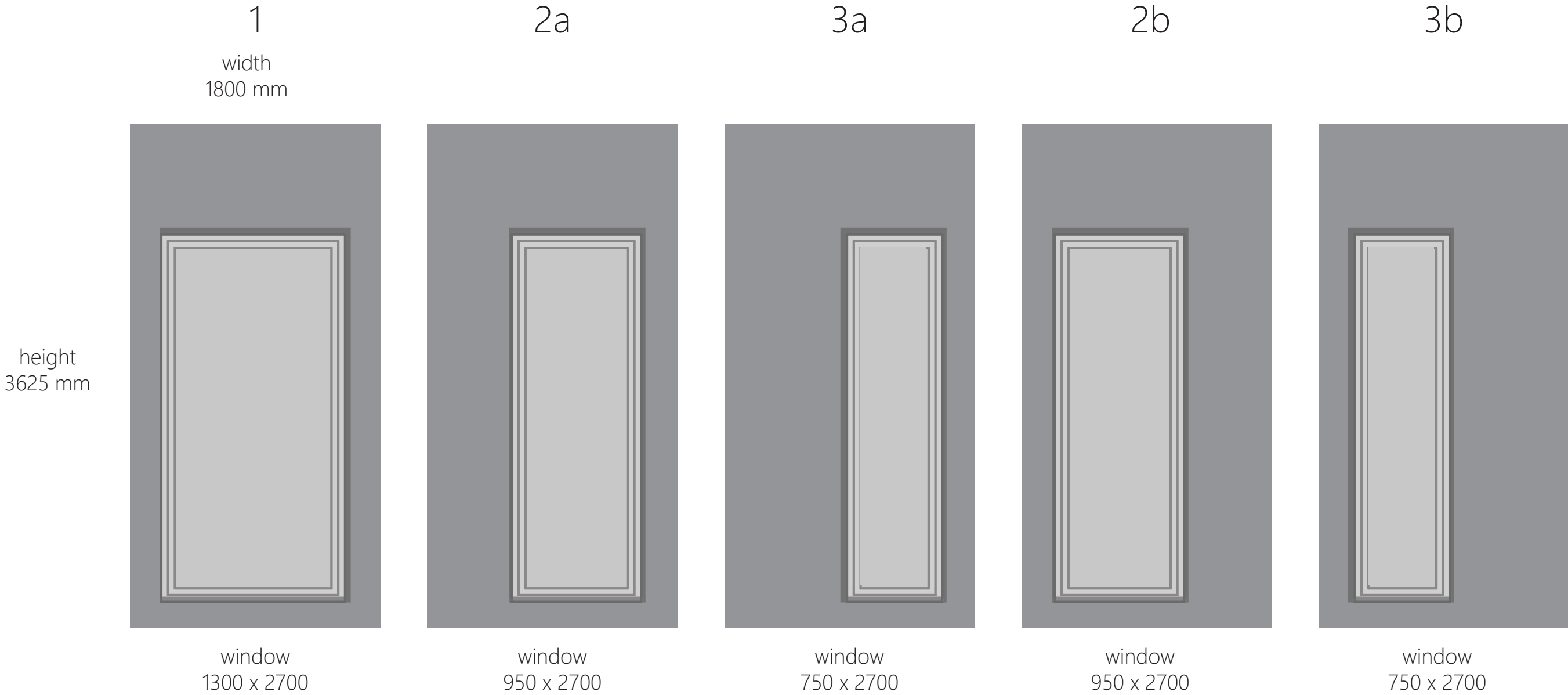
EXISTING CONCRETE STRUCTURE



NORTH - WEST ELEVATION 1:100

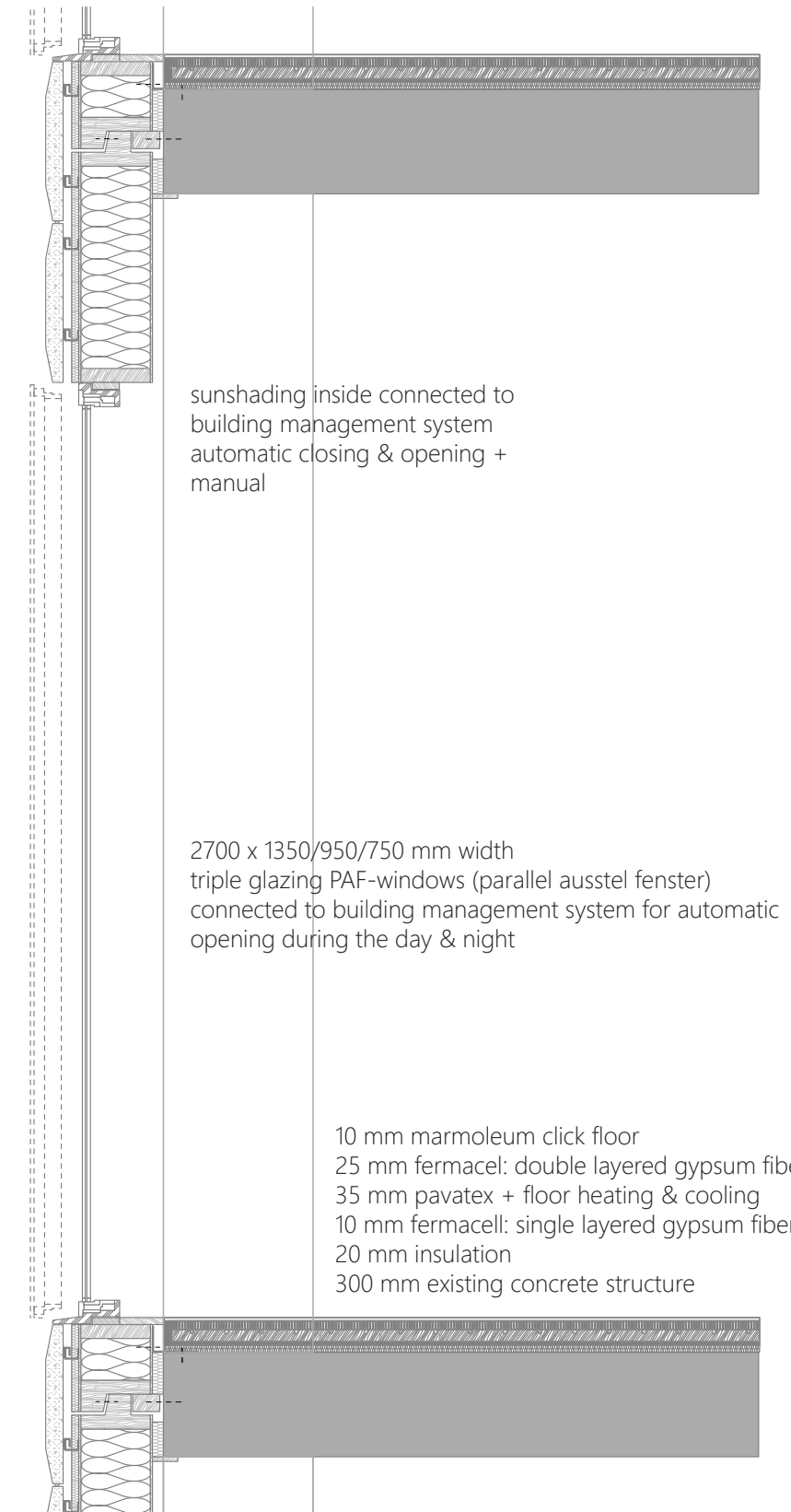
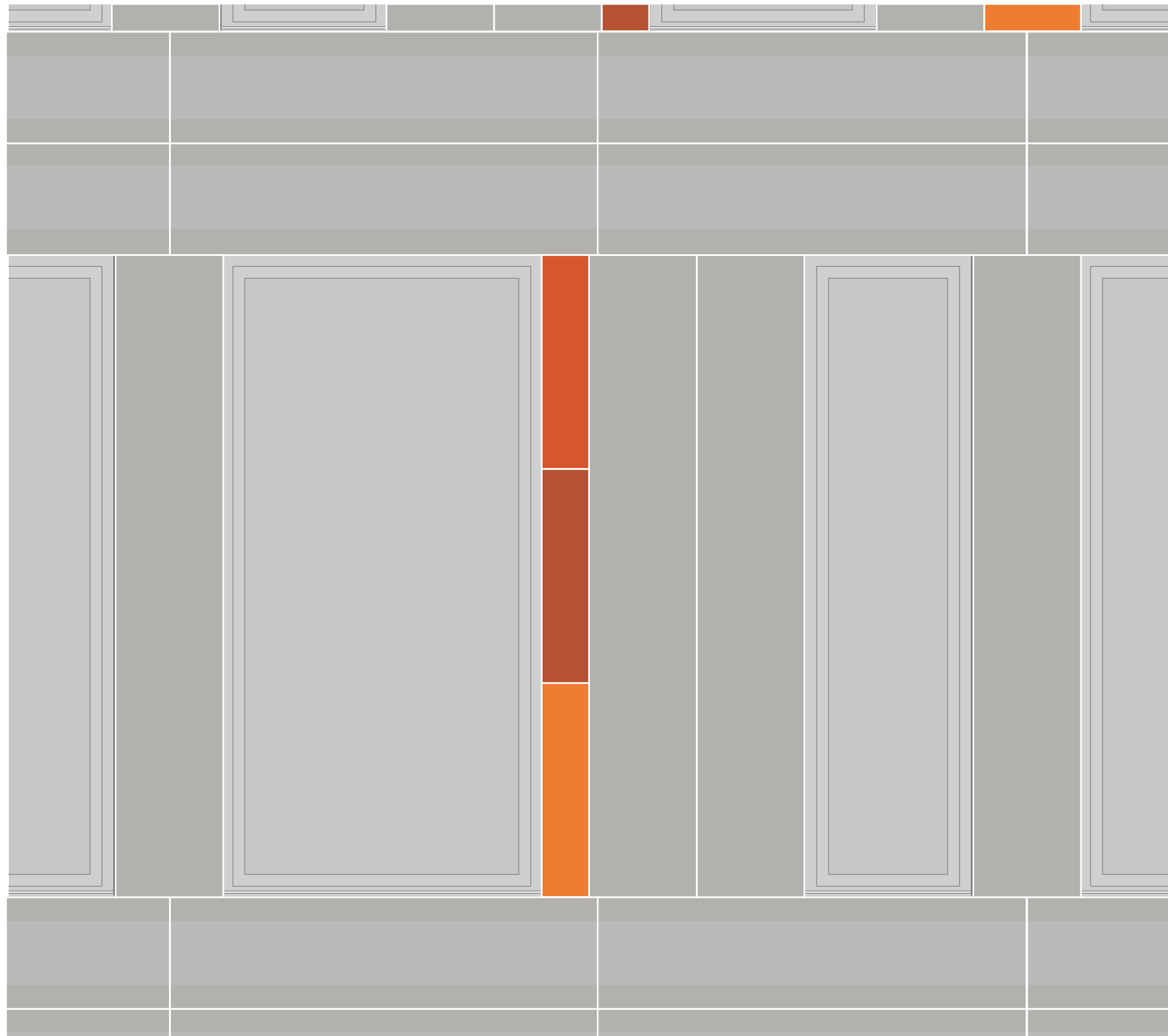
FACADE MODULES

PREFAB BASE



REUSED MATERIALS FACADE

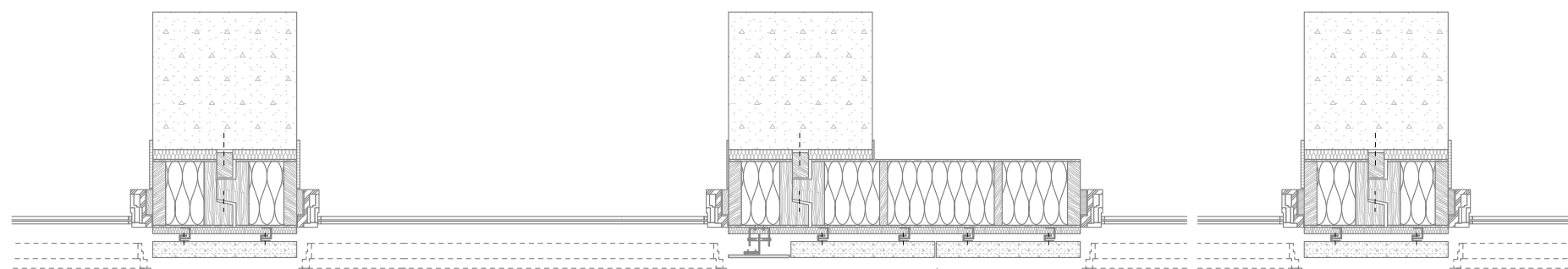
1:20



sunshading inside connected to
building management system
automatic closing & opening +
manual

2700 x 1350/950/750 mm width
triple glazing PAF-windows (parallel ausstel fenster)
connected to building management system for automatic
opening during the day & night

10 mm marmoleum click floor
25 mm fermacel: double layered gypsum fiber board
35 mm pavatex + floor heating & cooling
10 mm fermacell: single layered gypsum fiber board
20 mm insulation
300 mm existing concrete structure



prefab HSB element
with 200 mm hemp
insulation
vapor barrier
anchor
20 mm insulation
vapor barrier
20 mm cavity
50 mm reused
polished concrete

FACADE CONCEPT

**energy
producing**

**Rc-value 4,5-7
m²K/W**

**open &
accessible
ground floor**

**reuse existing
facade materials**

**combining
passive & active
techniques**

REUSED MATERIALS FACADE

1:200



REUSED MATERIALS FACADE

1:200

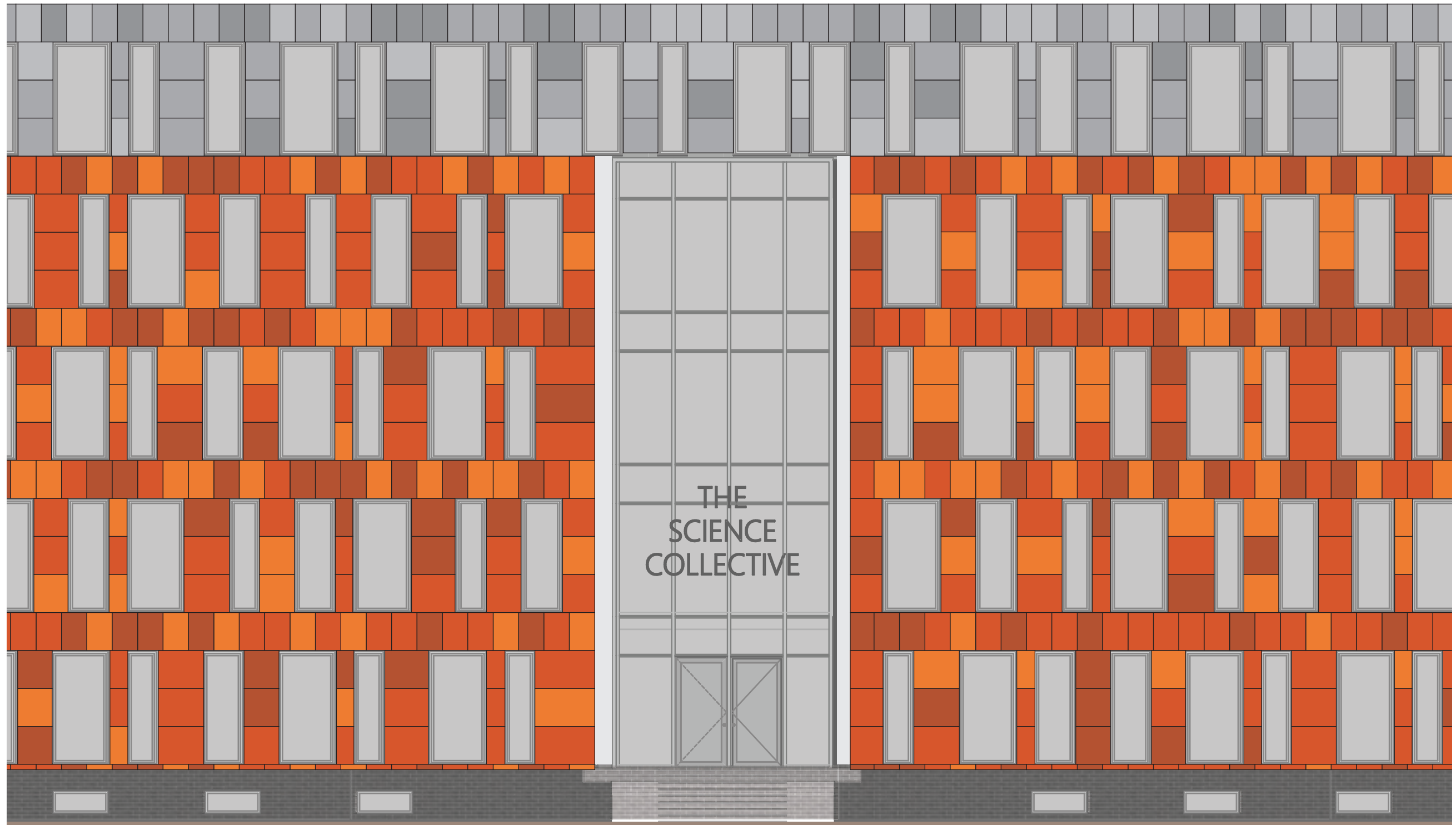




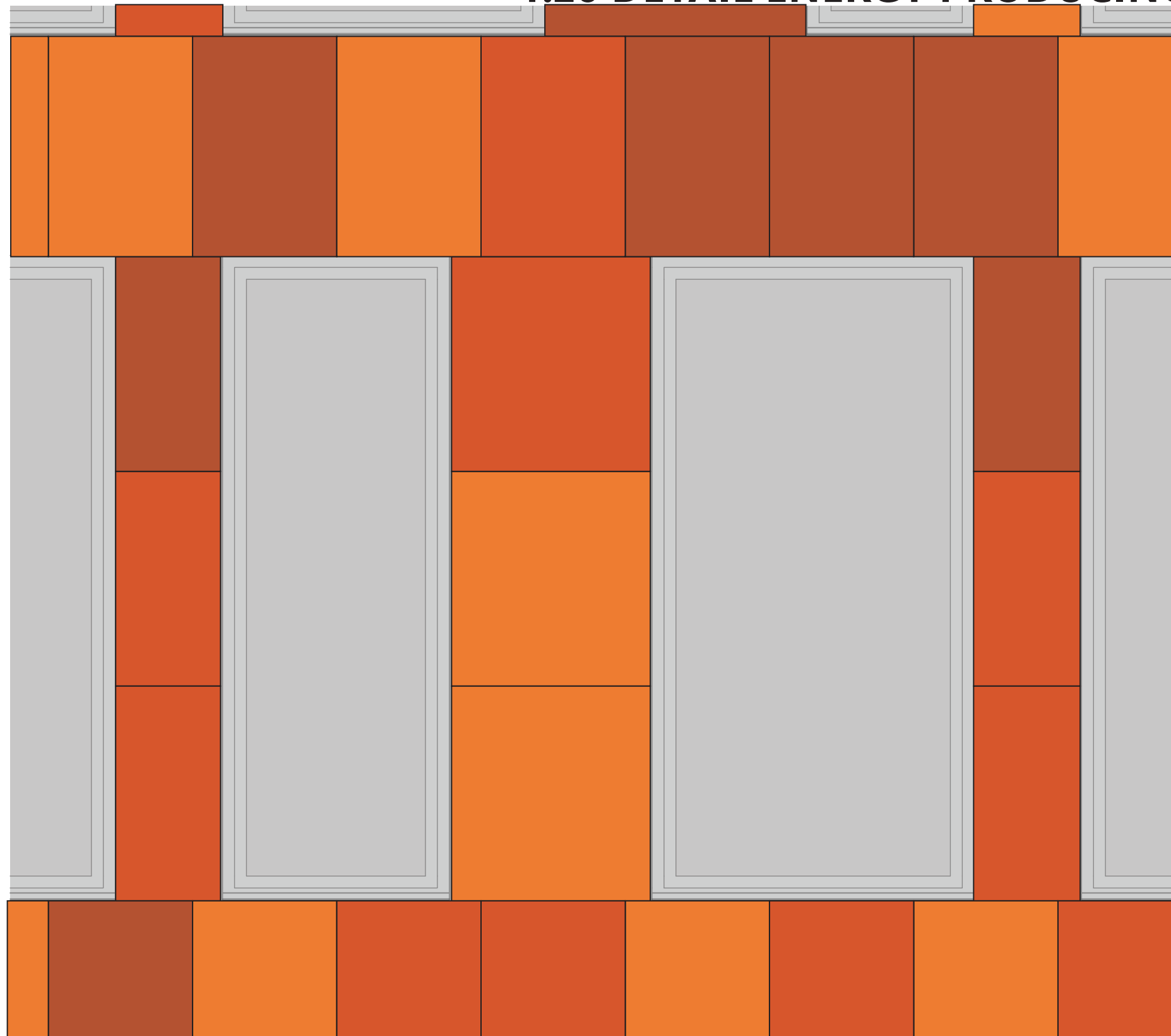
ENERGY PRODUCING FACADE



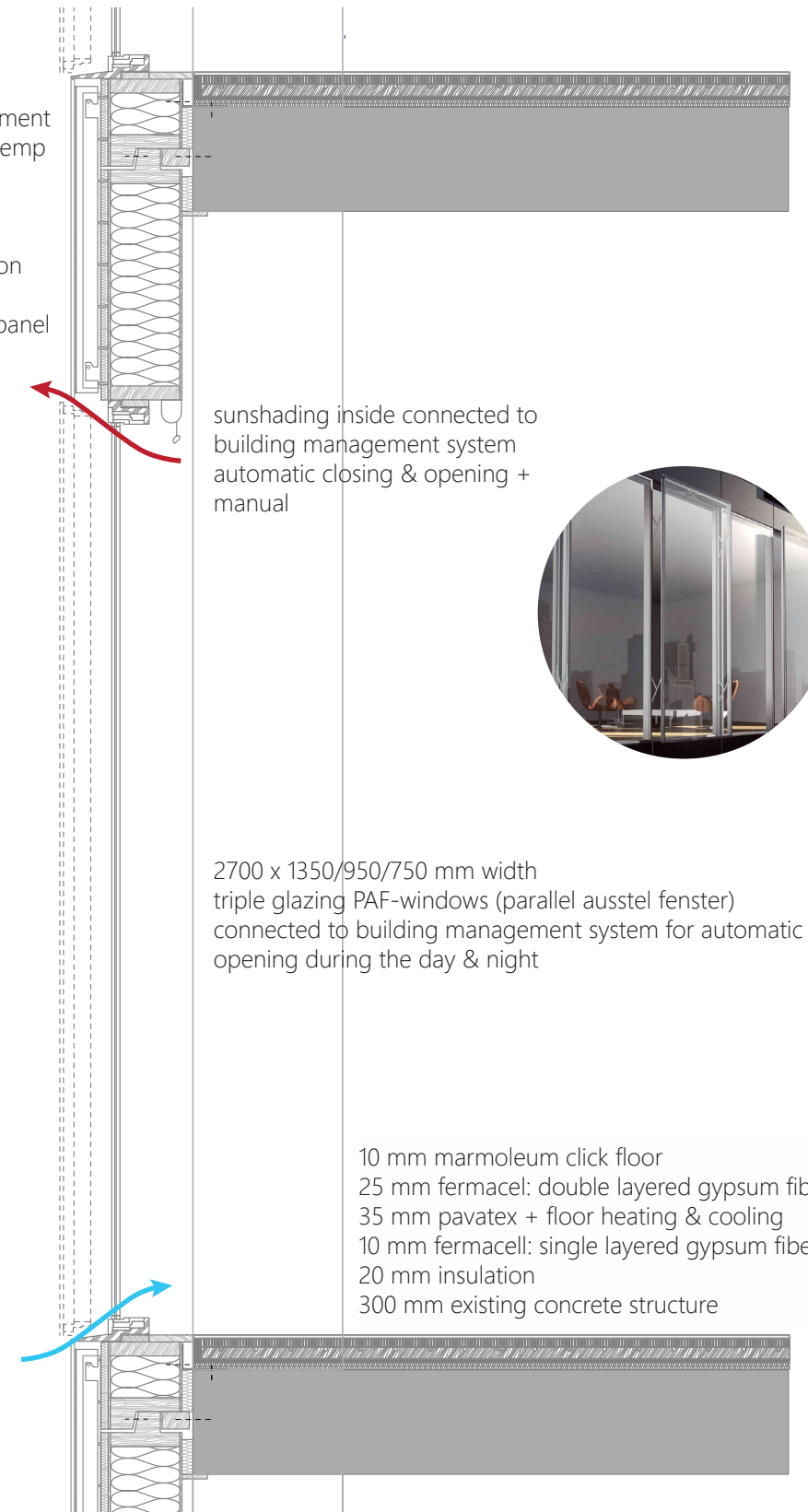
1:100 MAIN ENTRANCE



1:20 DETAIL ENERGY PRODUCING FACADE



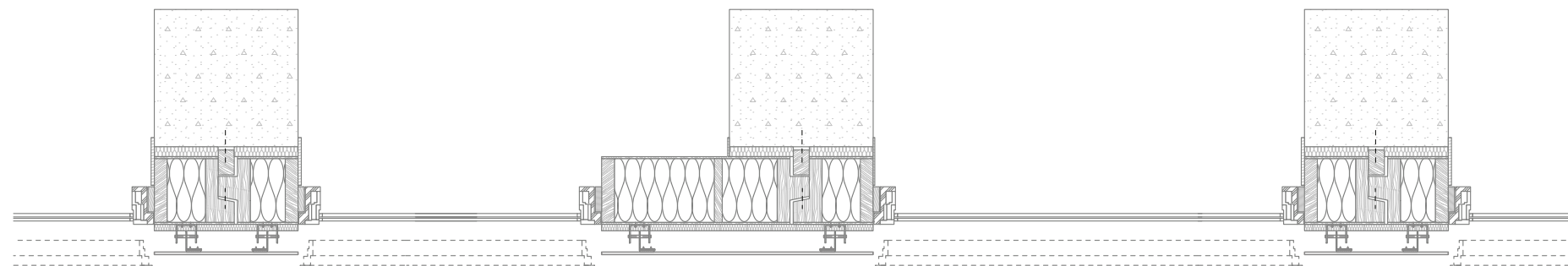
prefab HSB element
with 200 mm hemp
insulation
vapor barrier
anker
20 mm insulation
vapor barrier
color blast PV panel



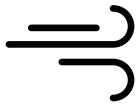
sunshading inside connected to
building management system
automatic closing & opening +
manual

2700 x 1350/950/750 mm width
triple glazing PAF-windows (parallel ausstel fenster)
connected to building management system for automatic
opening during the day & night

10 mm marmoleum click floor
25 mm fermacel: double layered gypsum fiber board
35 mm pavatex + floor heating & cooling
10 mm fermacell: single layered gypsum fiber board
20 mm insulation
300 mm existing concrete structure



CLIMATE CONCEPT



NATURAL VENTILATION

Parallel opening windows connected to building management system. Automatically open and close. Night flushing to naturally cool the building in summer.



SUN SHADING

Interior sun screens connected to building management system. Automatically open and close.

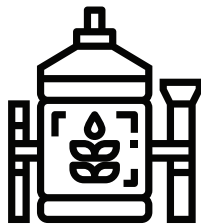


RENEWABLE ENERGY

Electricity is produced by solar panels integrated in the facade & on the roof

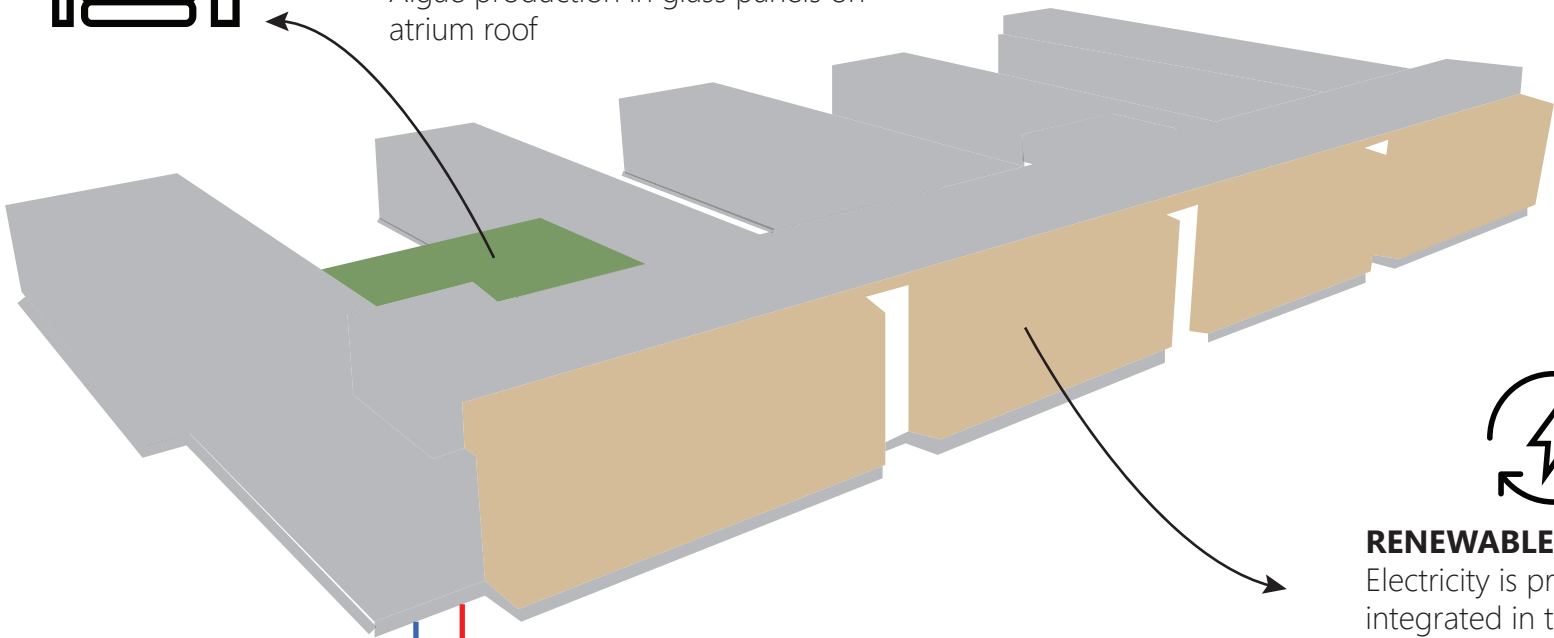
BIOGAS PLANT

Production of biogas from algae



ALGAE INTEGRATED ROOF

Algae production in glass panels on atrium roof



BIOGAS

As renewable fuel source for CHP

HEAT & COLD

Connected to campus heatgrid geothermal energy powers the CHP

SEASONAL HEAT & COLD STORAGE

COMBINED HEAT & POWER PLANT

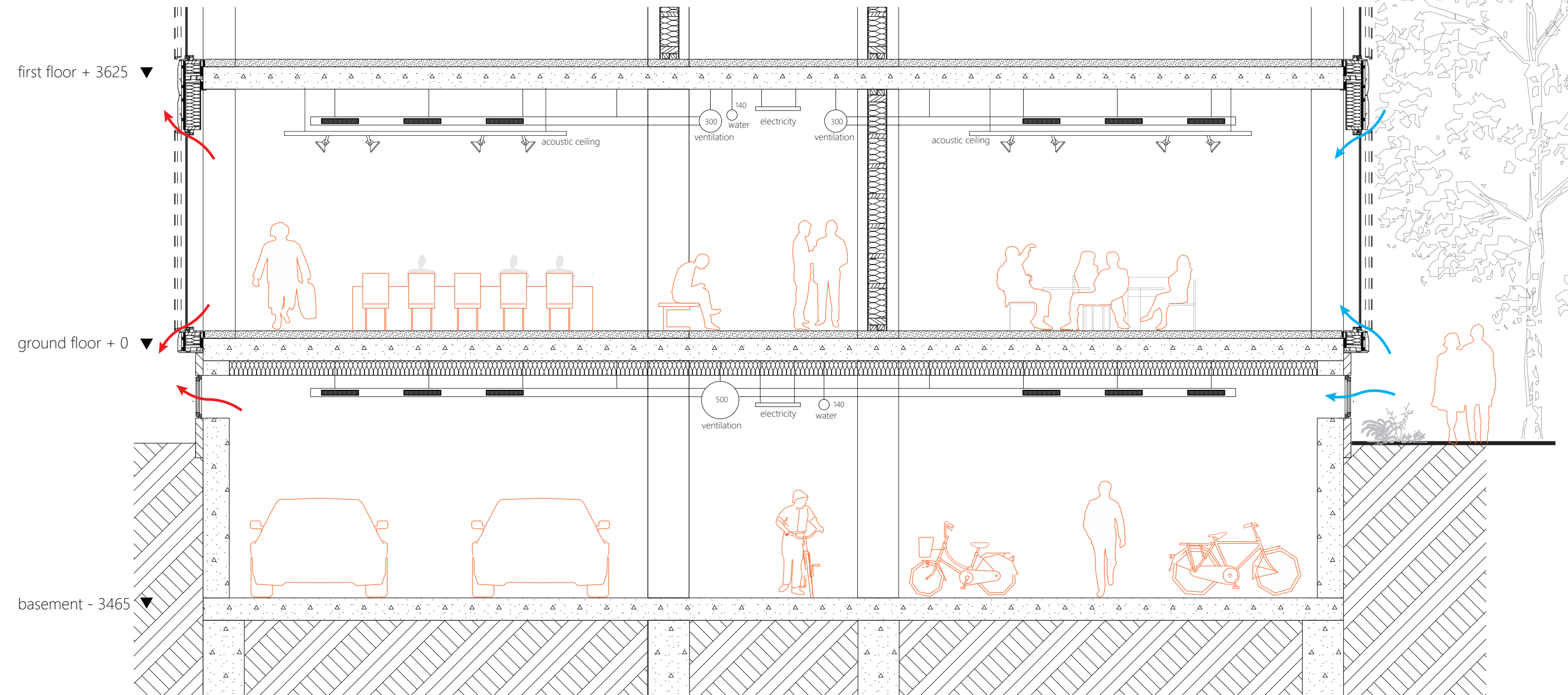
GEOHERMAL SOURCE

GEOHERMAL

Large source to supply the whole campus with heat

CLIMATE CONCEPT SUMMER

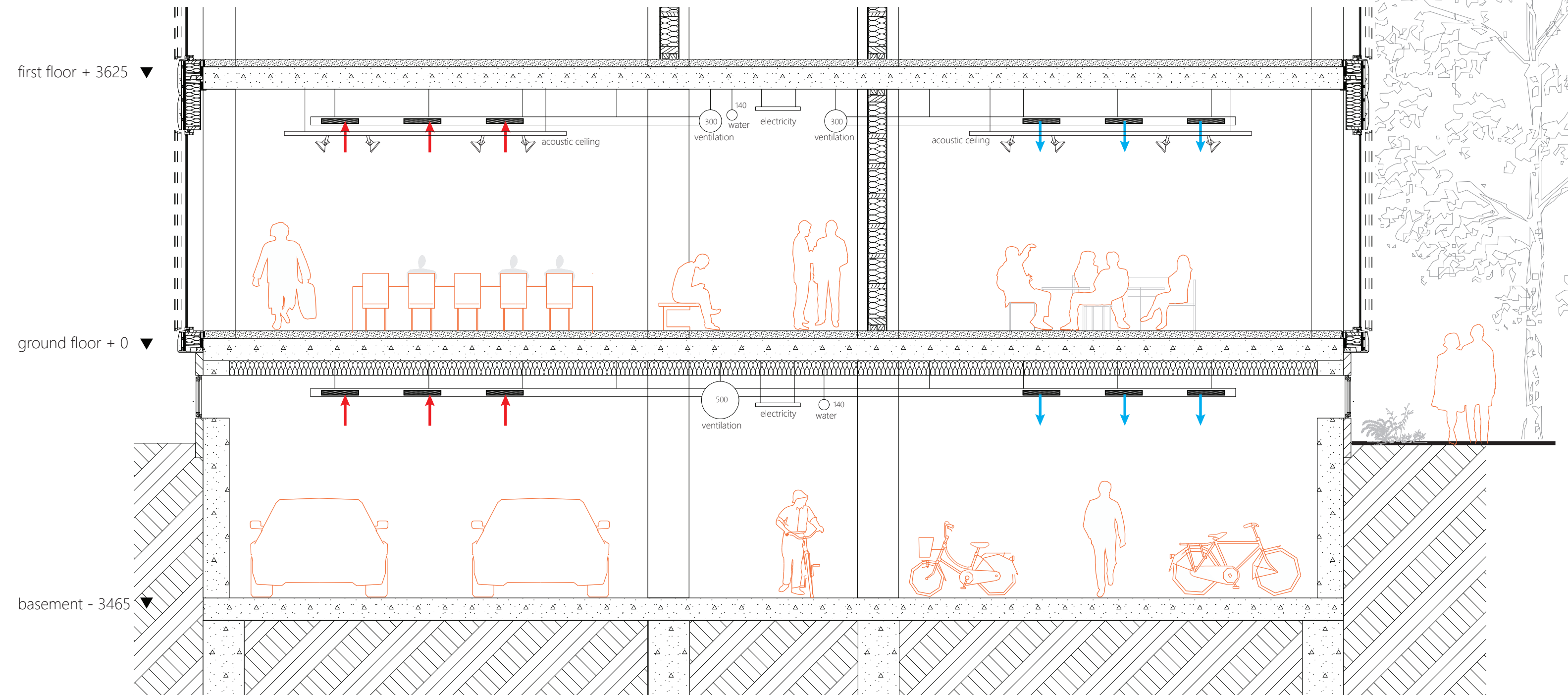
NATURAL VENTILATION & NIGHT FLUSHING



1:50

CLIMATE CONCEPT WINTER

MECHANICAL VENTILATION



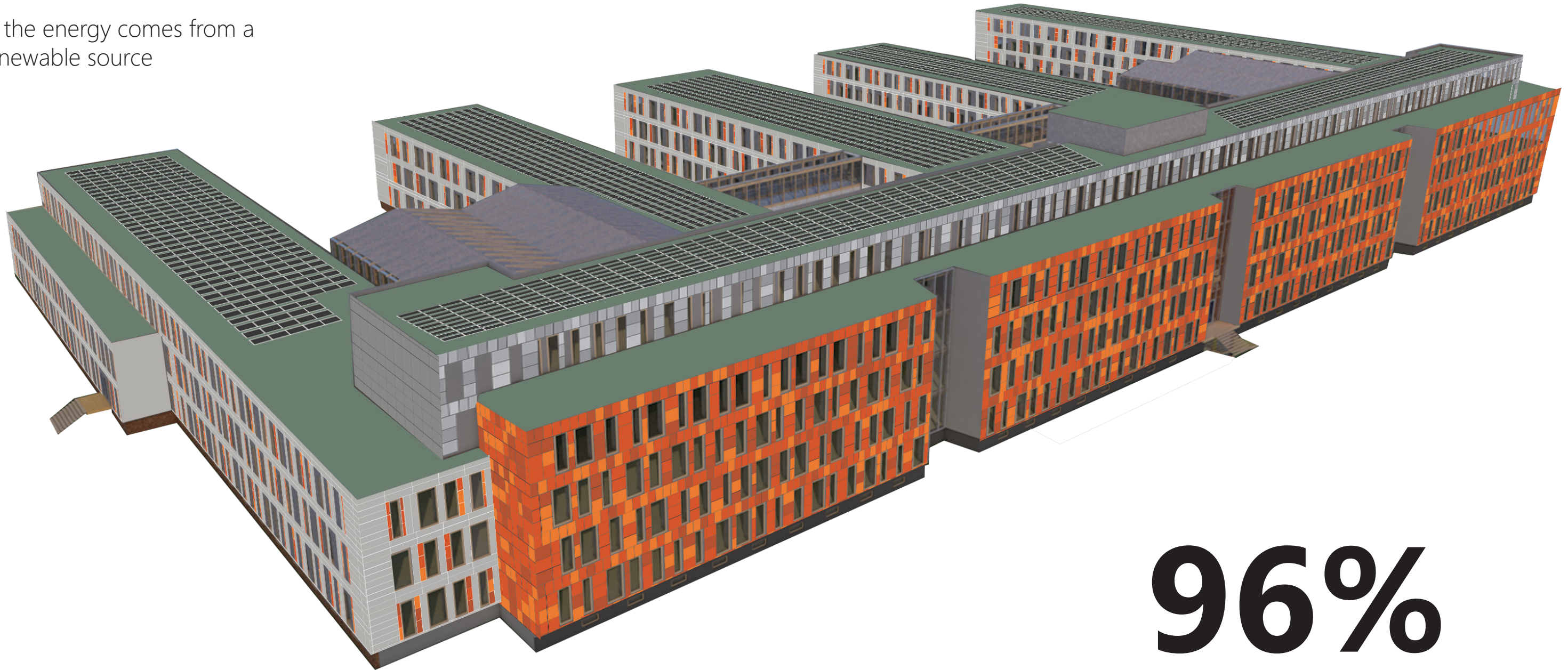
1:50

THE SCIENCE COLLECTIVE

A CIRCULAR RE-DESIGN OF THE APPLIED PHYSICS BUILDING

100%

of the energy comes from a
renewable source



96%

of the existing materials are reused

