

# Mycomorphosis

Access to Tools for Urban Waste Flows



***introduction***

*research*

*design brief*

*concept*

*implementation*

*development*

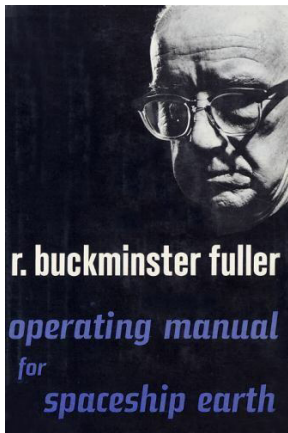
*visualisations*

*conclusion*

**“We have not been seeing our  
Spaceship Earth as an integrally-  
designed machine which to be  
persistently successful must be  
comprehended and serviced in total.”**

Buckminster Fuller

Operating Manual for Spaceship Earth

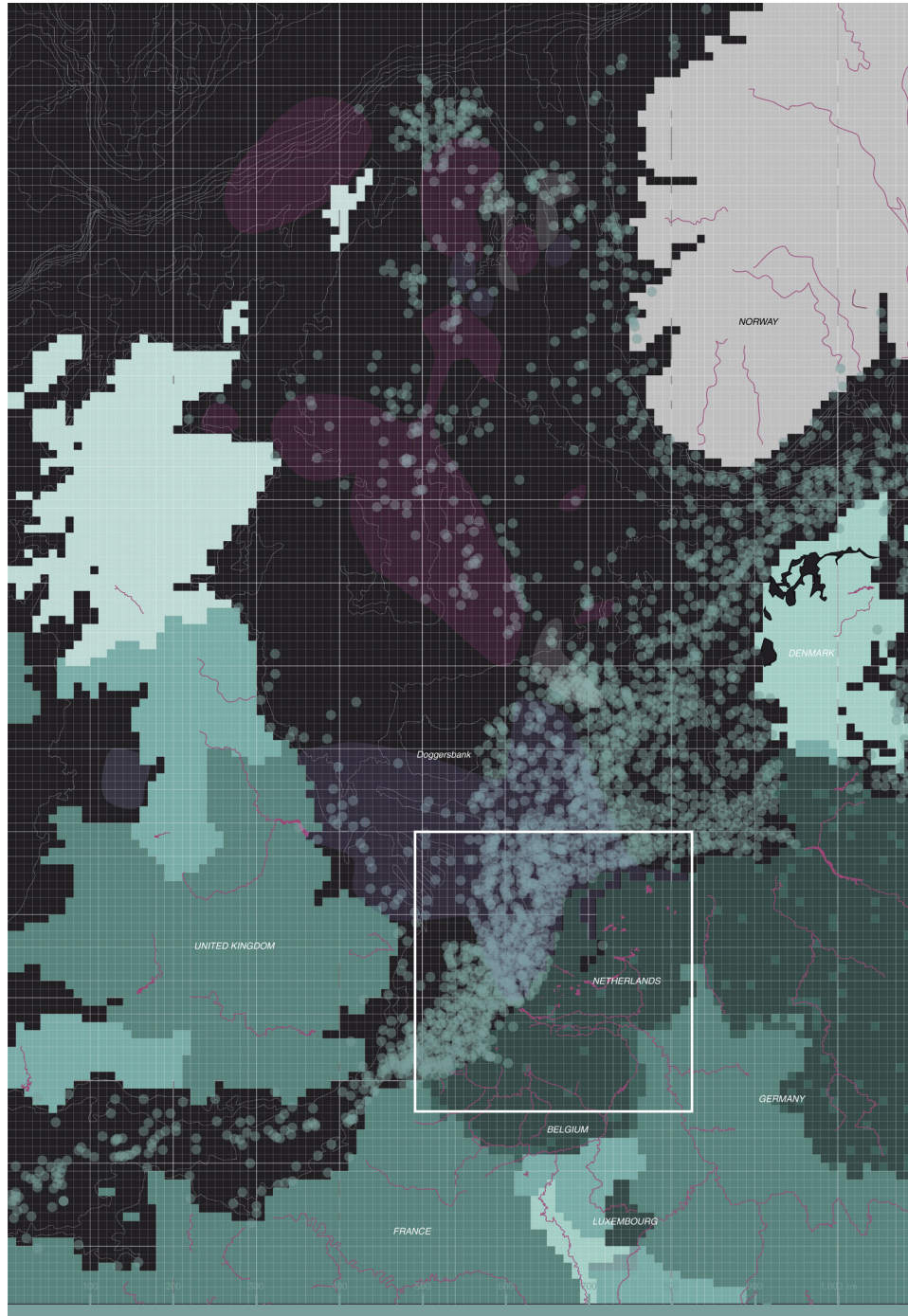


**“Ten years later, BP oil spill continues to harm wildlife.”**

National Geographic

2010 Deepwater Horizon Oil Spill

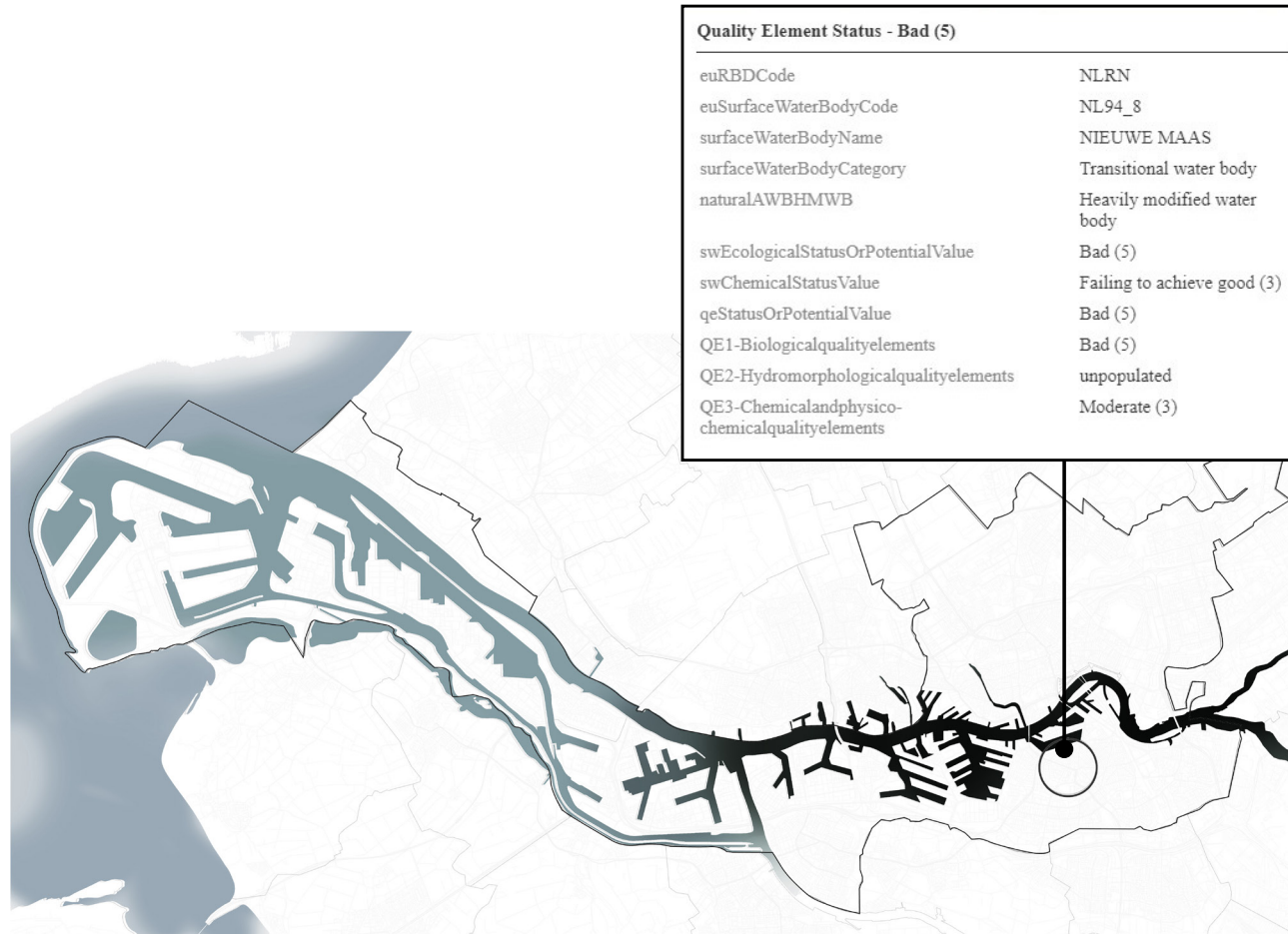
NASA



Percentage of classified water bodies holding less than good ecological status or potential

Data: European Environment Agency (modified by author)

- ≥90%
- 70-90%
- 50-70%
- 30-50%
- 10-30%
- No data
- Oil Fields
- Gas Fields
- Mixed Fields



Percentage of classified water bodies affected by pollution pressures (rivers /lakes)  
 source: European Environment Agency (modified by author)

*introduction*

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*visualisations*

*conclusion*

**How can urban agriculture act as a catalyst for confrontation against urban waste flows?**

- How does mycoremediation unveil toxic water and wastes through architecture?
- How can the fourth industrial revolution be manifested within mushroom cultivation and waste management?





## **AGRO-FOOD**

Horticulture  
(crop cultivations in controlled conditions)  
Food production



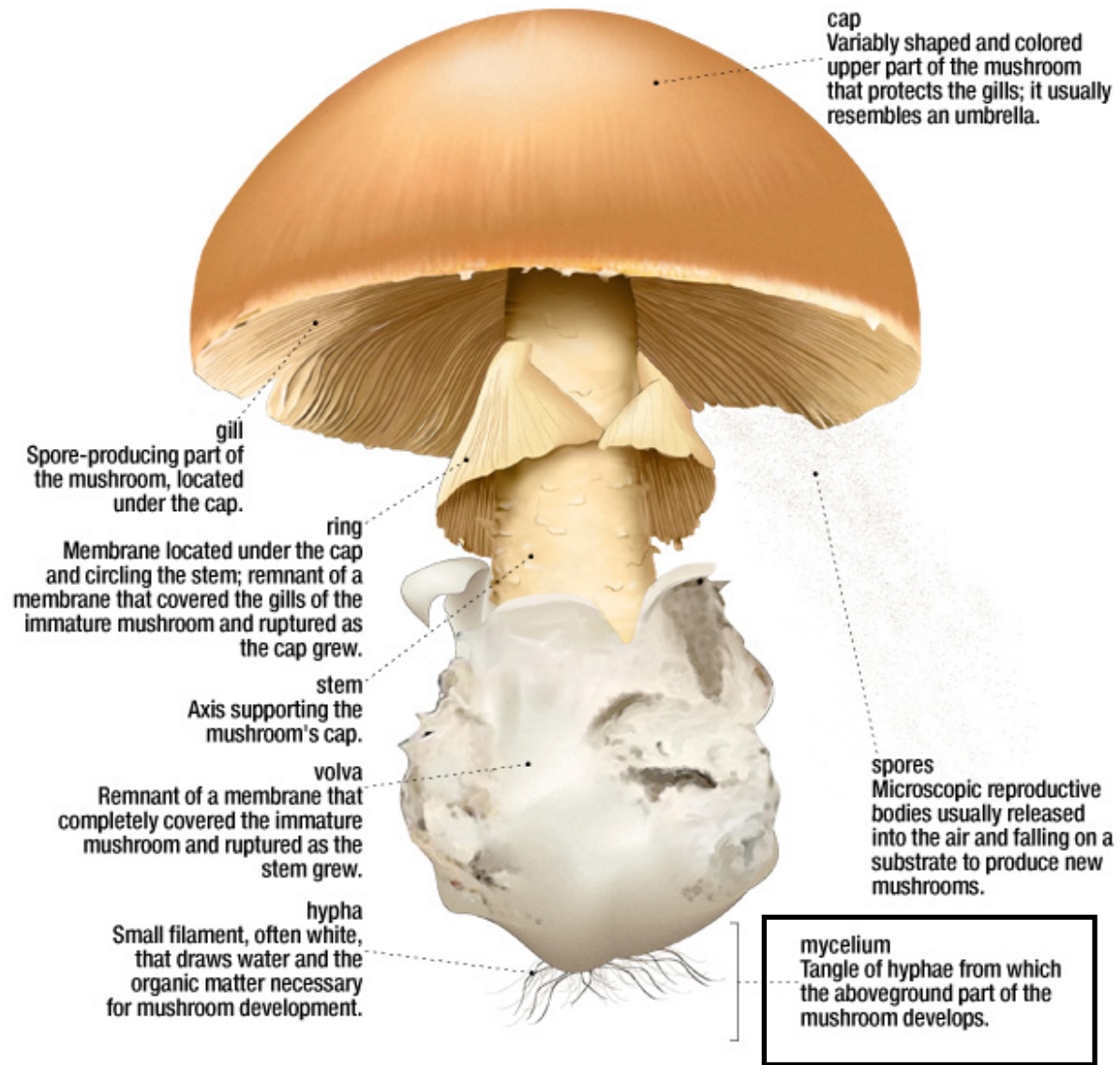
## **LIFE SCIENCE & HEALTH**

Health research & development  
Medical innovations  
Robotics  
Pharmaceutical industry



## **CLEANTECH**

Sustainability  
Renewable Energy  
Waste Management  
Recycling



AGRO-FOOD



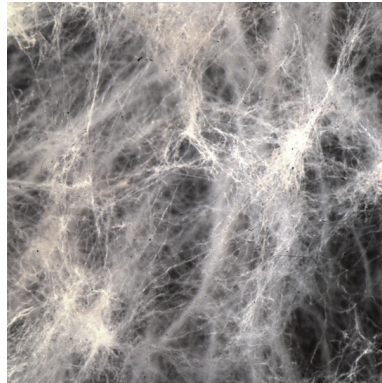
**FUNGI-BASED  
PRODUCTION**

Mycelium-based material production  
alternatives for plastic, leather, etc.

Mycelium as construction material

Mushroom plantation  
plant-based meat

LIFE SCIENCE & HEALTH



**MYCOLOGICAL  
RESEARCH**

Mycelium health research

Fungi-based medication

eg. Penicillin

CLEANTECH



**MYCOREMEDIATION**

Decontamination of toxic soil/wastewater  
through fungi-based technology

Mycofiltration

**2ND**

**largest exporters of mushrooms  
in the world (after Poland)**

**80%**

**of the total production of  
mushrooms in the Netherlands is  
exported.**

**5,250**

**species of mushroom in the  
Netherlands.**

**50,000,000**

**kilos of fresh mushrooms  
exported / year**

**220,000,000**

**kilos of processed  
mushrooms exported / year**



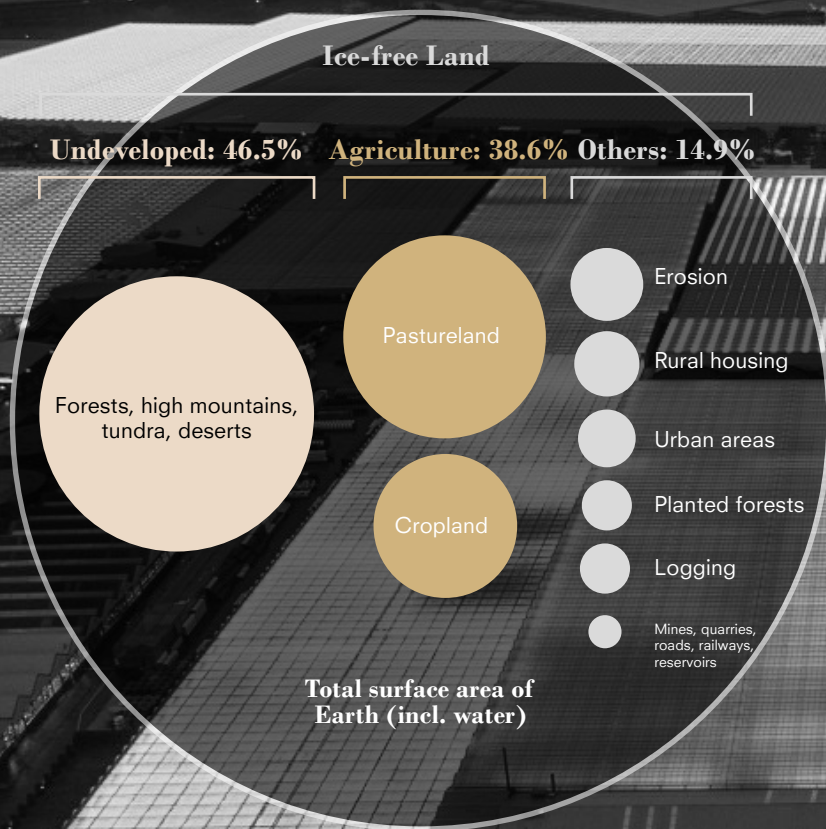
Agricultural waste 2018 tonnes

Data: eurostat  
(modified by author)

- >2,000,000
- 1,000,000-2,000,000
- 500,000-1,000,000
- 100,000-500,000
- <100,000

# “Agriculture’s footprint has caused the loss of whole ecosystems around the globe.”

Jonathan Foley  
National Geographic





“Vertical farming is an alternative to feeding a growing global population sustainably and efficiently.”

Atmospheric factors effecting cultivation



Temperature  
(optimum: 24-27C)



Humidity  
(optimum: 95-100%)



Brightness  
(depends on species)  
does not require sunlight

CO<sub>2</sub>

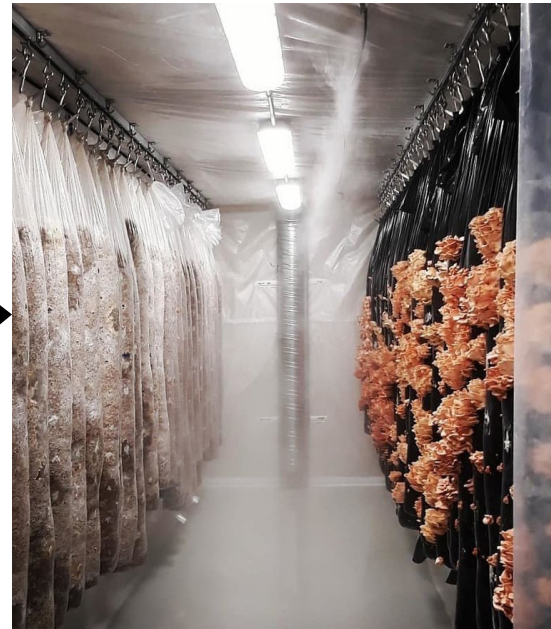
CO2 Level  
(high concentration)  
10,000 - 20,000 ppm  
during growth

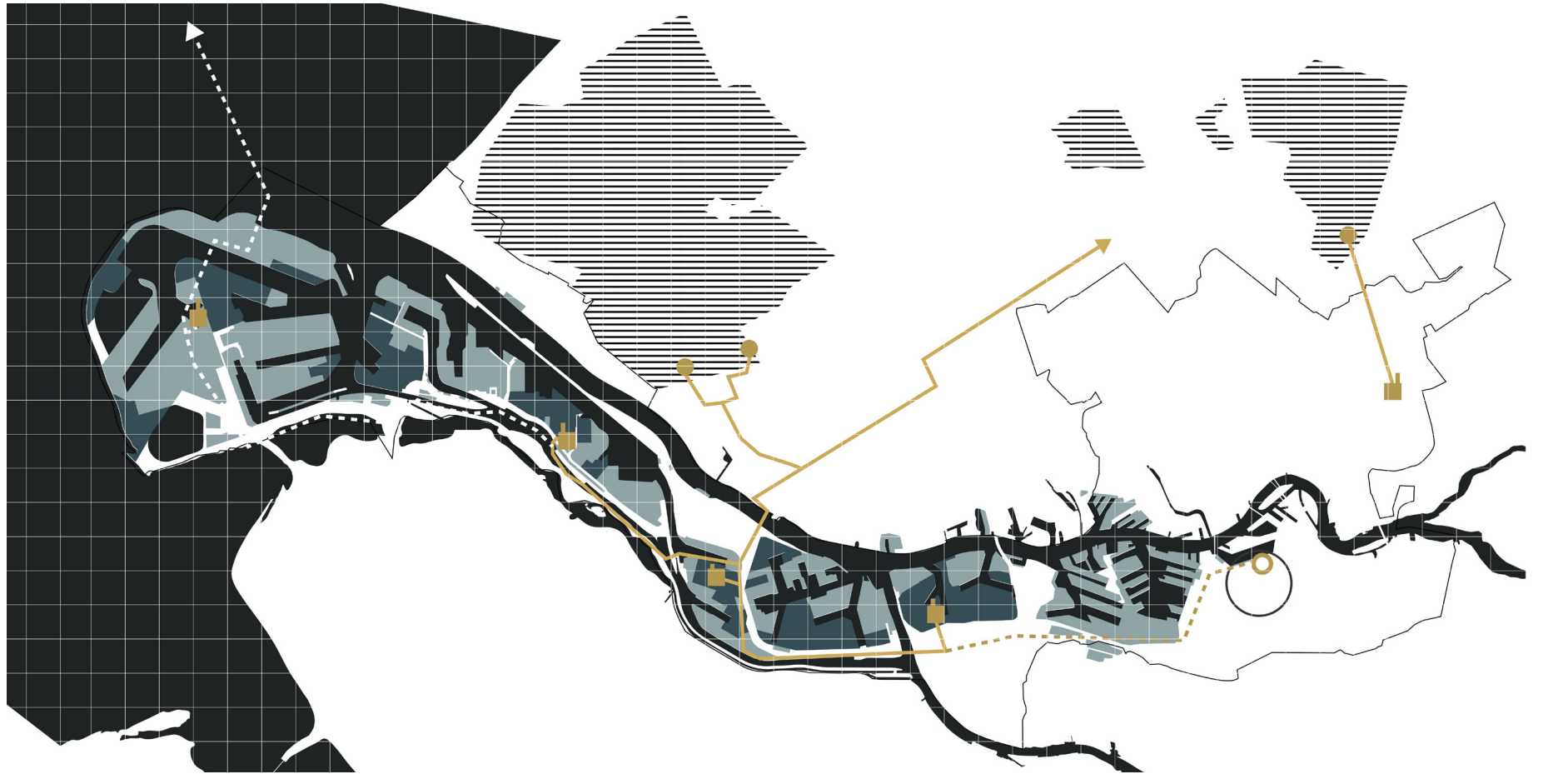


Sterilization



Tranferring port CO2





- CO2 capture
- CO2 release
- Site
- Greenhouse area
- Chemical refineries / energy
- Other port activities
- Existing CO2 pipeline
- Future pipeline
- Potential pipeline

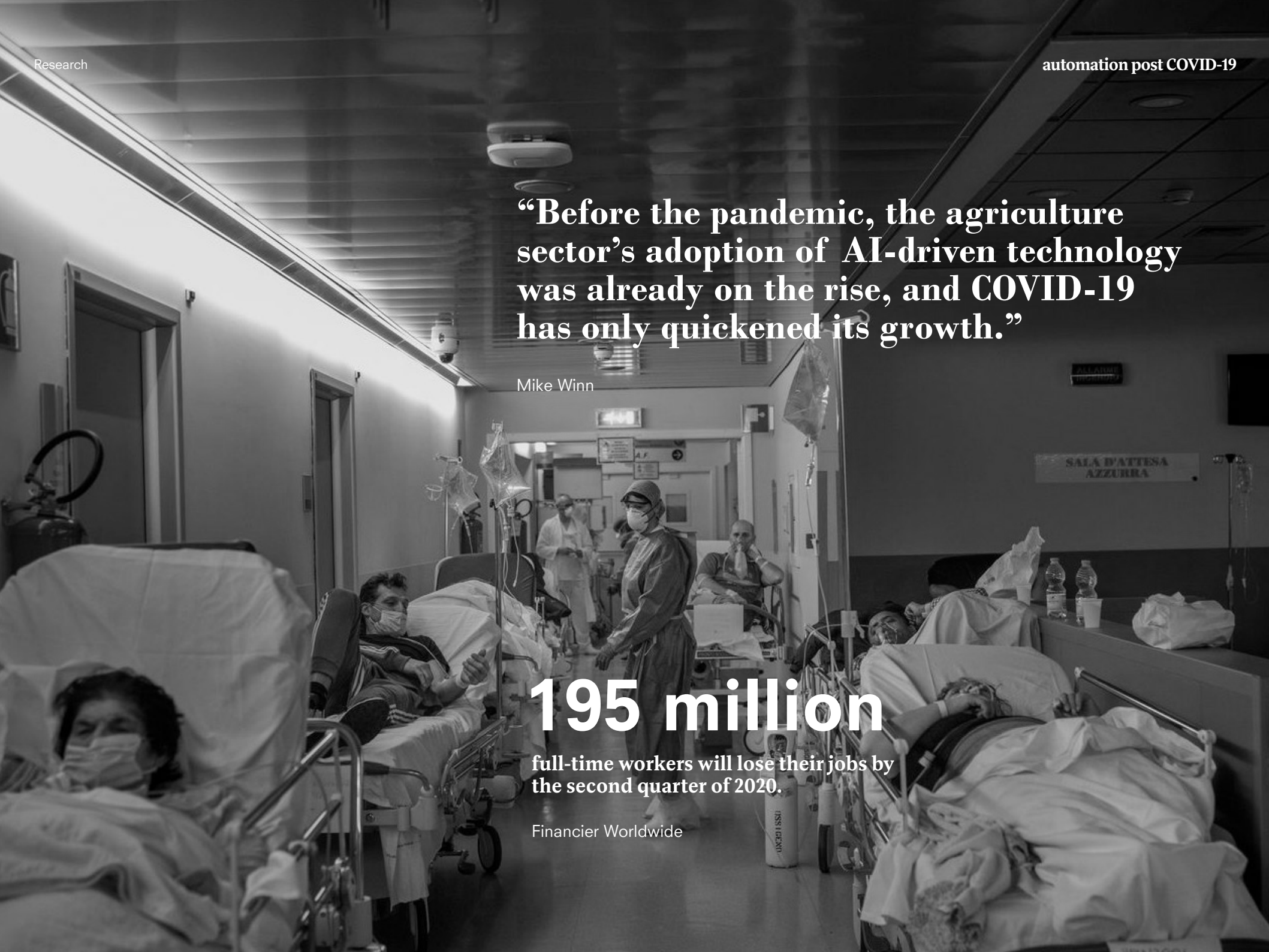
**“Before the pandemic, the agriculture sector’s adoption of AI-driven technology was already on the rise, and COVID-19 has only quickened its growth.”**

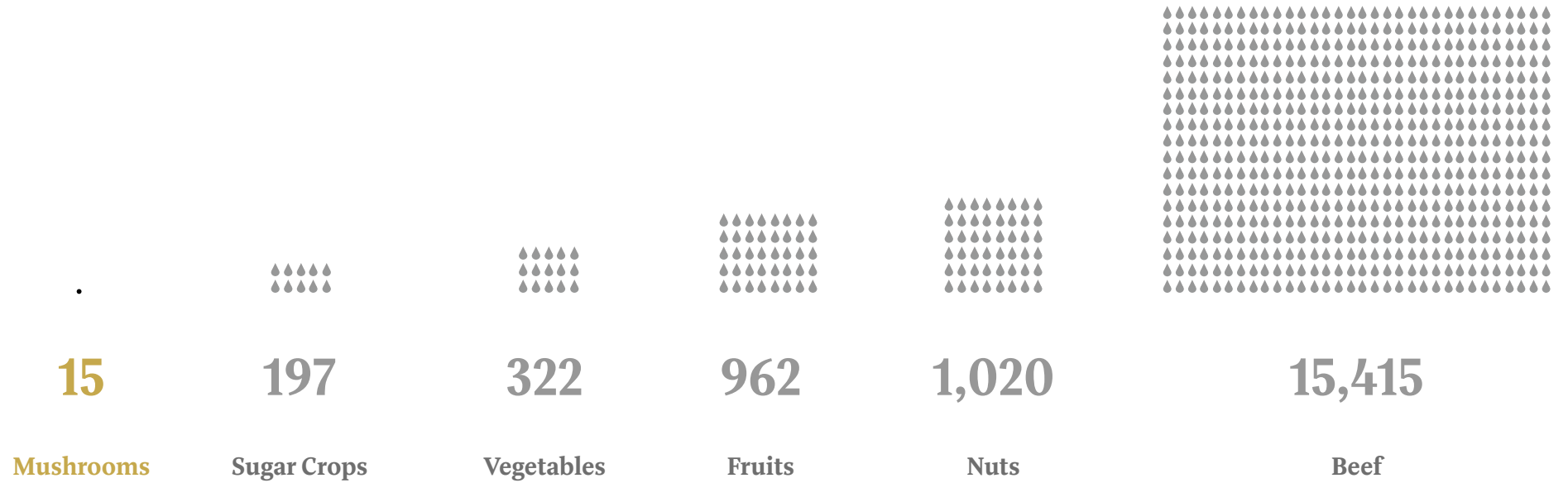
Mike Winn

**195 million**

full-time workers will lose their jobs by the second quarter of 2020.

Financier Worldwide





Water footprint (litre of water per 1 kg of product)

source: waterfootprint.org

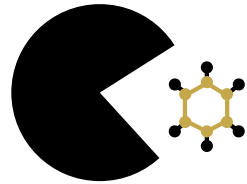
 **Coastguard Netherlands**  
@Coach\_Coach 

The # Coastguard plane took photos of the tanker that lost 200,000 liters of crude fuel oil in 3rd Petroleumhaven (Rotterdam) due to collision with a jetty. # Botlek area is not 'our' area. Follow @rijnmondveilig for all information & amp; updates



21:02 - 23 Jun. 2018

## Possible Applications



Enzymes produced by fungi break down hydrocarbon bonds in petroleum/pollutants in water and soil



Enzymes remanufacture hydrocarbons into carbohydrates to feed the mushrooms and turn some into CO<sub>2</sub> and water

### Metals (water/soil/land)

Lead  
Cadmium  
Nickel  
Copper  
Zinc

### Organic Pollutants

Petroleum  
Phenols  
polychlorinated biphenyl (PCB)

### Pesticides

### Dyes

source: Mycelium Running, Paul Stamets

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# Research Centre for Mycoremediation

Rituals through time and stages of mushroom cultivation



**agriculture**



**water**



**waste**





## agriculture

Engage users to participate in mushroom cultivation from first to last stage

Explore mycoremediation as a tool for urban wastes and wastewater

Experiment with products of mushroom cultivation through new fabrication methods





**water**

Speculate symbiosis between  
human and water

Investigate water as  
architectural guidance and  
wayfinding tool

Employ water as heating /  
cooling and energy harvesting  
(through vapour collection)



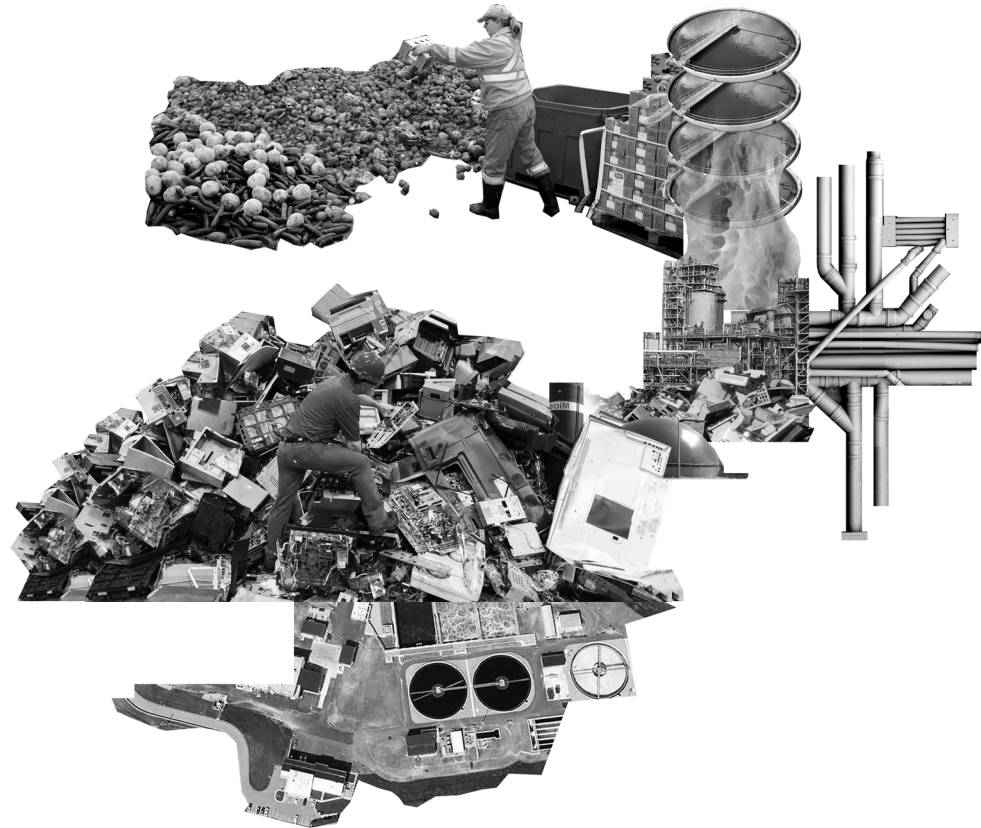


waste

Expose urban waste flows  
through architecture

Set energy standards  
through waste to clean  
energy

Engage users to participate  
in sequential stages of  
wastewater treatment





Visiting Purpose

**culture**

**education**

**employment**

Programme

Vertical Farm  
Myco Market  
Waterfront  
Restaurant / Cafe  
Exhibition  
Auditorium  
Myco Park

Classroom / Workshops  
Waste Processing  
Wastewater Treatment  
Energy Plant  
Manufacturing / Fabrication

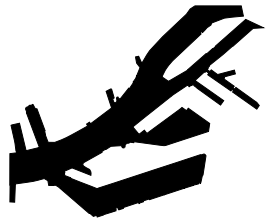
Myco Market  
Wastewater Treatment  
Energy Plant  
Mycology Research Lab  
Manufacturing / Fabrication  
Loading Bay  
Offices

User

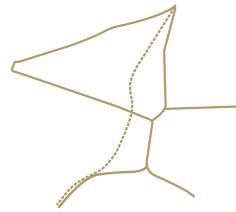
**Regional and international visitors**

**Local communities**  
**Exposing traditionally private programmes**

**Current low-income migrant workers in Collage City**



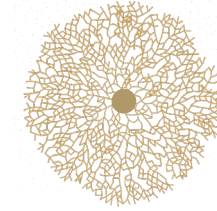
Access to urban water bodies  
(water treatment)



Water logistics (transport  
of mushroom products  
/ wastes) + public  
transportation



Centre for cleantech &  
agro-food, located between  
North & South centres

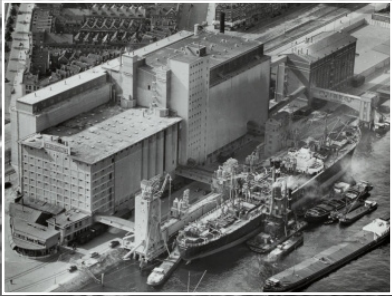


Close to source of mycelium  
spawn and substrate



Low sunlight  
(mushroom cultivation)





Maassilo (1910)



Quaker Oats



The De Maas flour factory (1913)

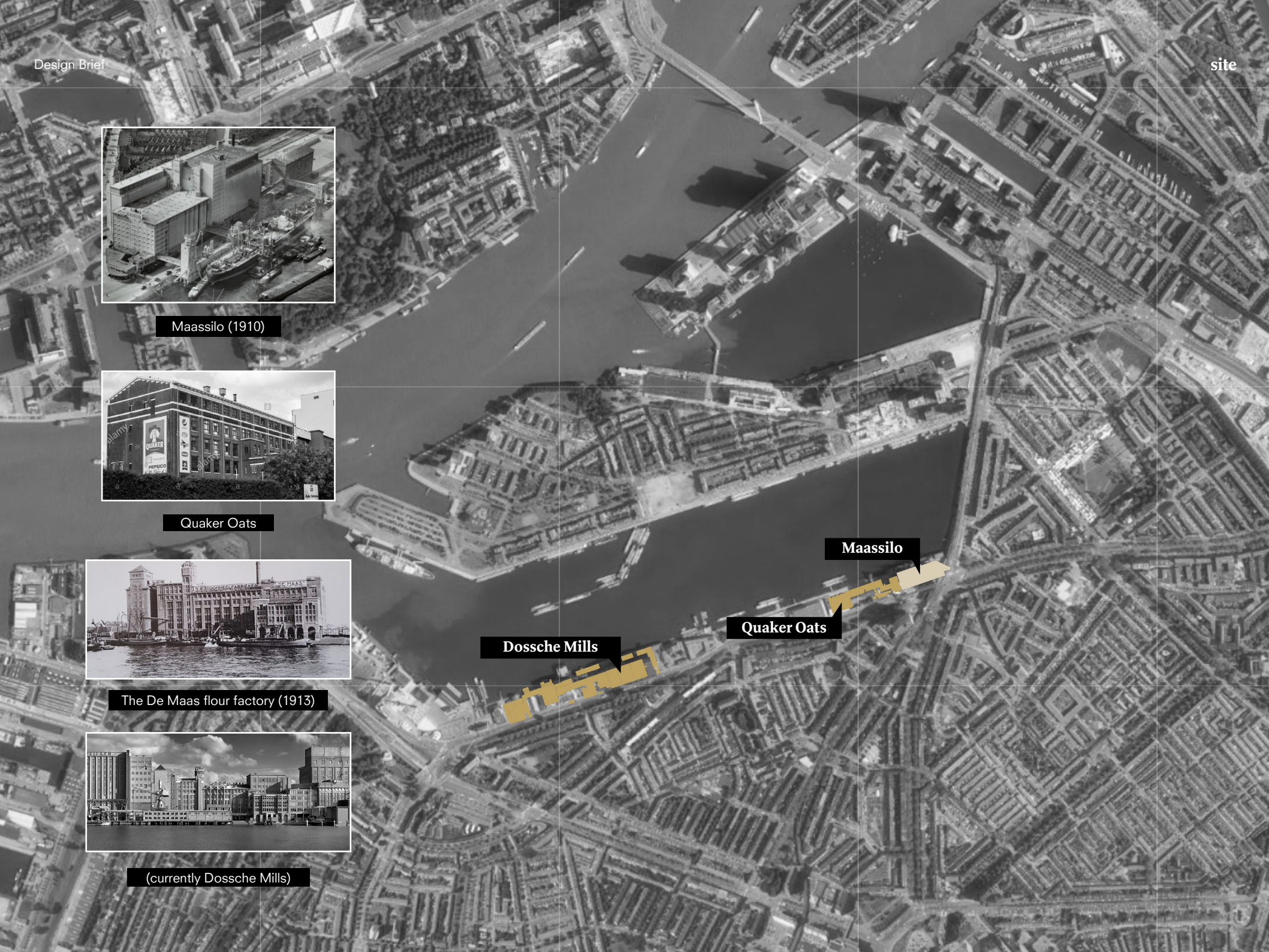


(currently Dossche Mills)

Dossche Mills

Quaker Oats

Maassilo









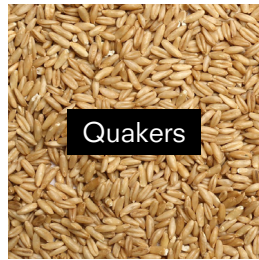
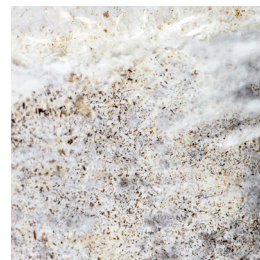
Rye



Spelt



Wheat



Oat



Barley

Mycelium is placed onto steam-sterilized grain, and in time the mycelium completely grows through the grain. This grain/mycelium mixture is called **spawn**, and is used to "seed" mushroom compost.



Sawdust



Straw



Compost



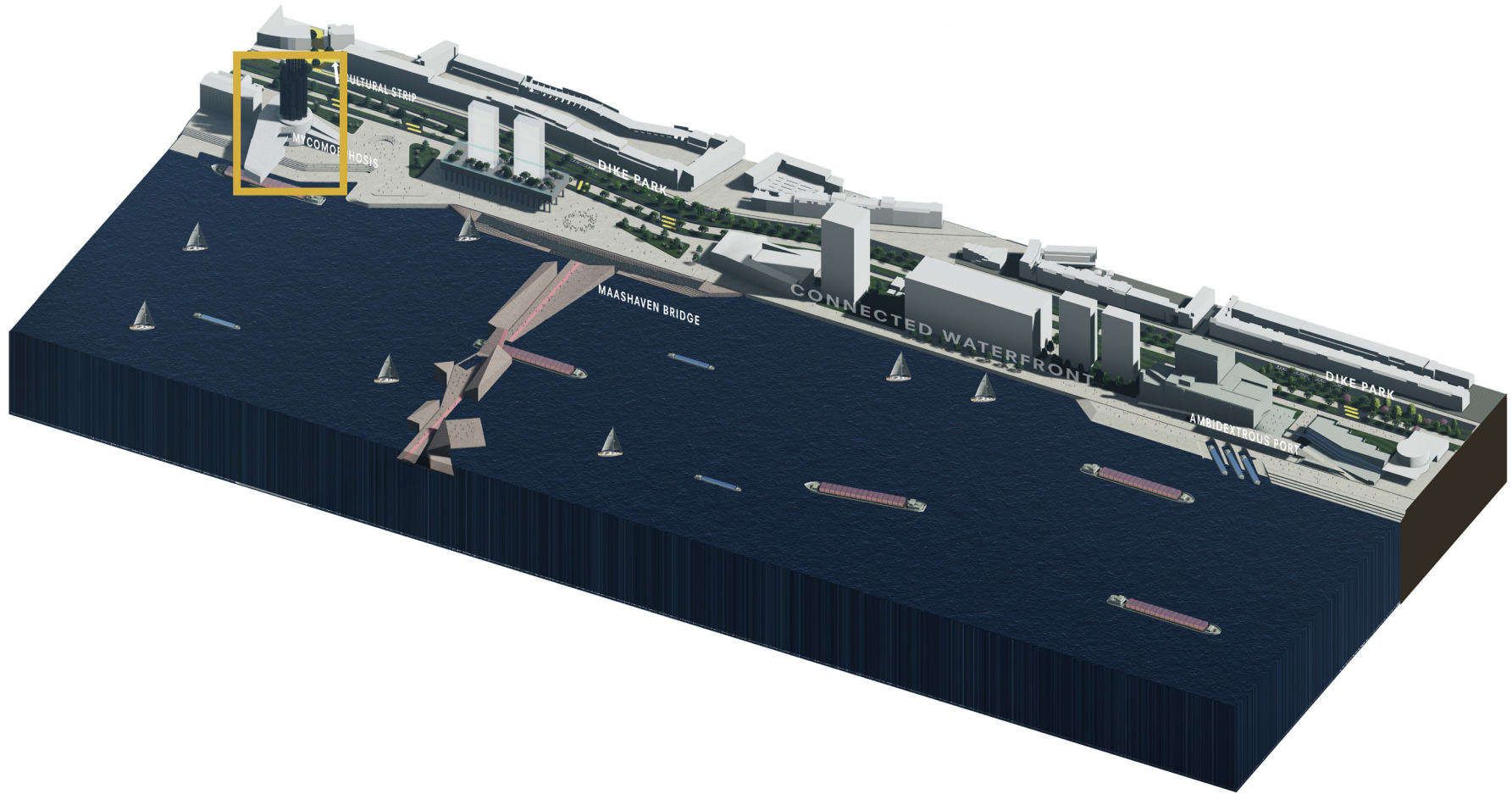
Coffee Grounds

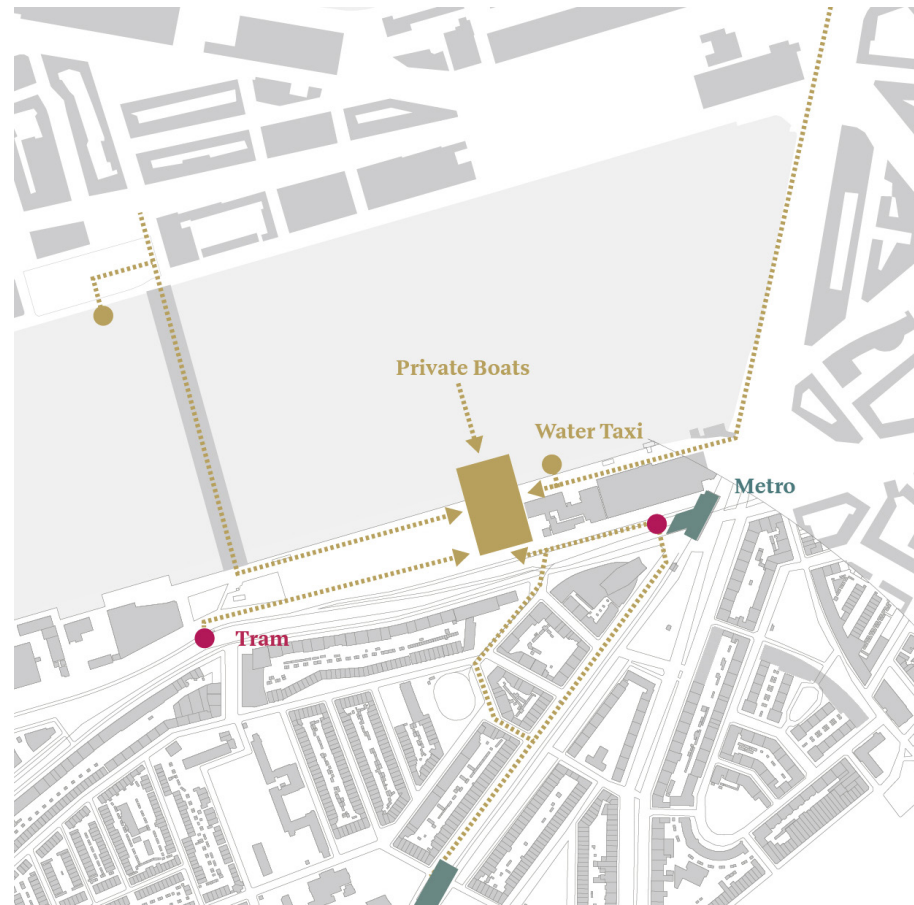


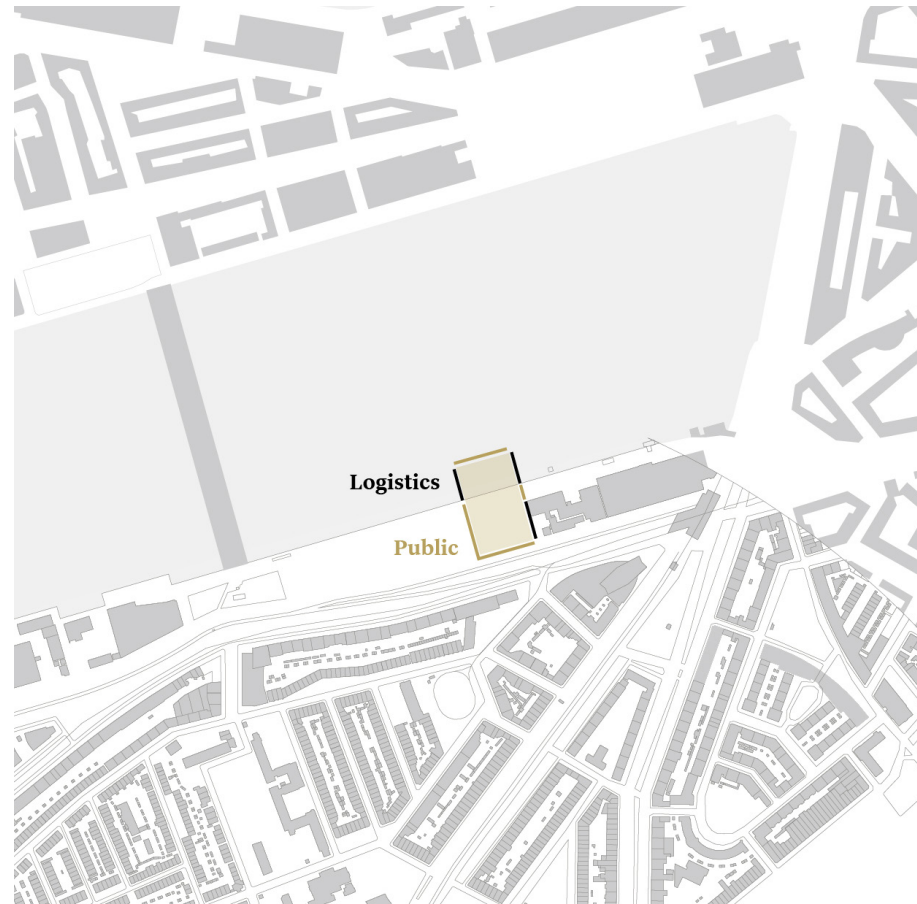
Cardboard

a **substrate** is the primary source of food for fungi to grow on.

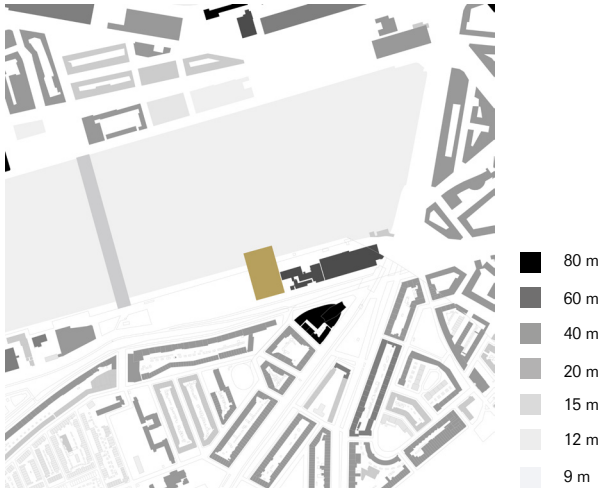






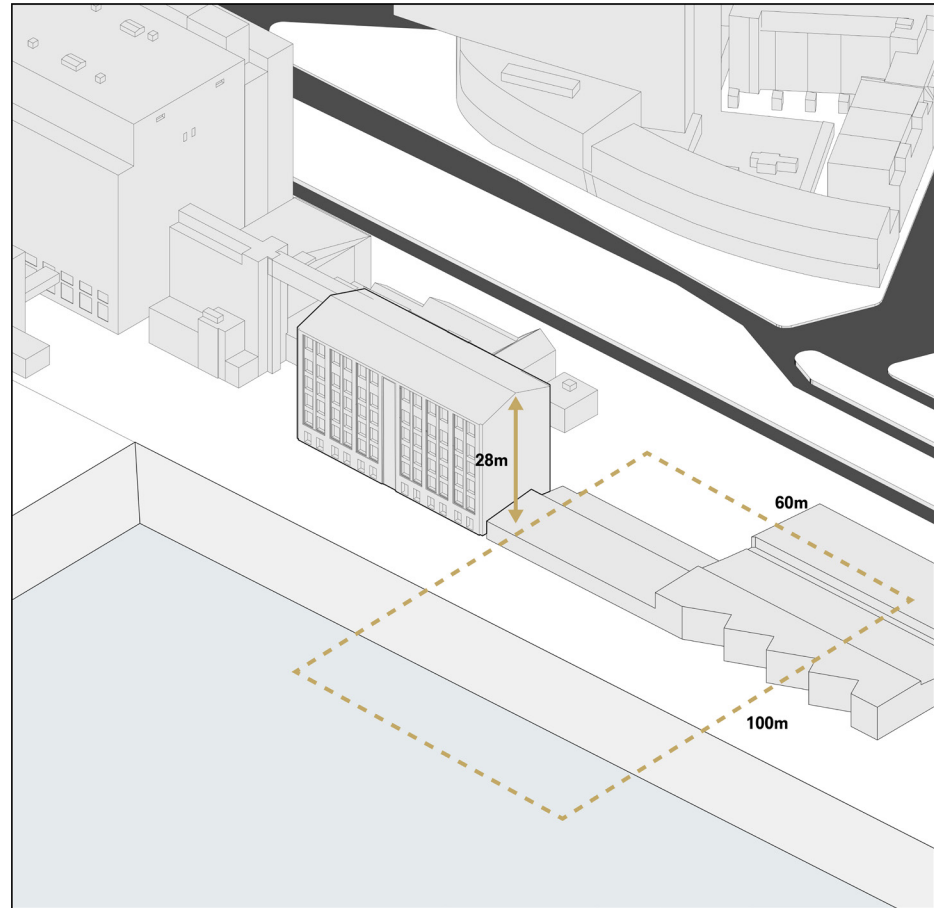






average height at waterfront = 60 m

maximum building height (regulation) = 28 m







average height at waterfront = 60 m

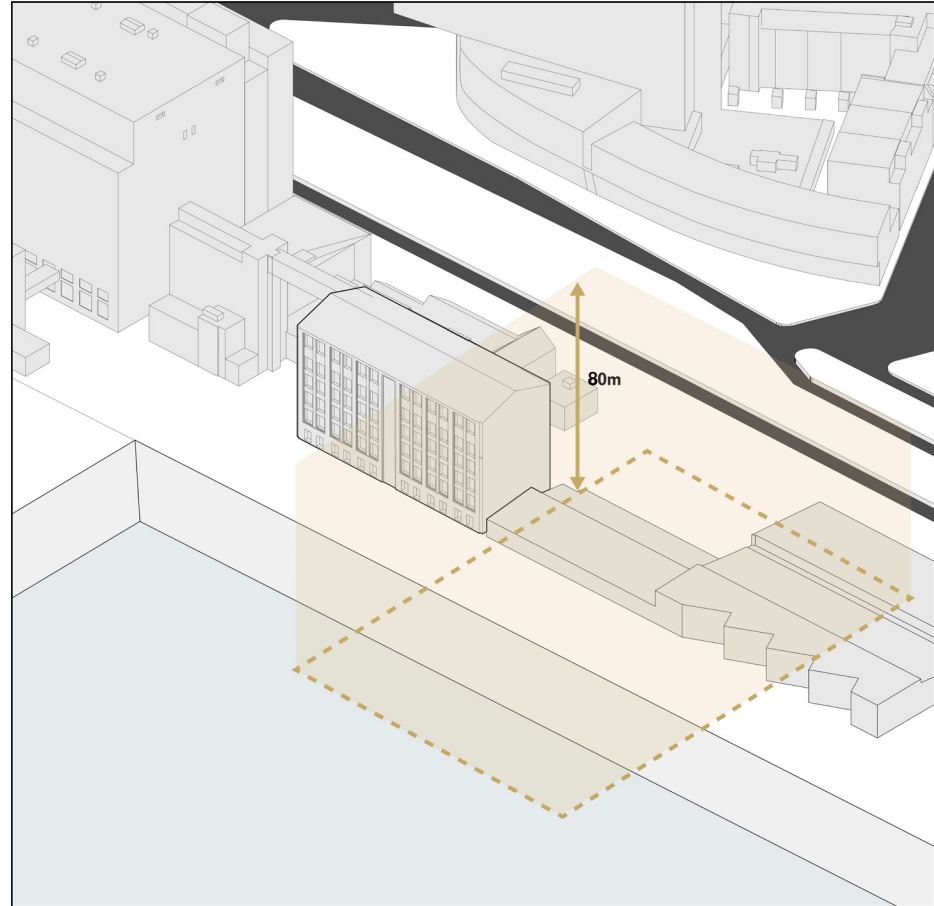
maximum building height (regulation) = 28 m

+ new development of rijnhaven = 100-200 m

proposed maximum height for intervention = 80 m

maximum building volume = 80x 6,000

= 480,000 m<sup>3</sup>



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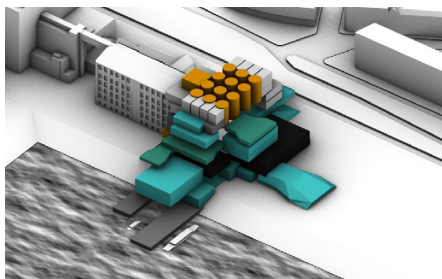
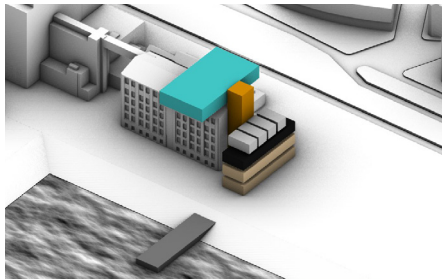
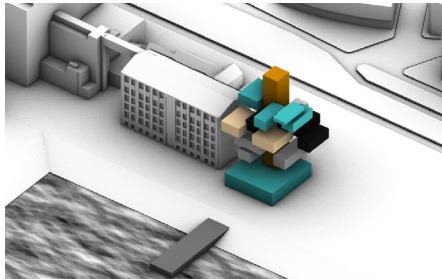
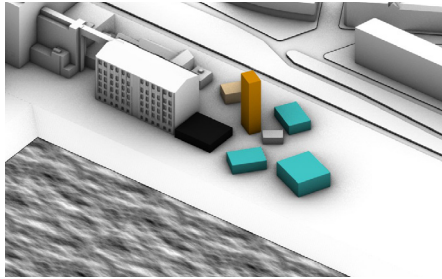
*development*

*visualisations*

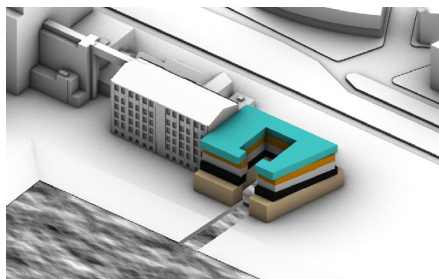
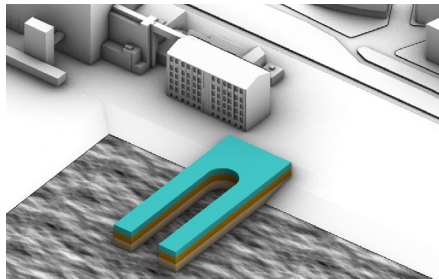
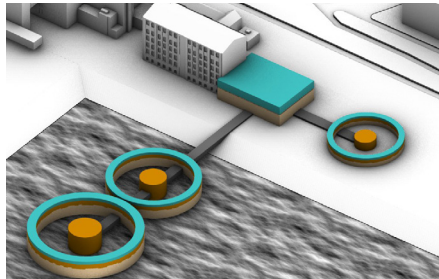
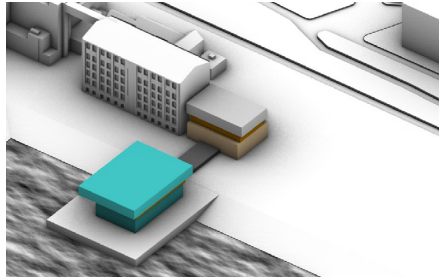
*conclusion*



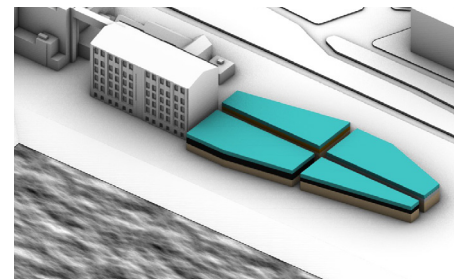
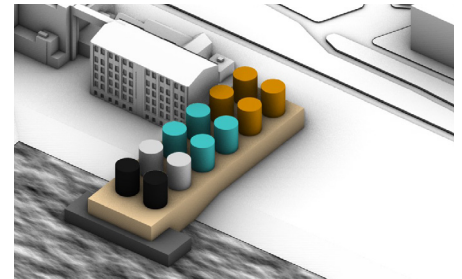
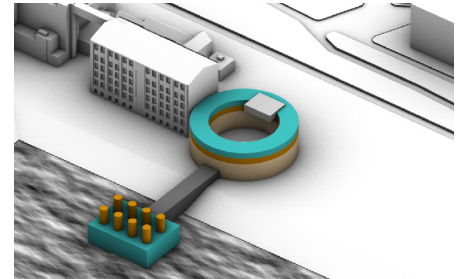
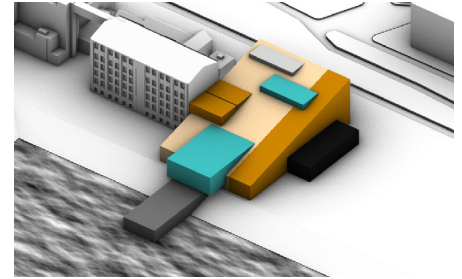
agriculture



water

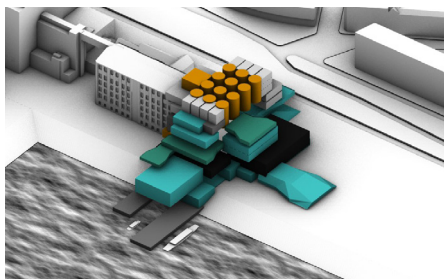
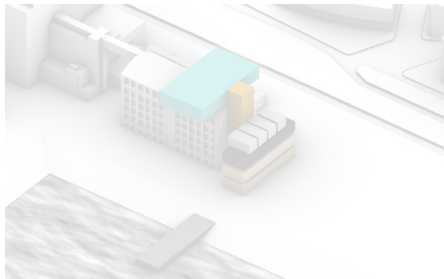
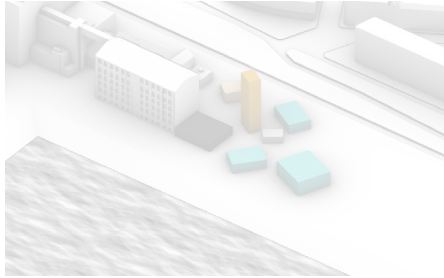


waste

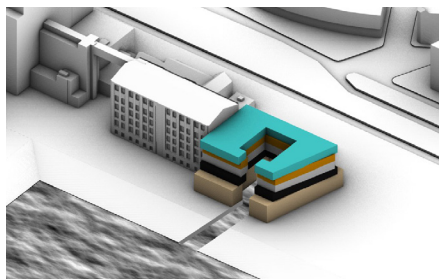
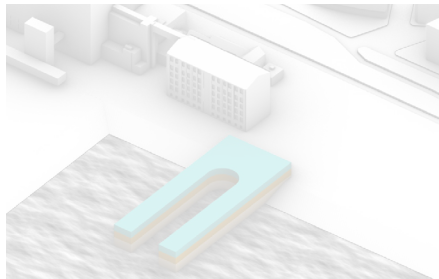
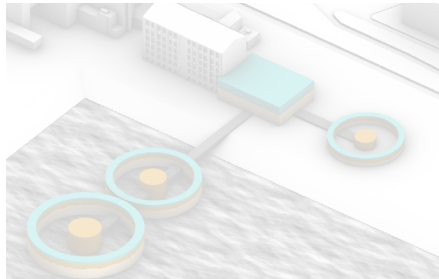
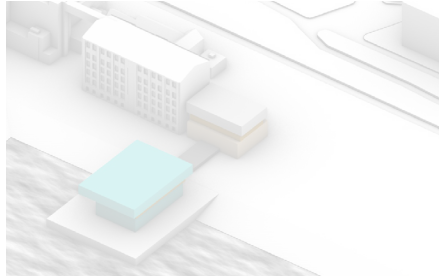




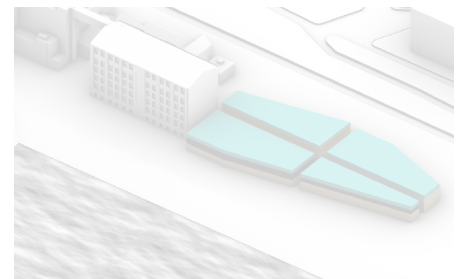
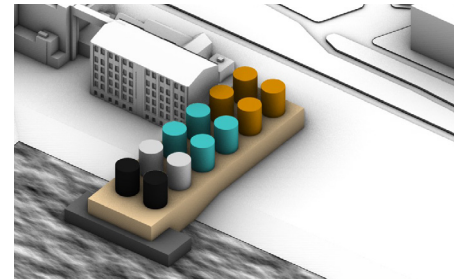
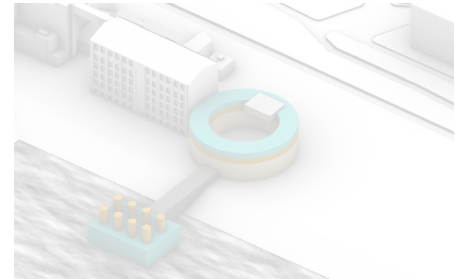
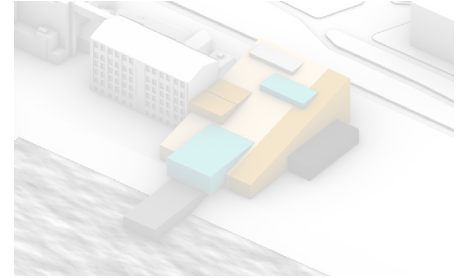
agriculture



water



waste



**How to expose three opposing flows  
(mushroom / waste / water) in one building?**

**Public**

**Private**

**Public**

**Private**

**Free Access**

**Tickets  
Required**

**Visible but  
no entry**

**Public**

**Private**

**Free Access**

**Tickets  
Required**

**Visible but  
no entry**

**mushroom  
route**

**waste  
route**



**Public**

**Private**

**Free Access**

**Tickets  
Required**

**Visible but  
no entry**

Atrium  
Myco Market  
Waterfront  
Restaurant / Cafe  
Exhibition  
Auditorium  
Myco Park  
Classroom / Workshops

mushroom  
route

waste  
route

Mycology Research Lab  
Manufacturing / Fabrication  
Mycoremediation Research Lab

organic waste  
to energy

wastewater  
treatment

mycoremediation



**Agriculture**

Vertical Farm  
Water Tanks  
Cultivation Lab  
Oxygen Storage  
CO2 Storage



**Waste & Energy**

Organic waste Processing  
Wastewater Treatment  
Sludge Treatment  
Biofuel Processing / Storage  
Generator Room



**Public**

Atrium  
Myco Market  
Waterfront  
Restaurant / Cafe  
Exhibition  
Auditorium  
Myco Park  
Classroom / Workshops



**Laboratories**

Mycology Research Lab  
Manufacturing / Fabrication  
Mycofiltration Lab  
Mycoremediation Lab



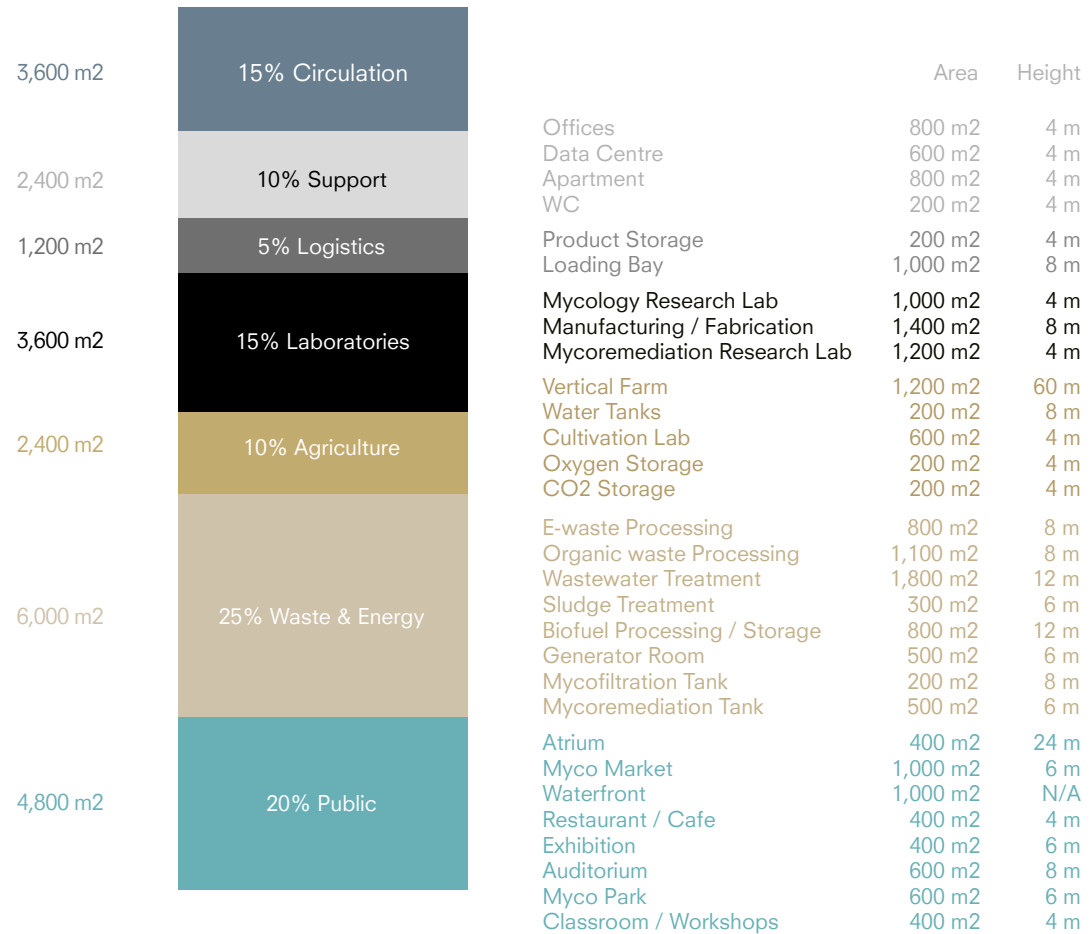
**Logistics**

Product Storage  
Loading Bay



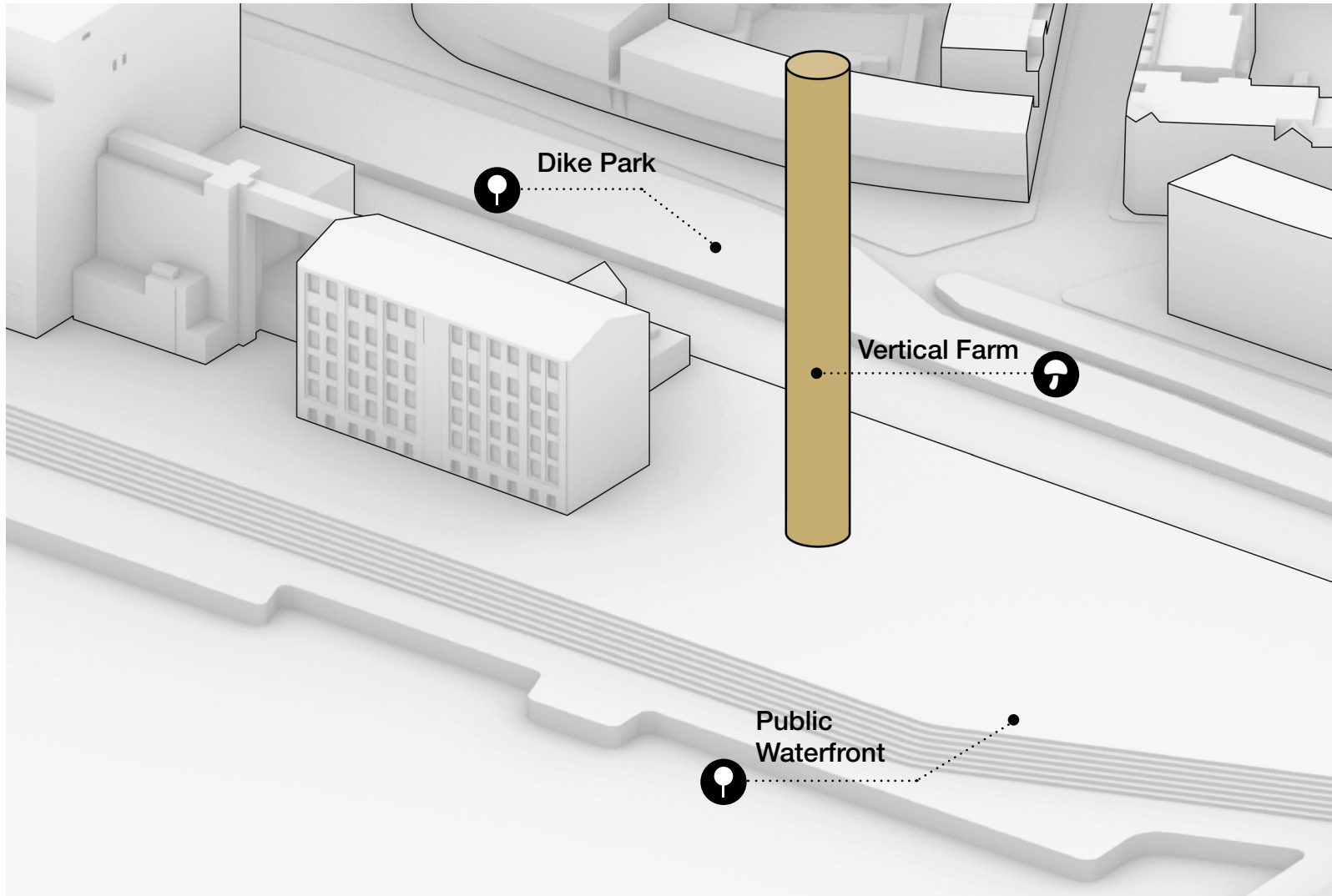
**Support**

Offices  
WC

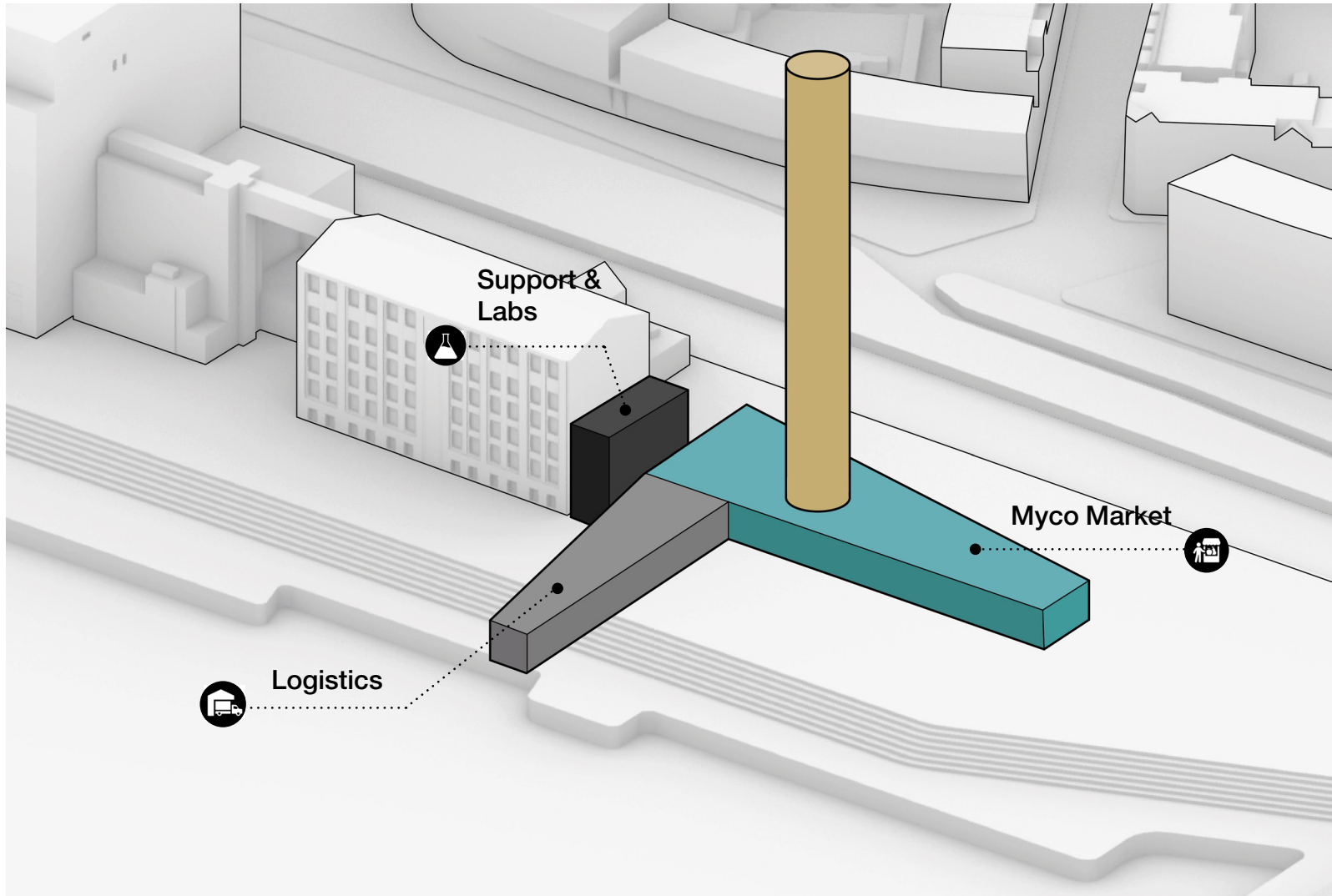


**GFA = 24,000 m<sup>2</sup>**

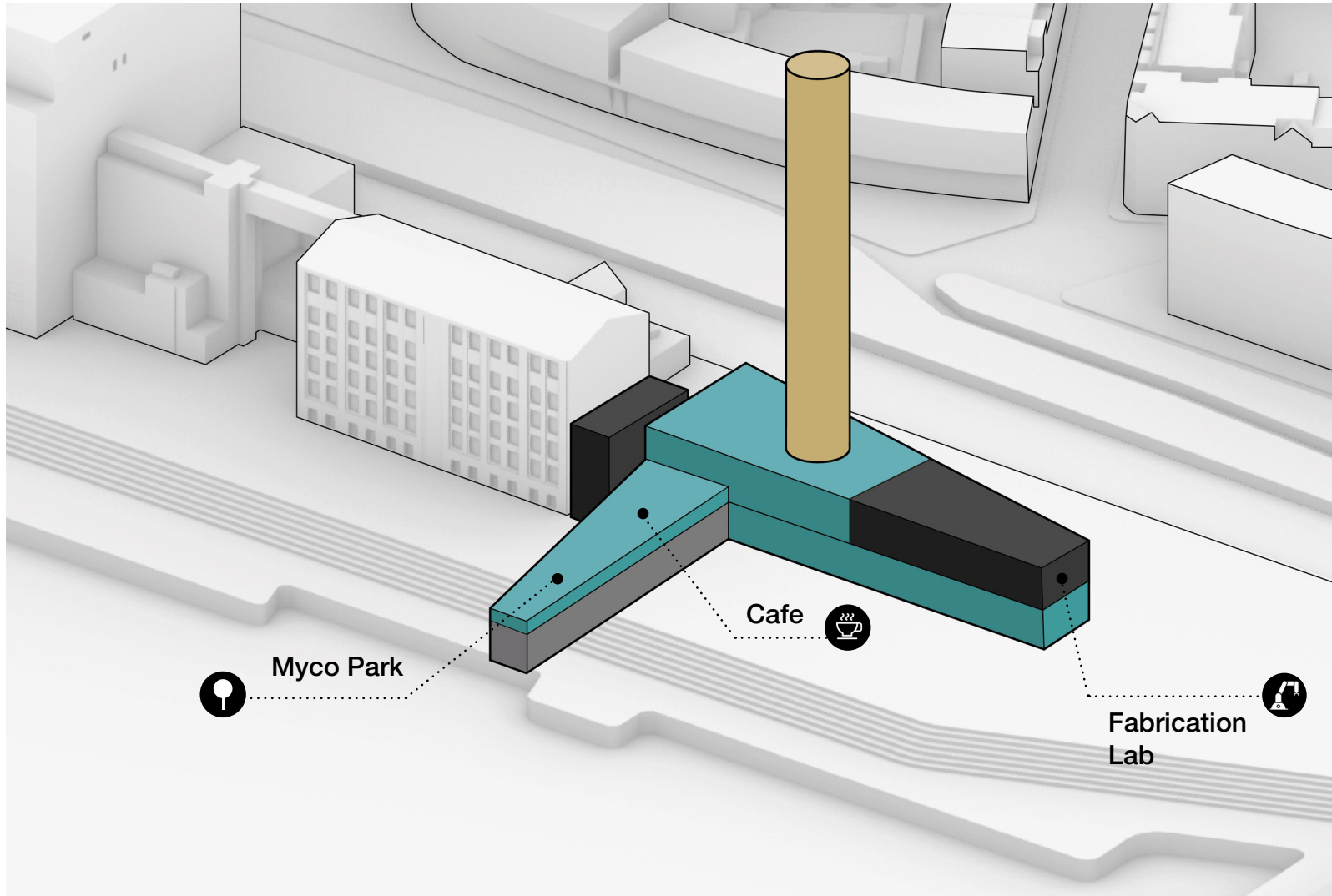
**footprint = 6,000 m<sup>2</sup>**



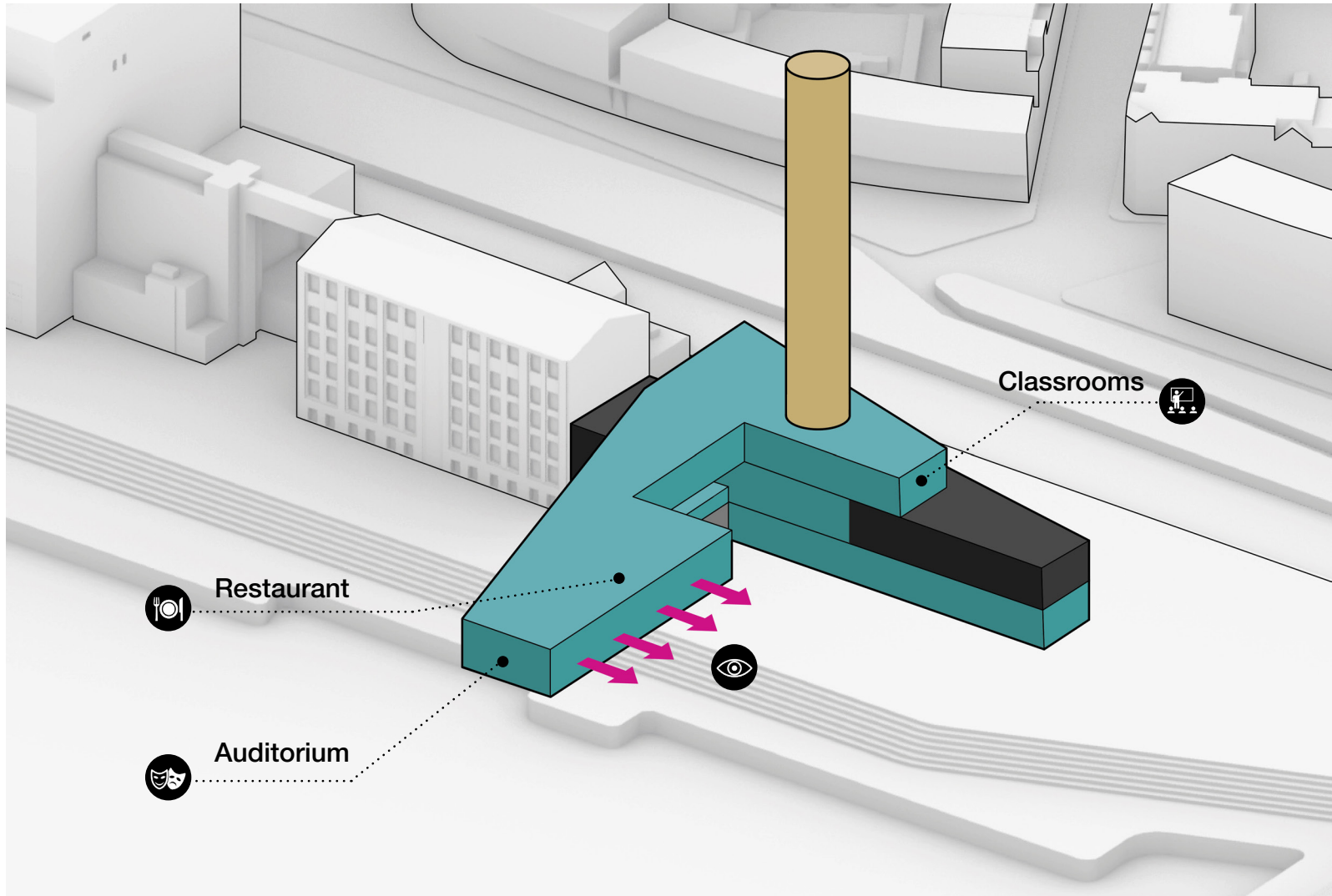
**Vertical Mushroom Farm**



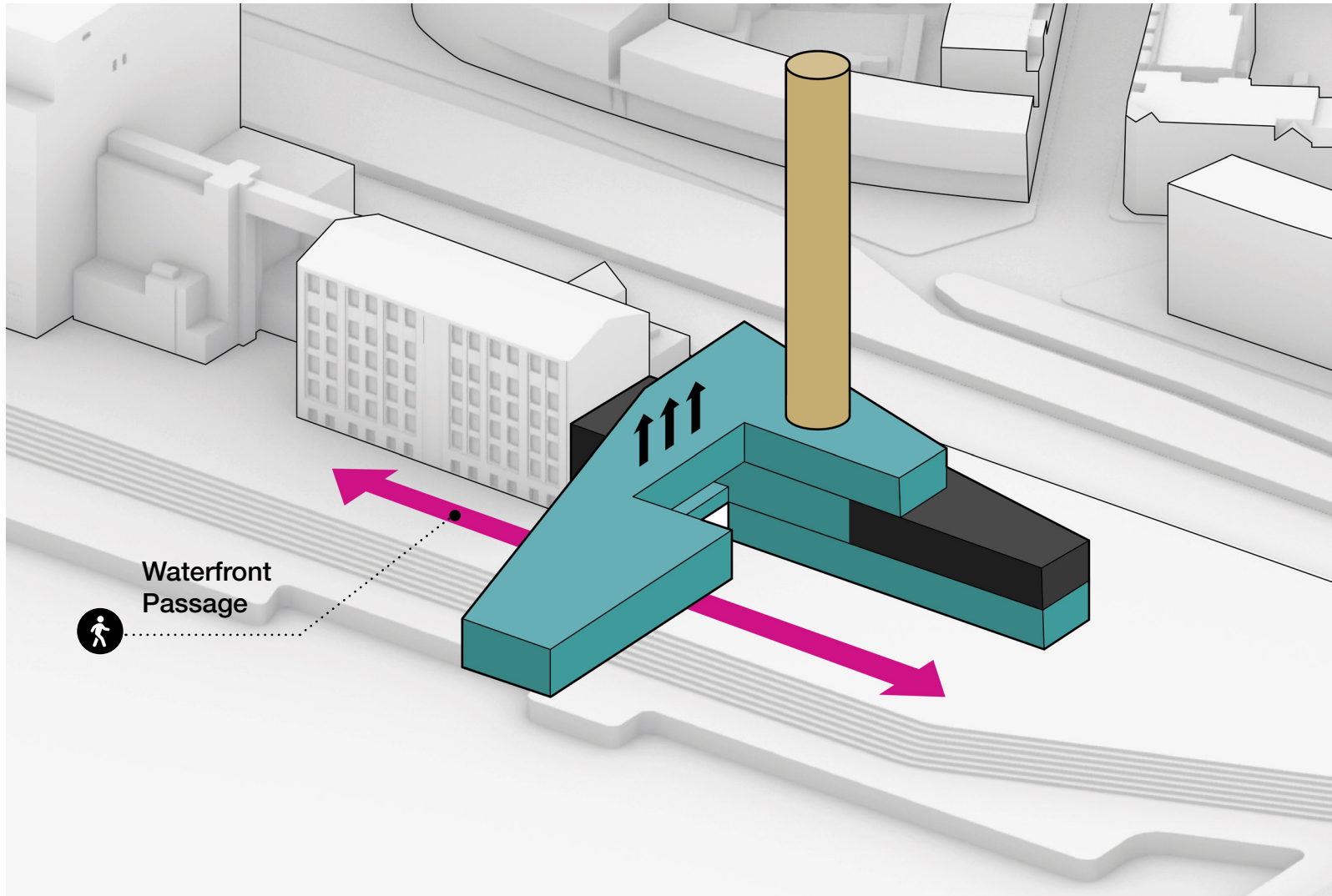
**Waterfront Connection**



**Myco Park & Fabrication**

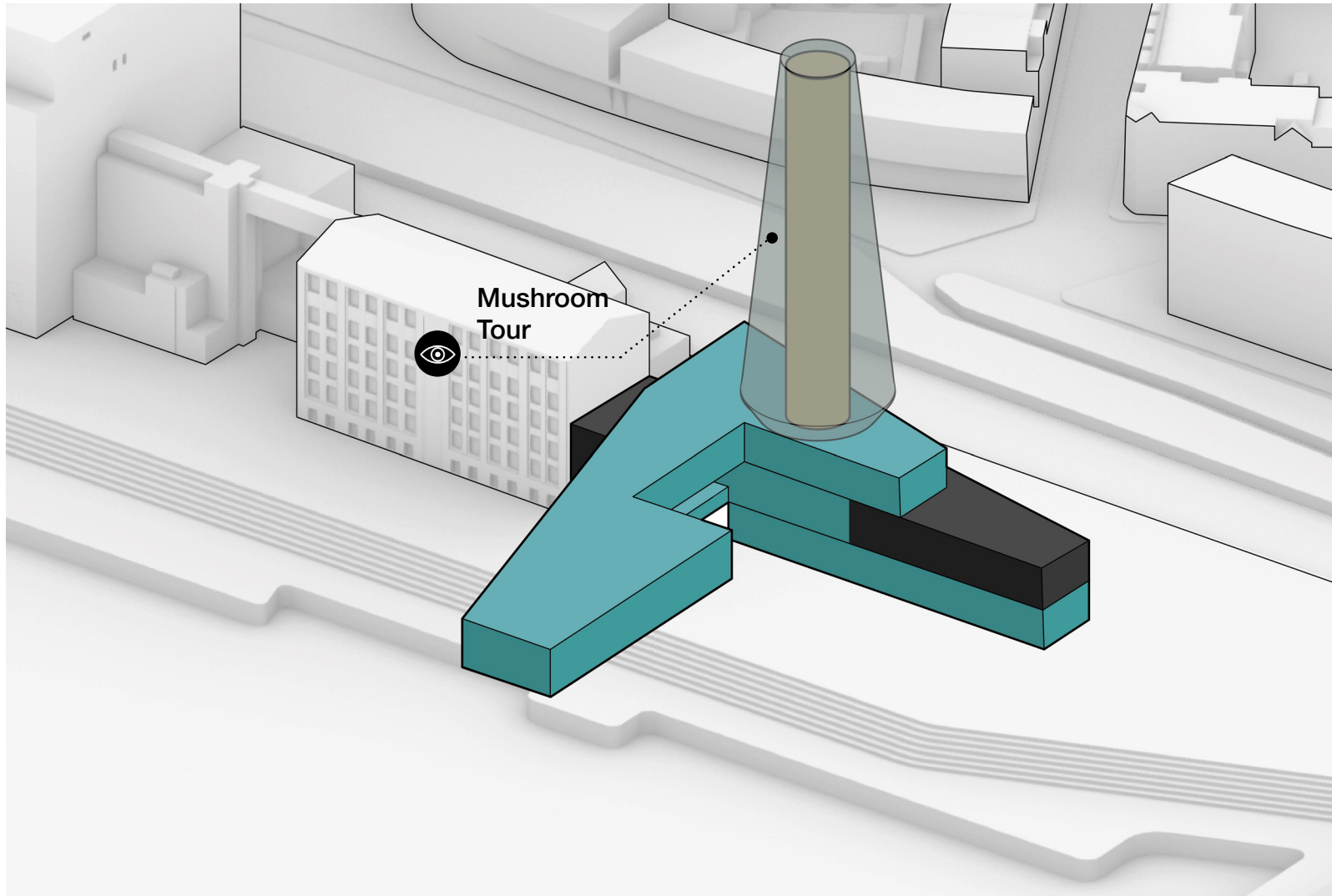


**Top Floor Public Programmes**

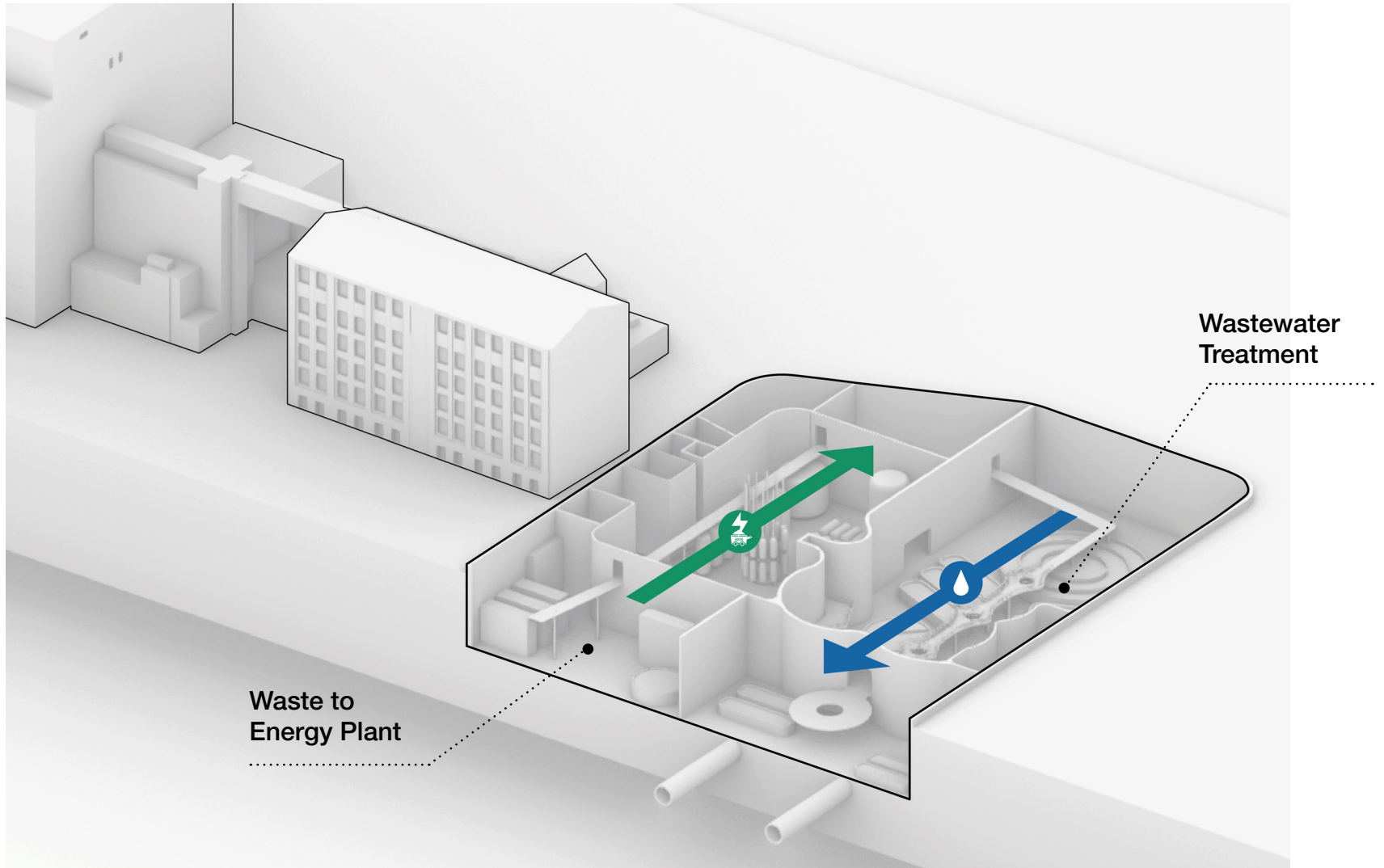


Lifted Waterfront Passge

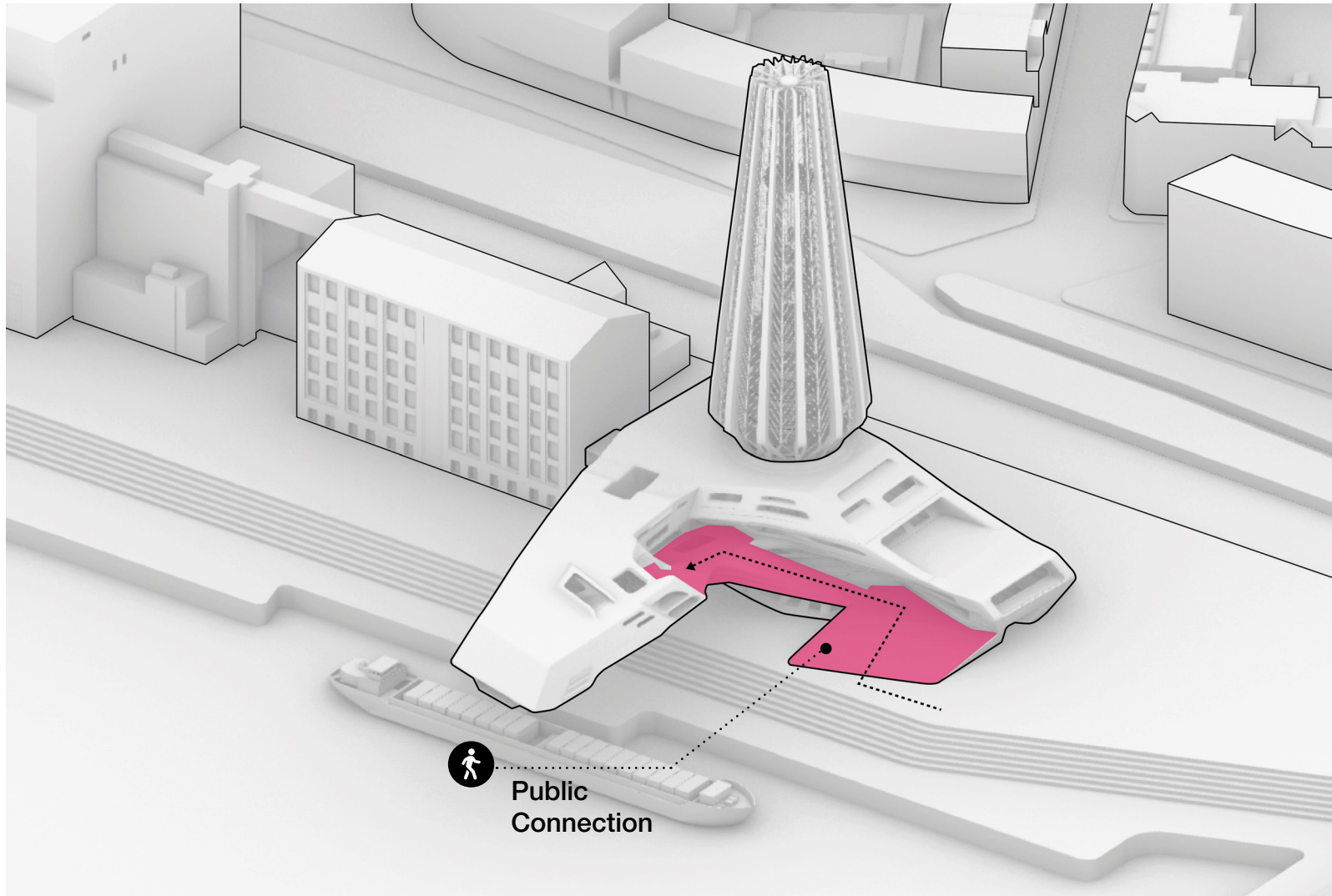




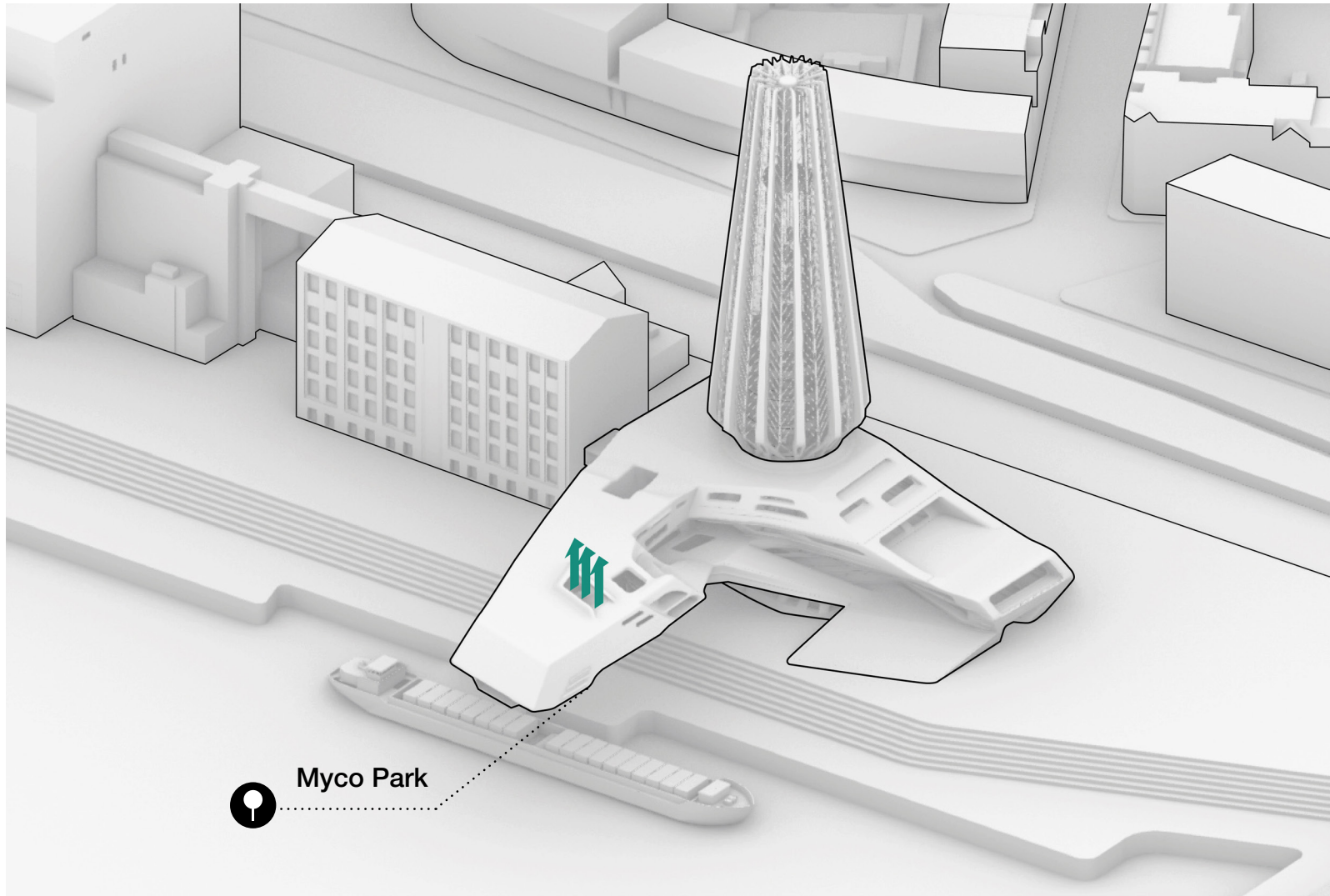
**Vertical Farm Circulation**



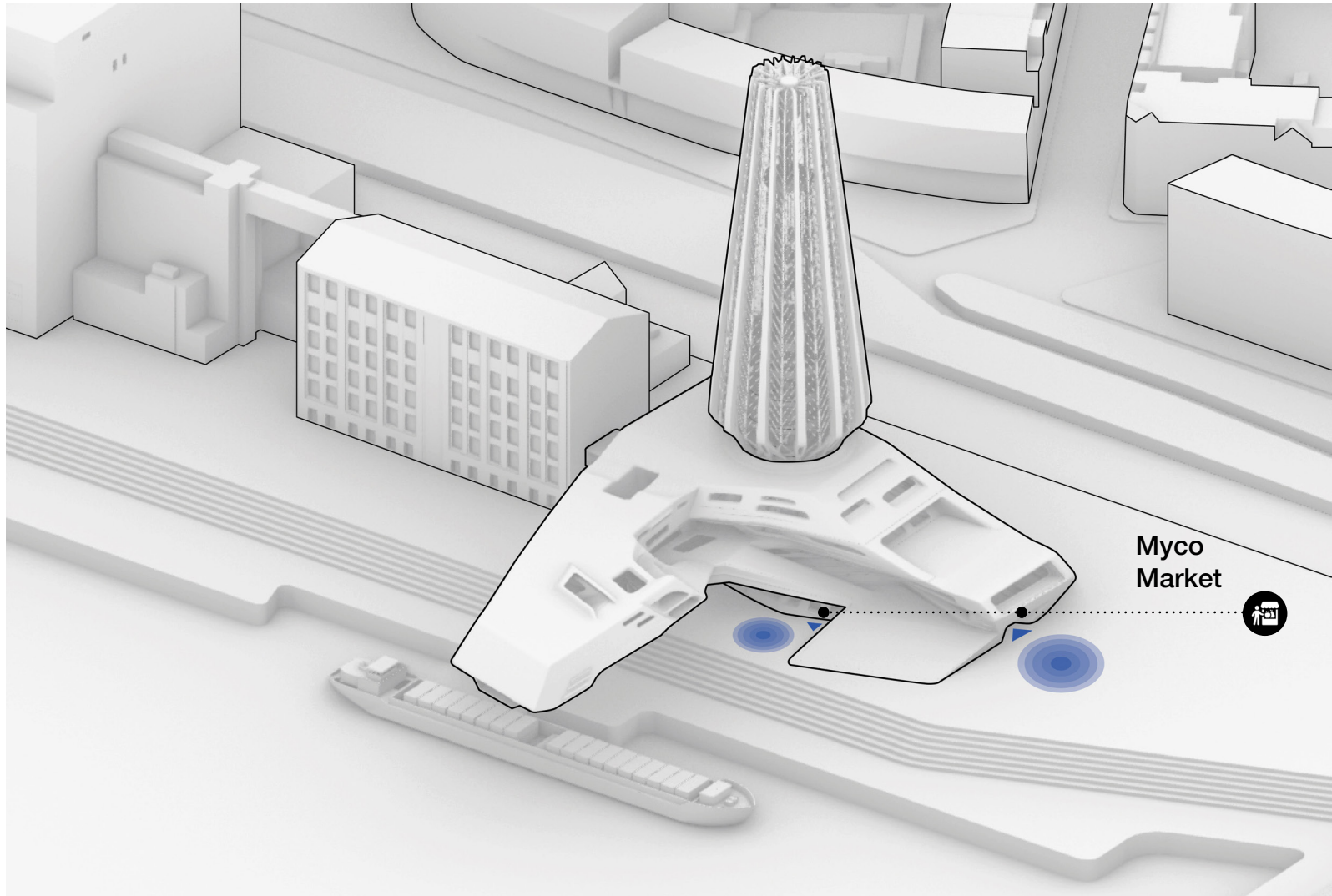
**Underground Facilities**



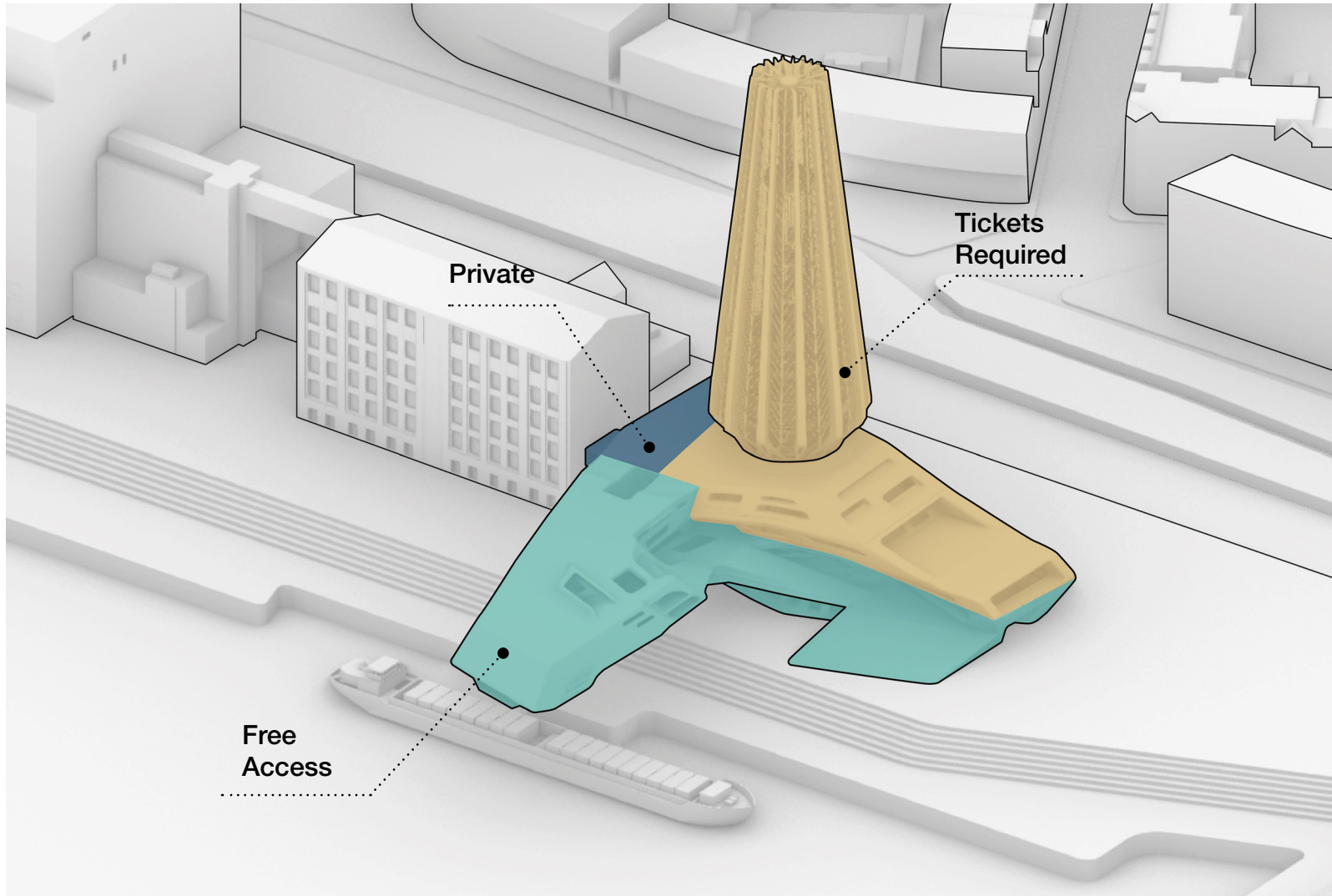
**Outdoor Connection**



Roof Void for Park



Market Entrances & Meeting Areas



**Public v Private**

*introduction*

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*design brief*

*concept*

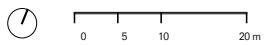
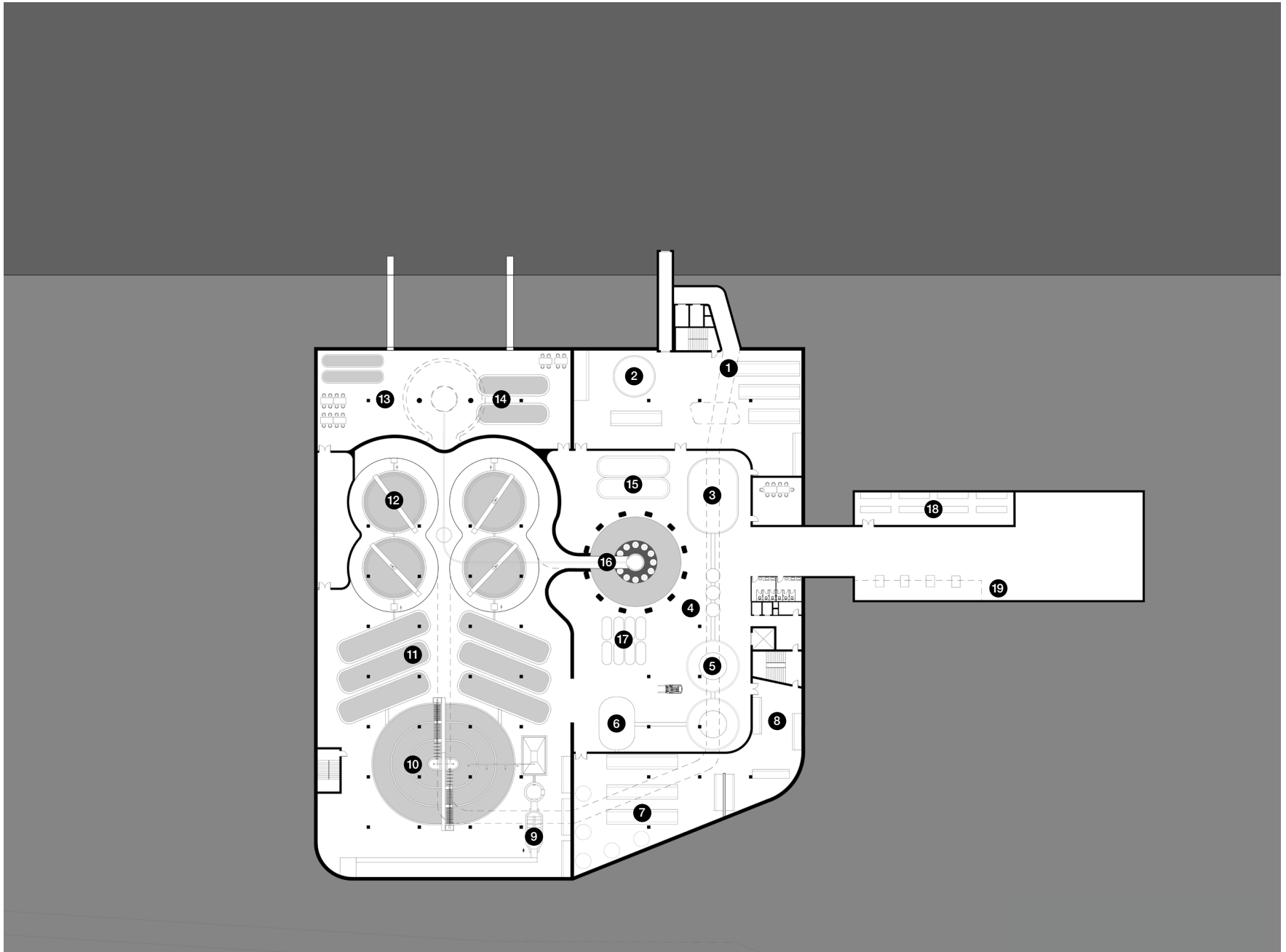
**implementation**

*development*

*visualisations*

*conclusion*

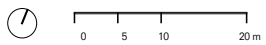
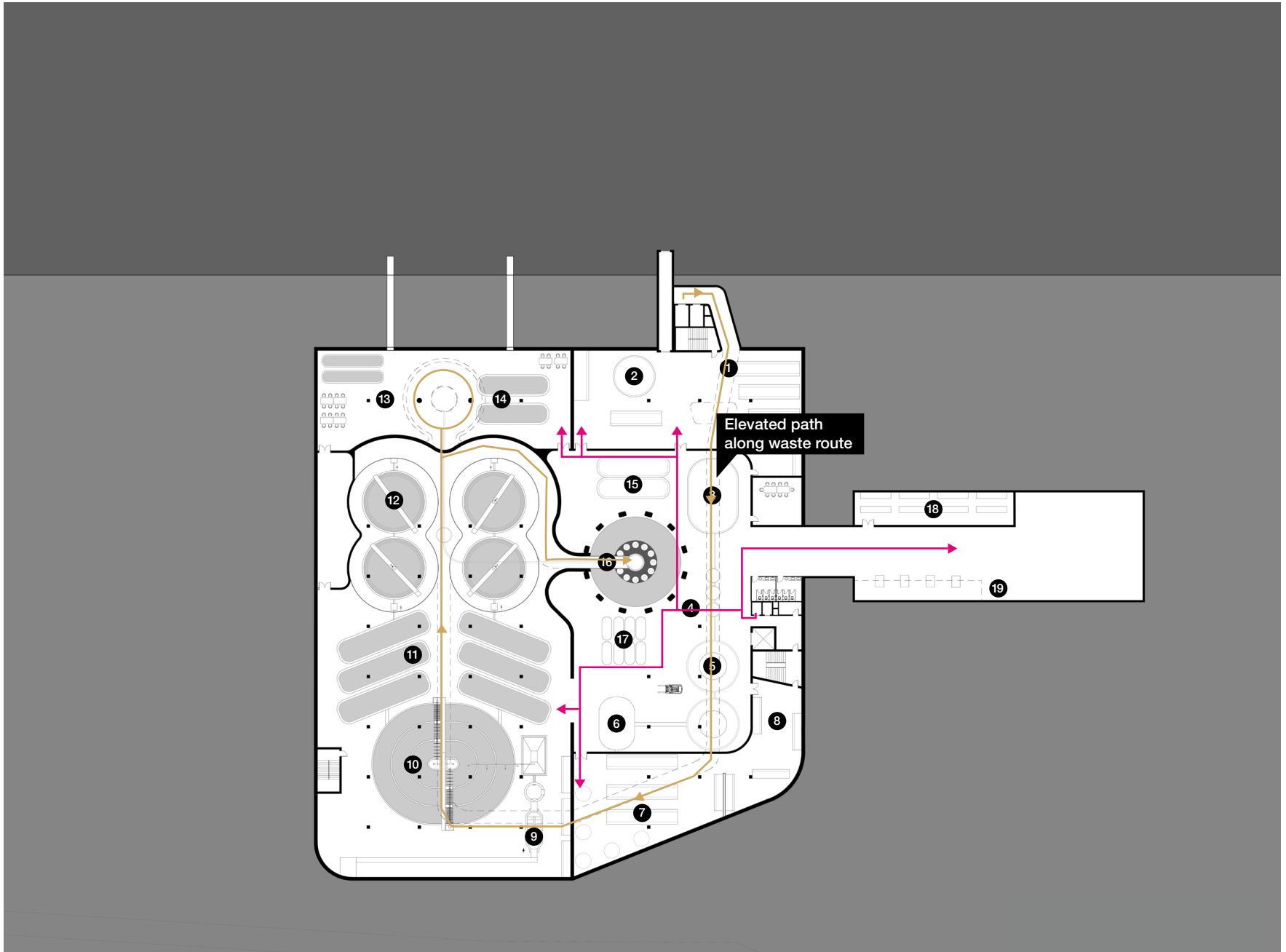
- 1 tour starts
- 2 organic waste sorting
- 3 mixing tank
- 4 pasteurization
- 5 anaerobic digester
- 6 storage tank
- 7 generator
- 8 mechanical room
- 9 grit chamber
- 10 primary clarifier
- 11 aeration tank
- 12 secondary clarifier
- 13 mycofiltration
- 14 mycoremediation
- 15 sludge
- 16 tour ends
- 17 CO2/O2
- 18 storage
- 19 logistics

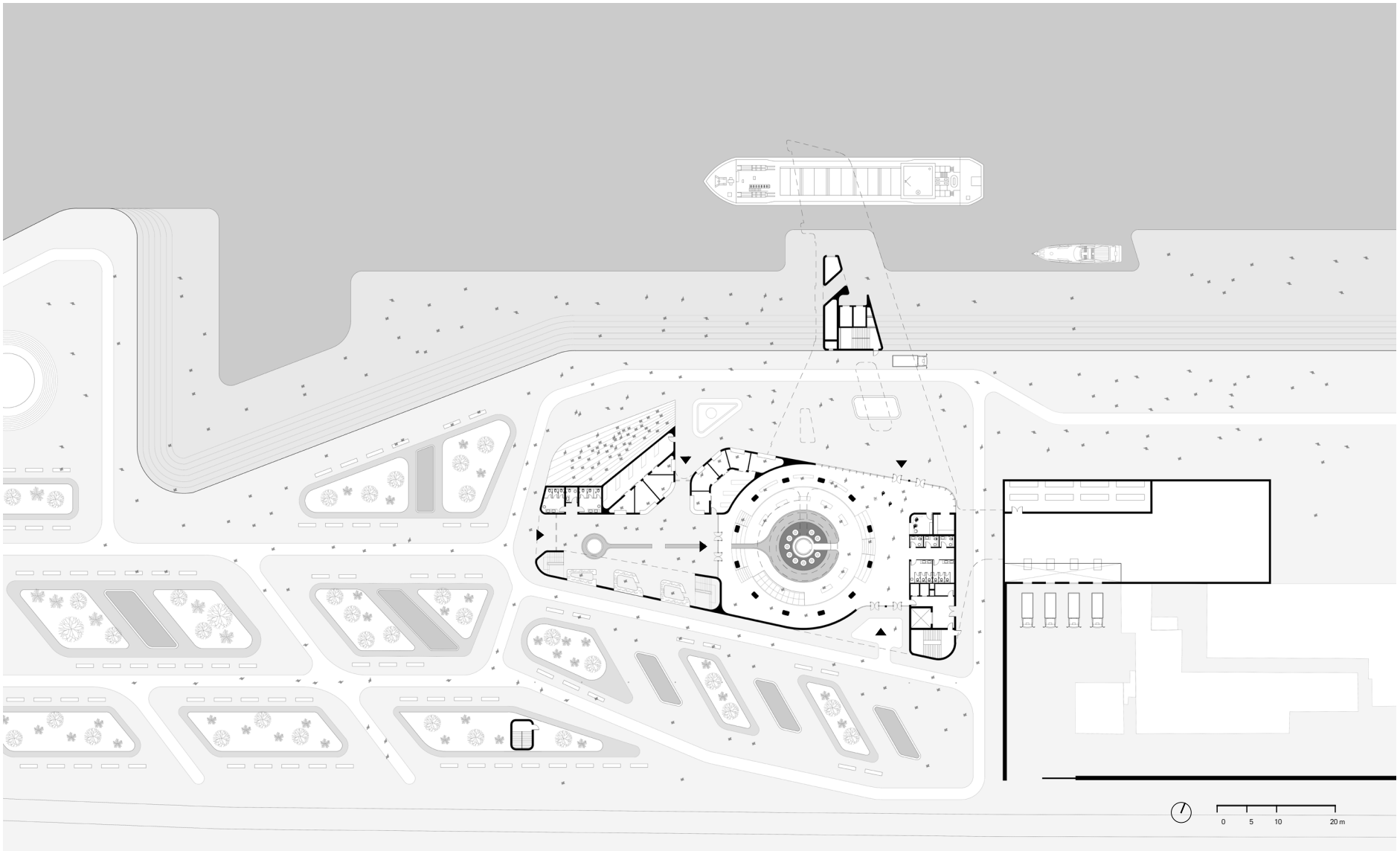




- Free Access
- Tickets Required
- Private

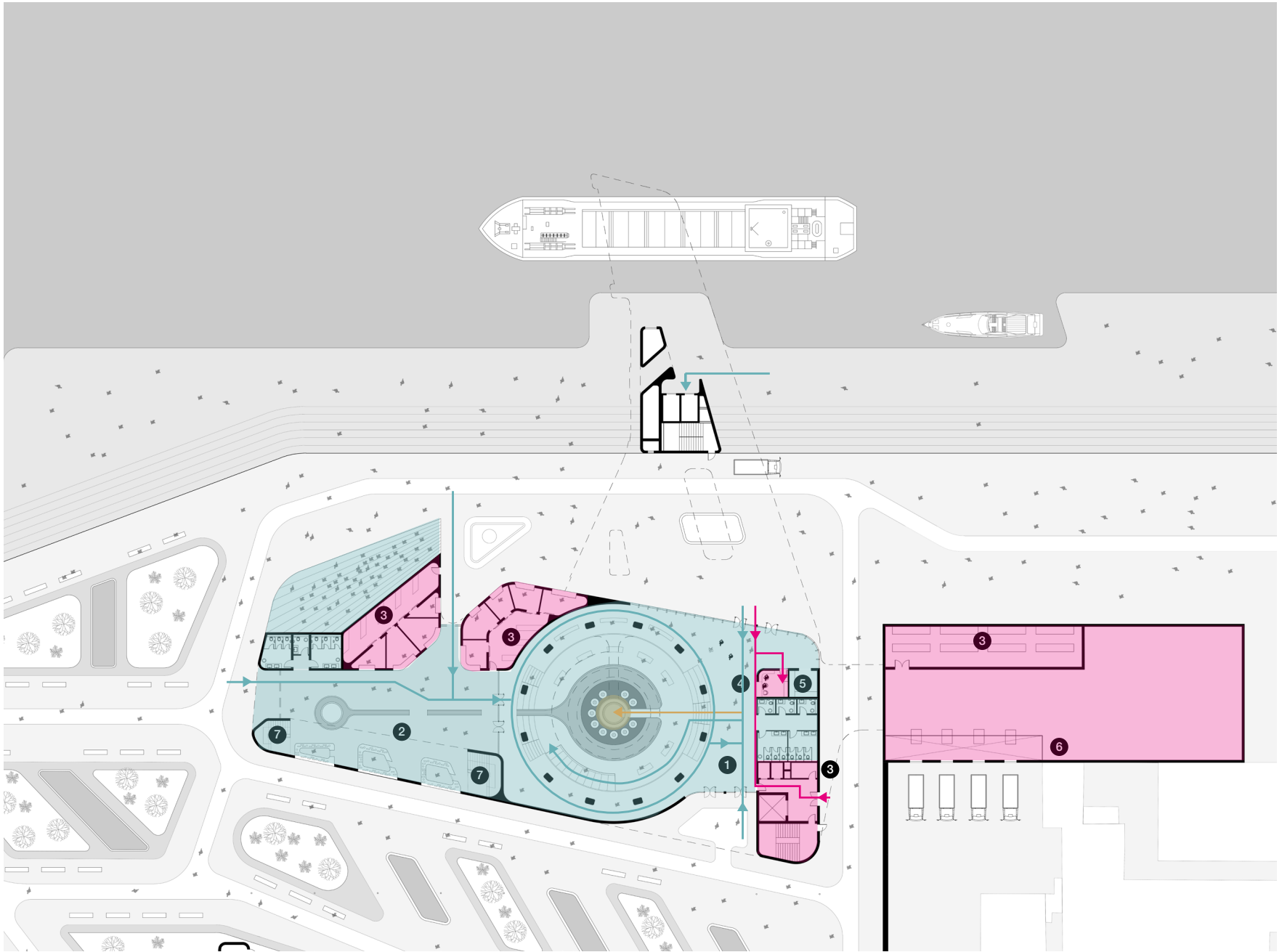
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- 16 tour ends
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- 19 logistics





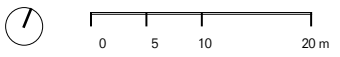
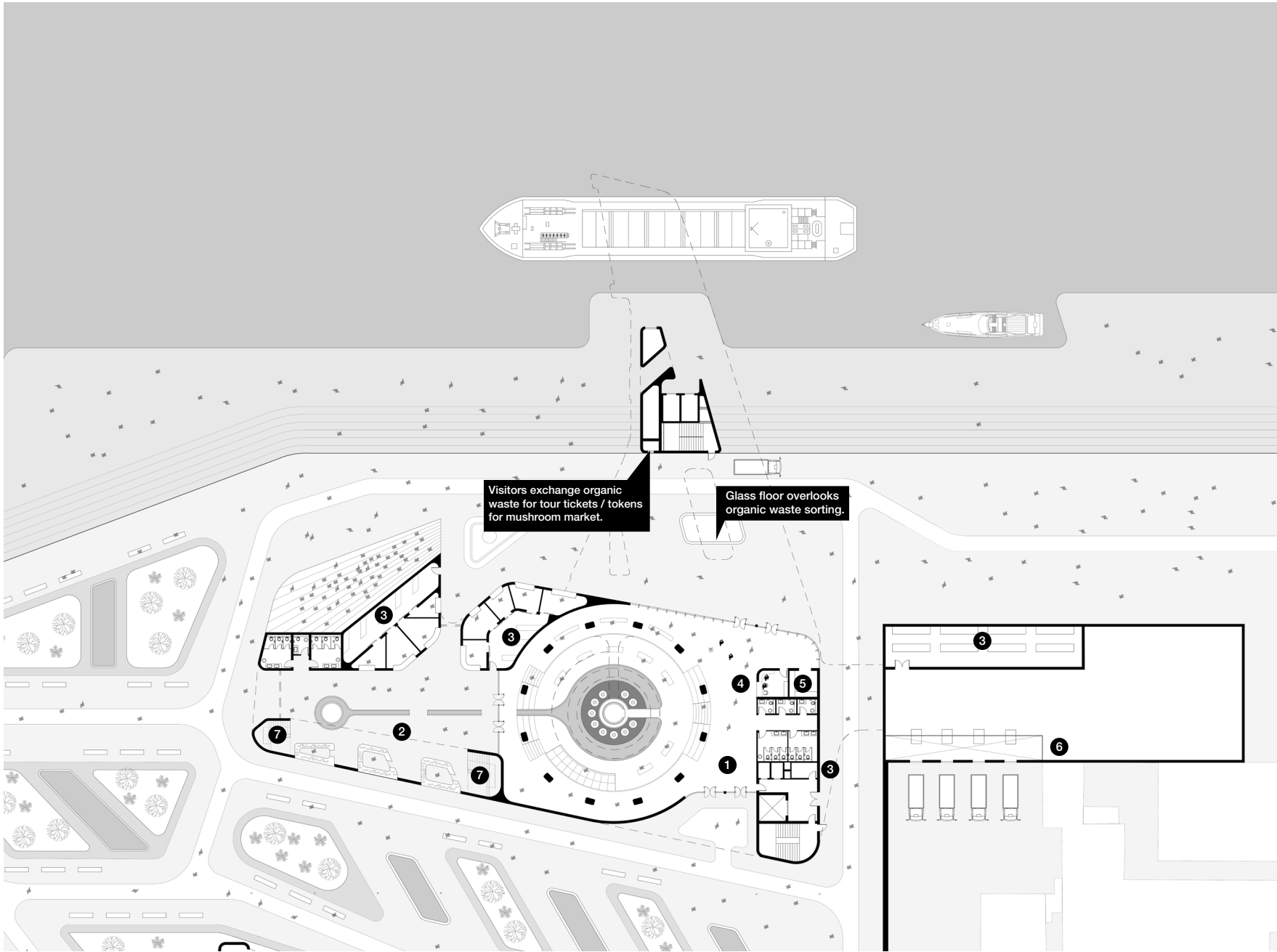
- Free Access
- Tickets Required
- Private

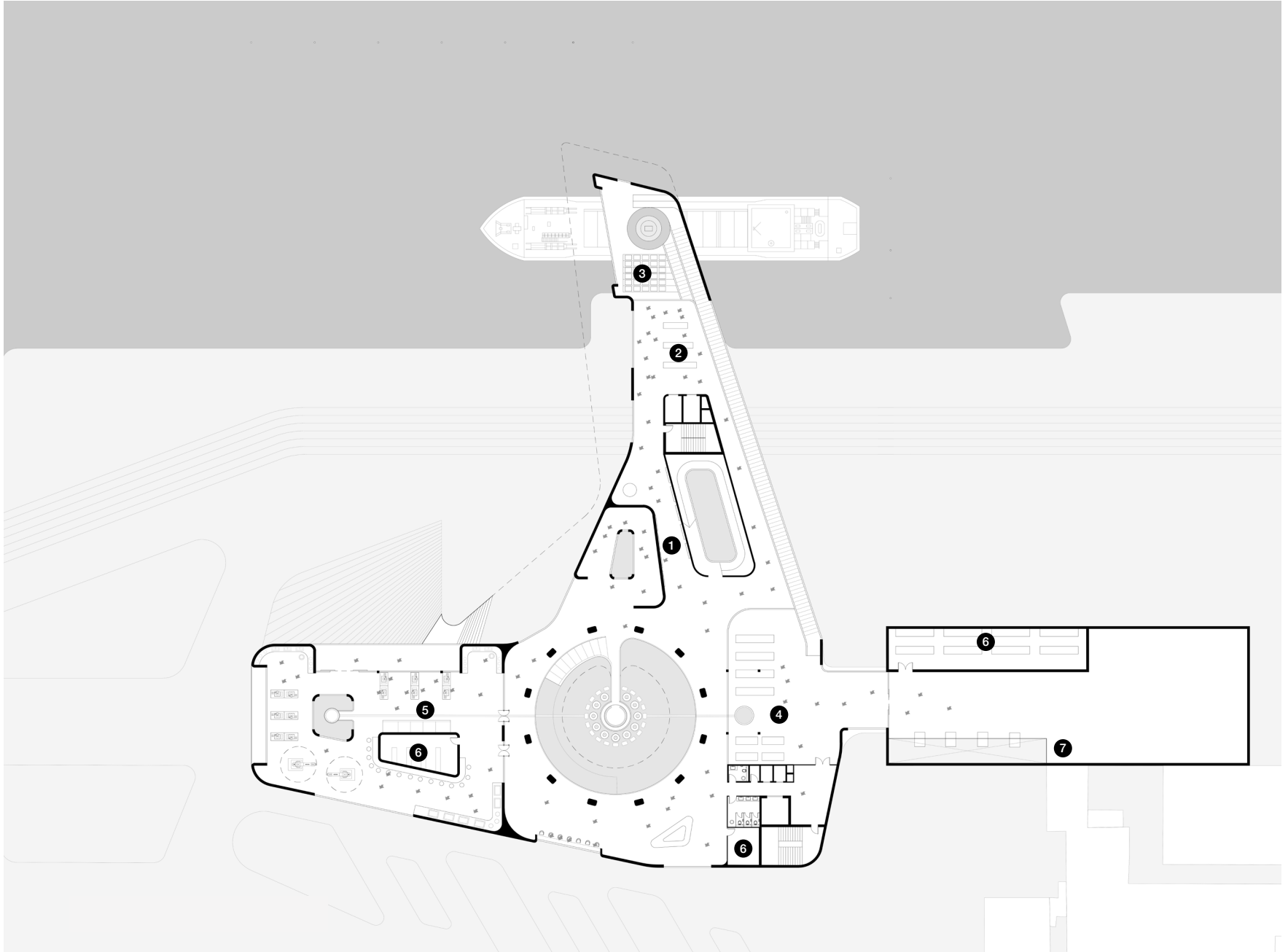
- 1 lobby
- 2 myco market
- 3 storage
- 4 ticket office
- 5 cloak room
- 6 logistics
- 7 to seating area



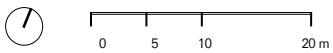
- Free Access
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- Private

- 1 lobby
- 2 myco market
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- 7 to seating area



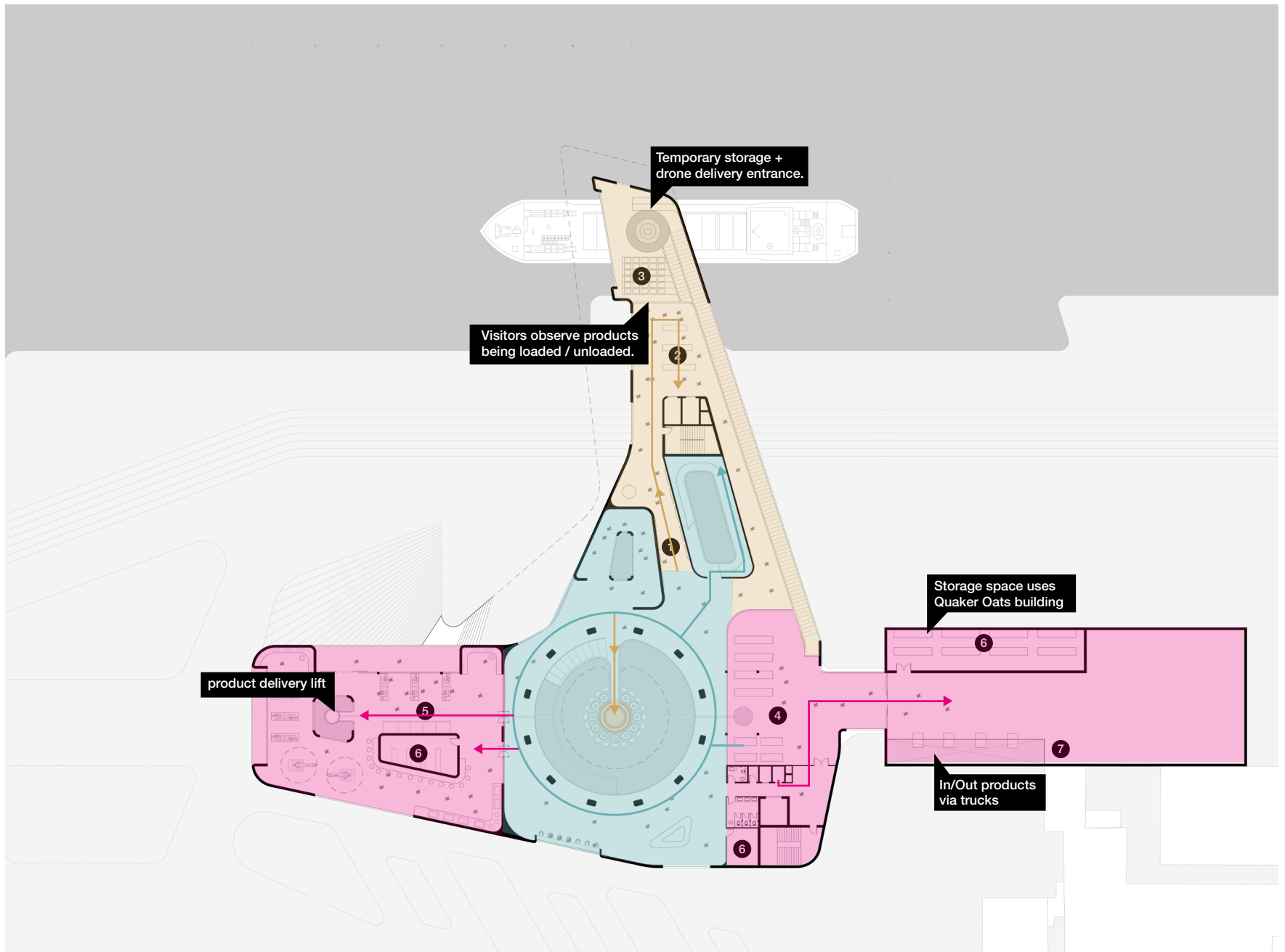


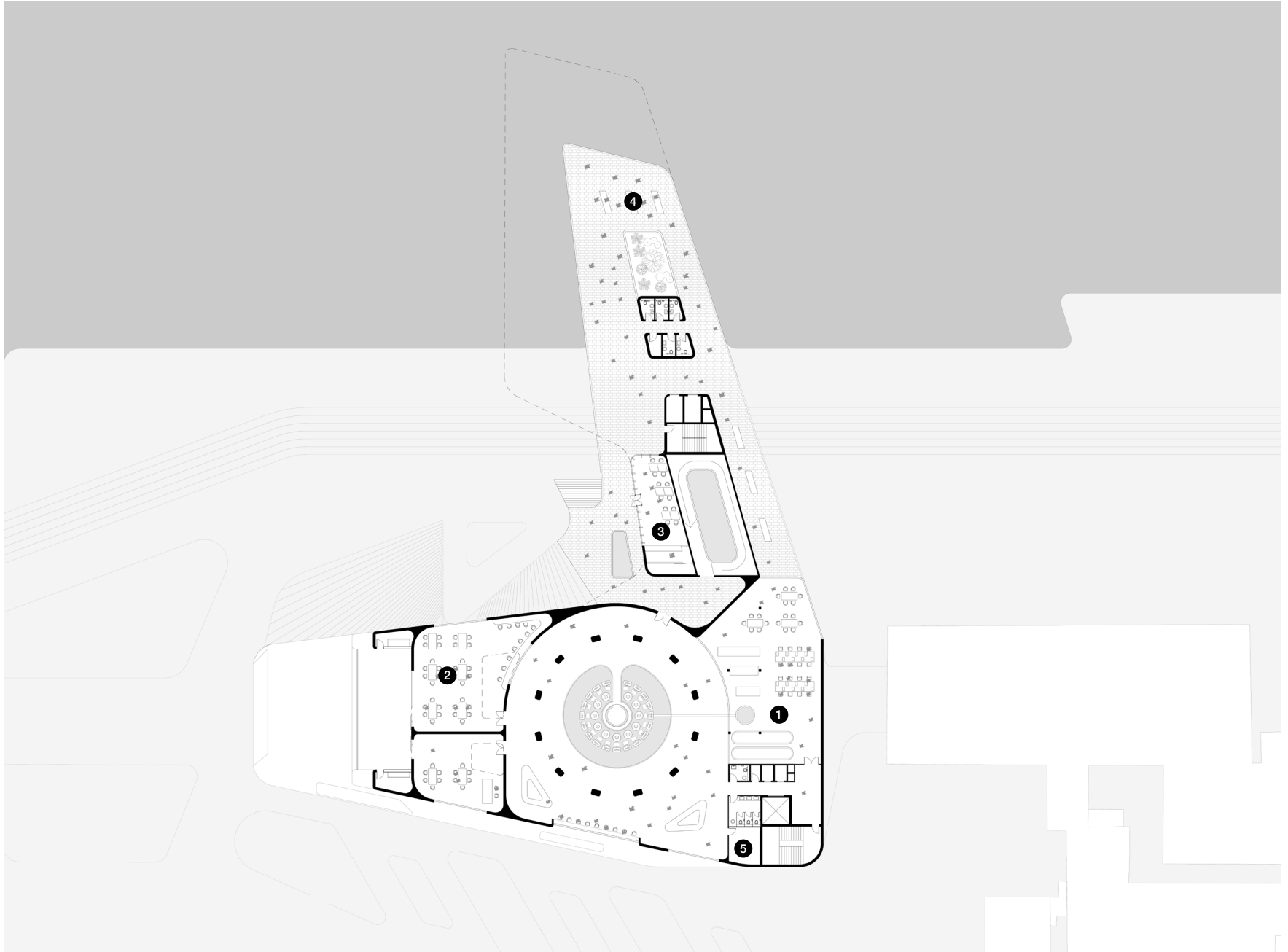
- 1 exhibition
- 2 start of waste tour
- 3 logistics + storage
- 4 sorting
- 5 fabrication lab
- 6 storage
- 7 logistics



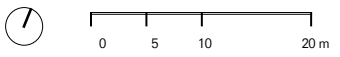
- Free Access
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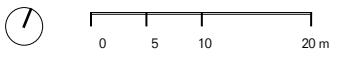
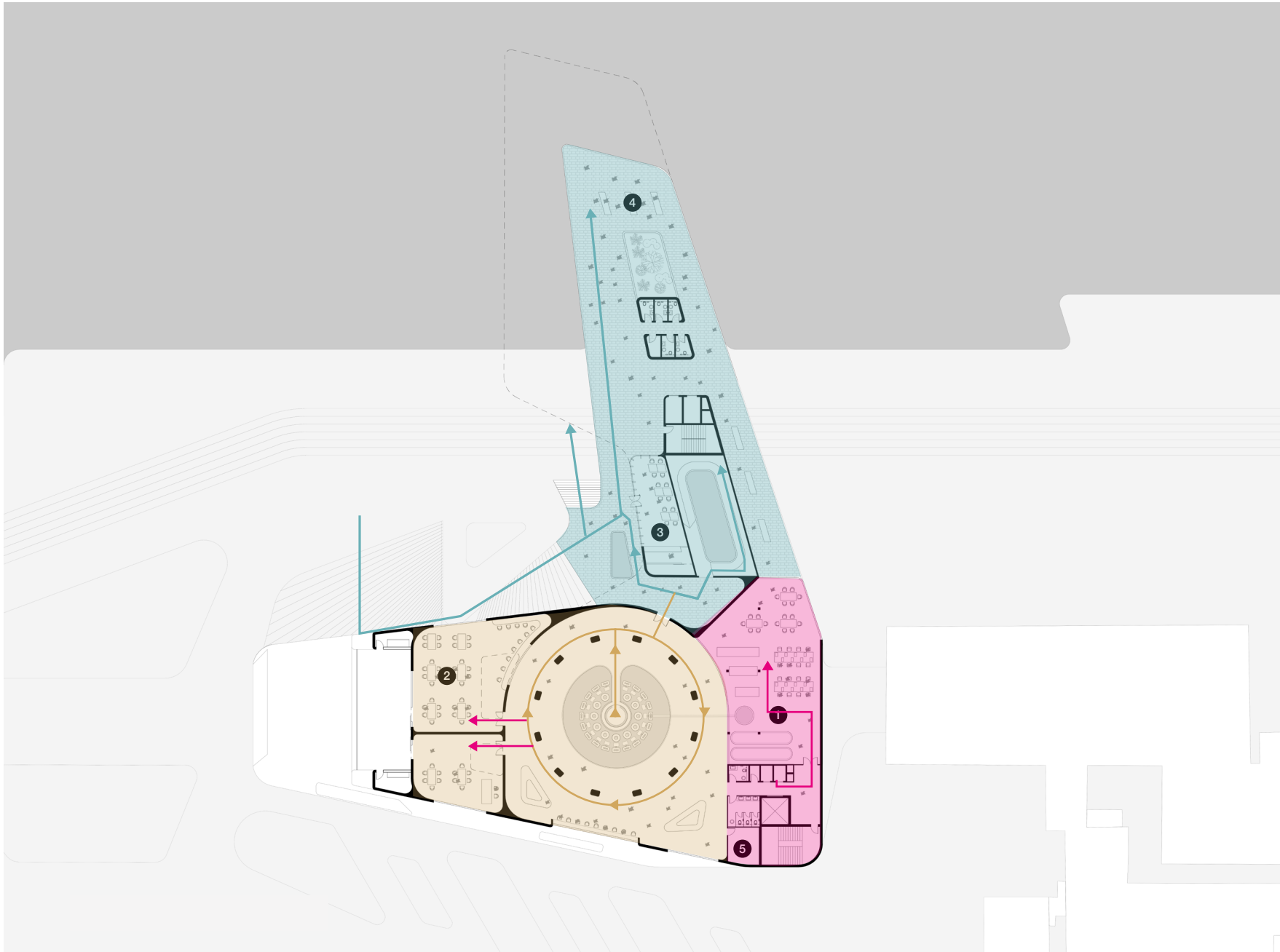


- 1 cultivation lab
- 2 classroom
- 3 cafe
- 4 myco park
- 5 storage

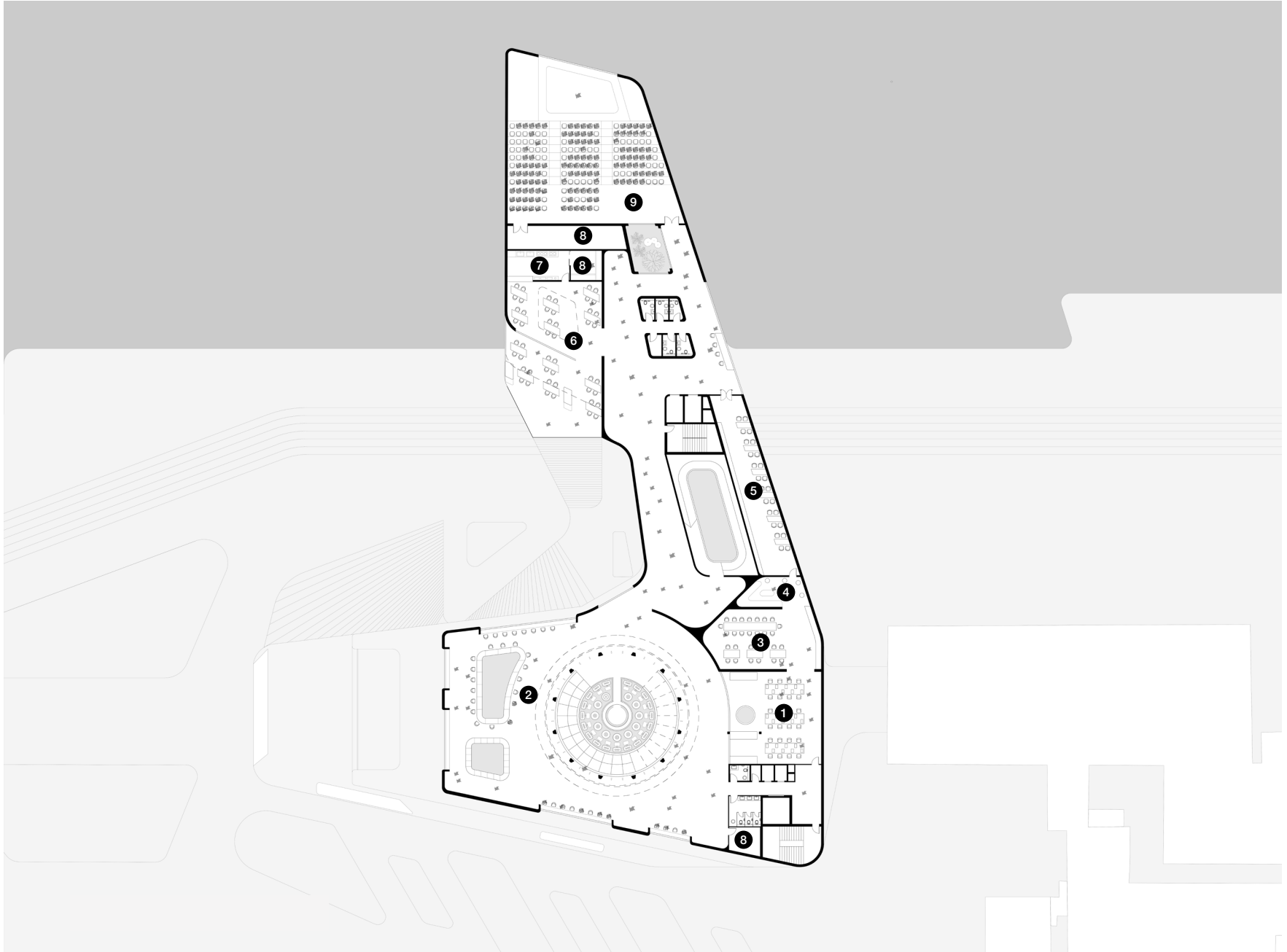


- Free Access
- Tickets Required
- Private

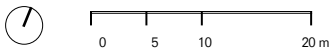
- 1 cultivation lab
- 2 classroom
- 3 cafe
- 4 myco park
- 5 storage





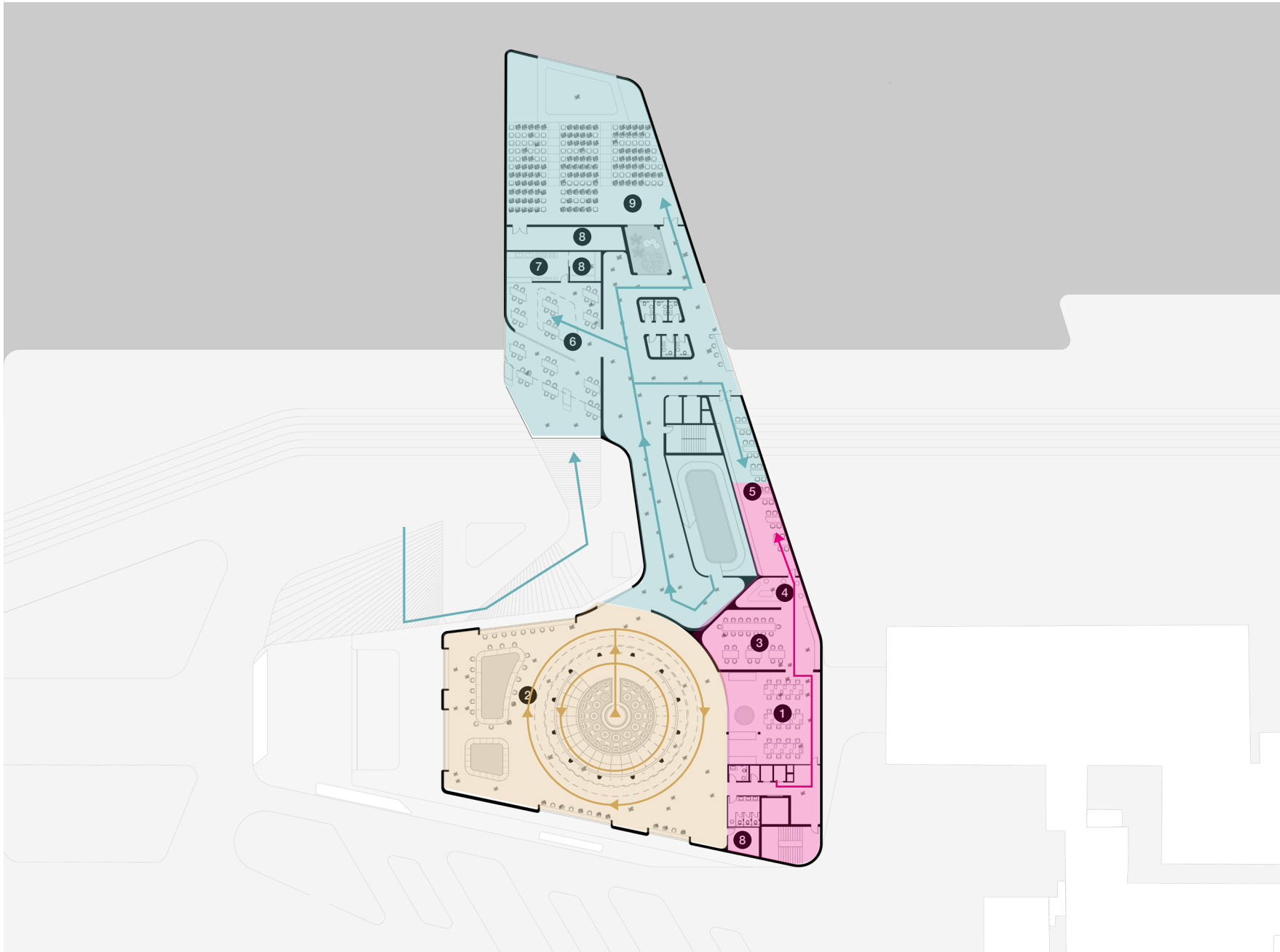


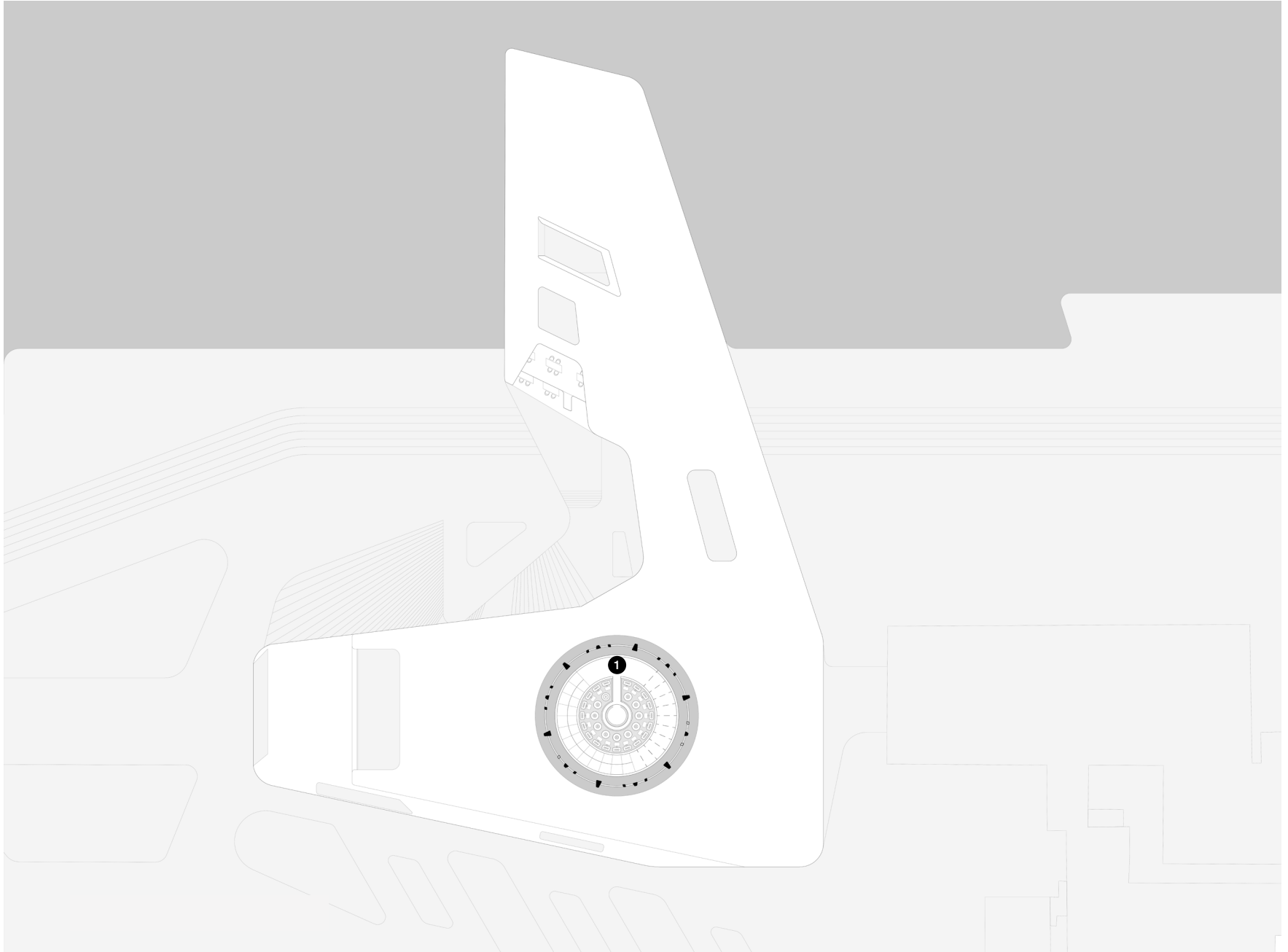
- 1 office
- 2 working space
- 3 staff canteen
- 4 living room
- 5 library
- 6 restaurant
- 7 kitchen
- 8 storage
- 9 auditorium



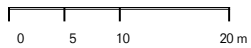
- Free Access
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- 1 office
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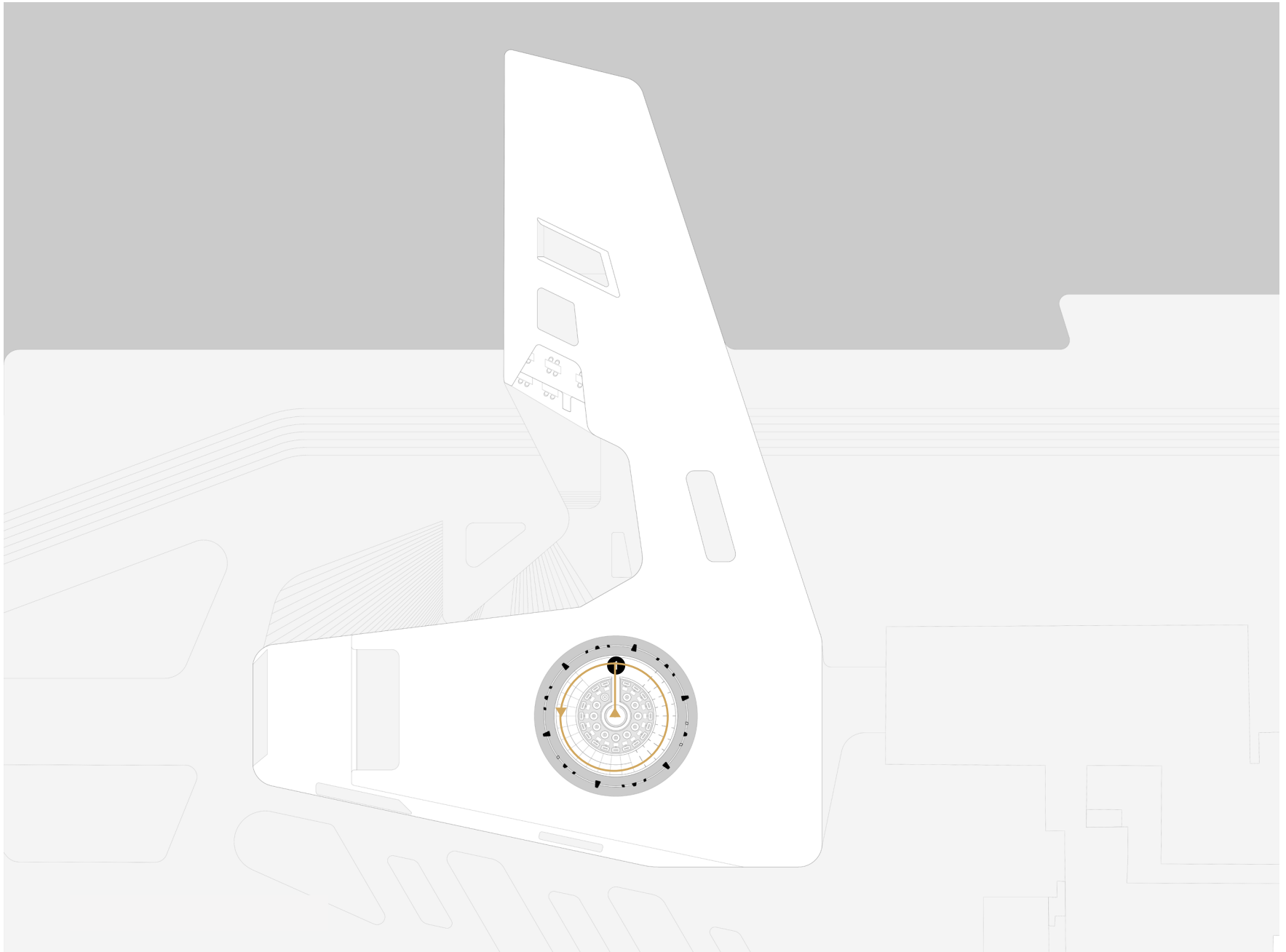




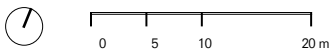
1 tower entrance

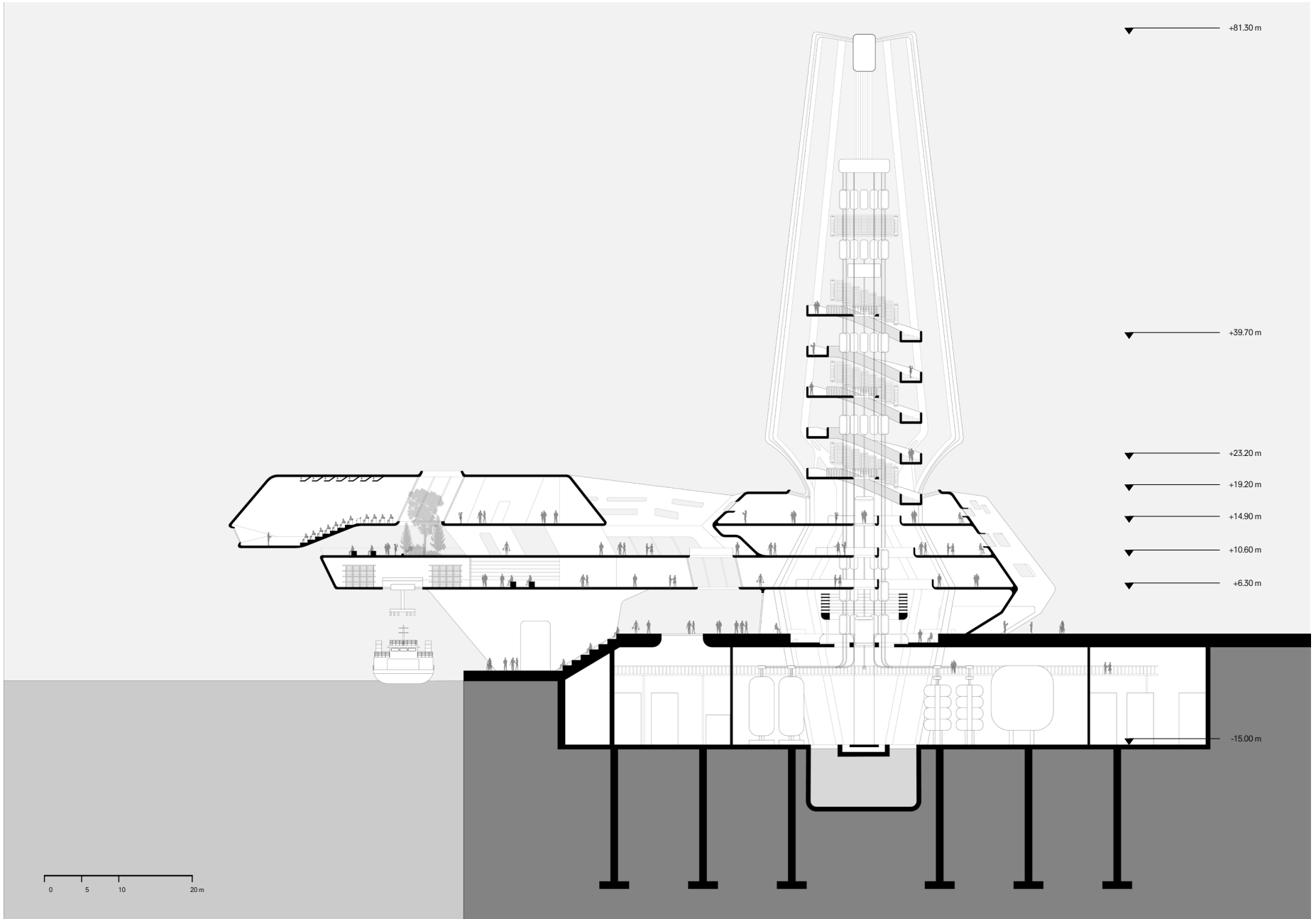


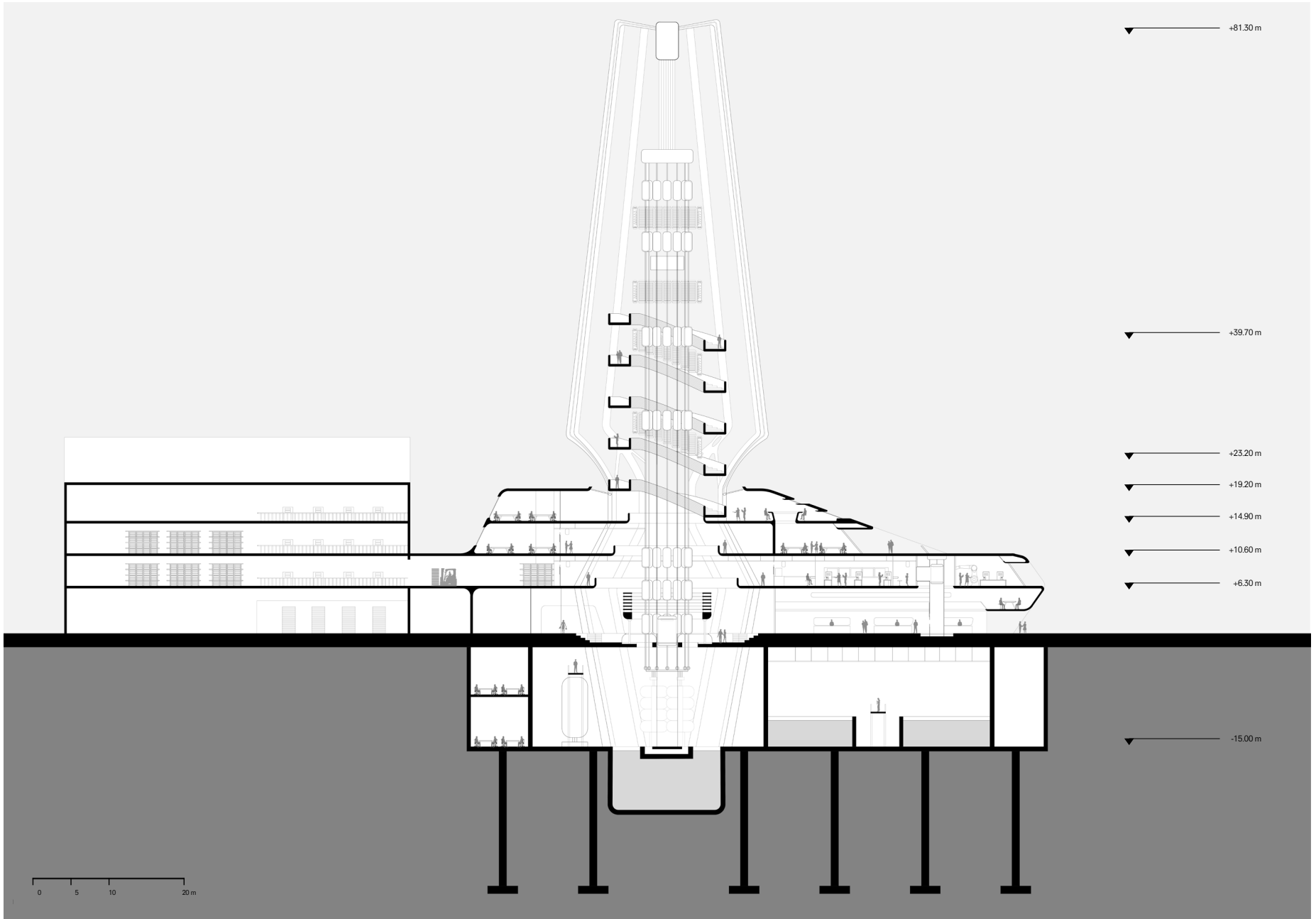
- Free Access
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- Private

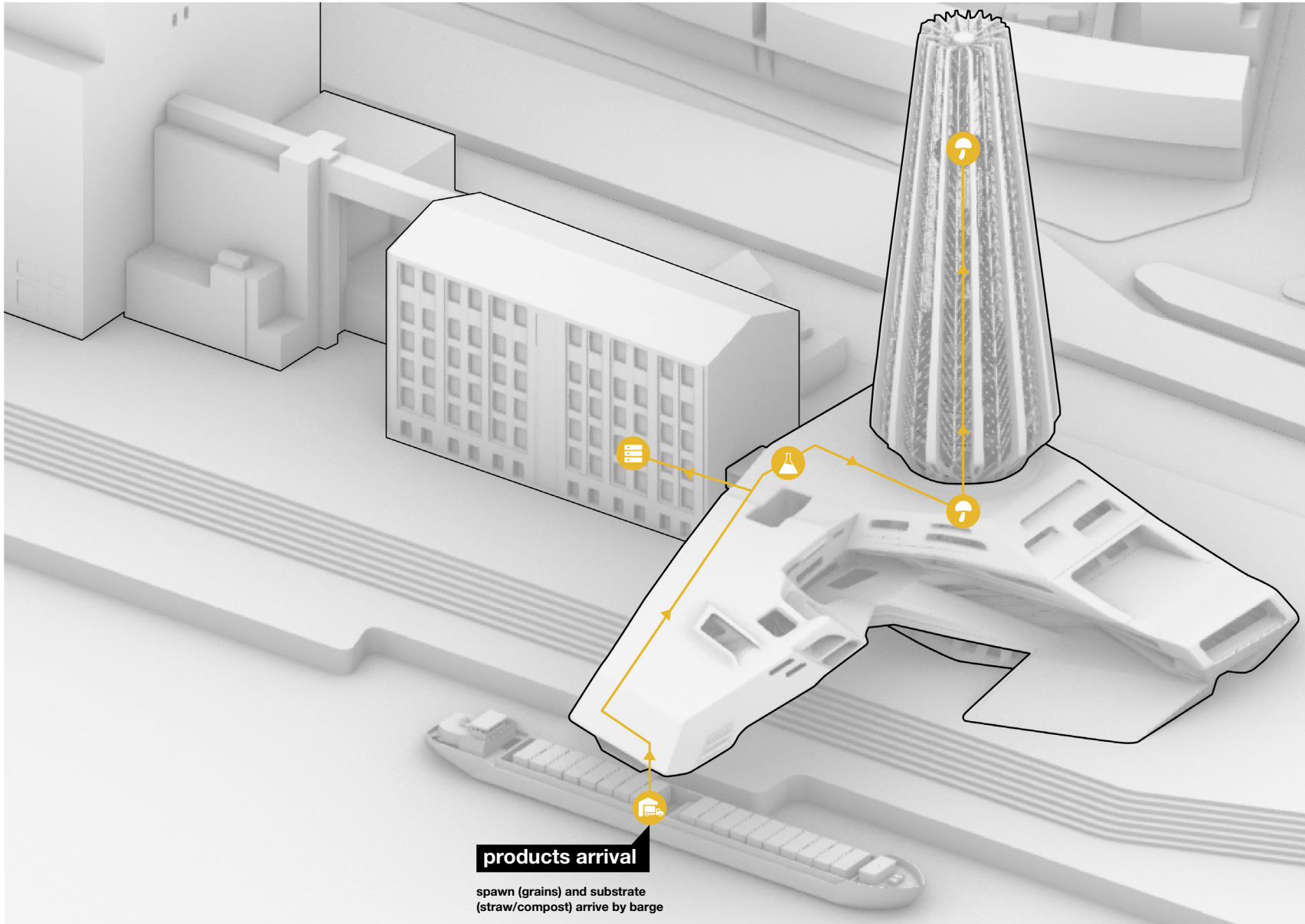


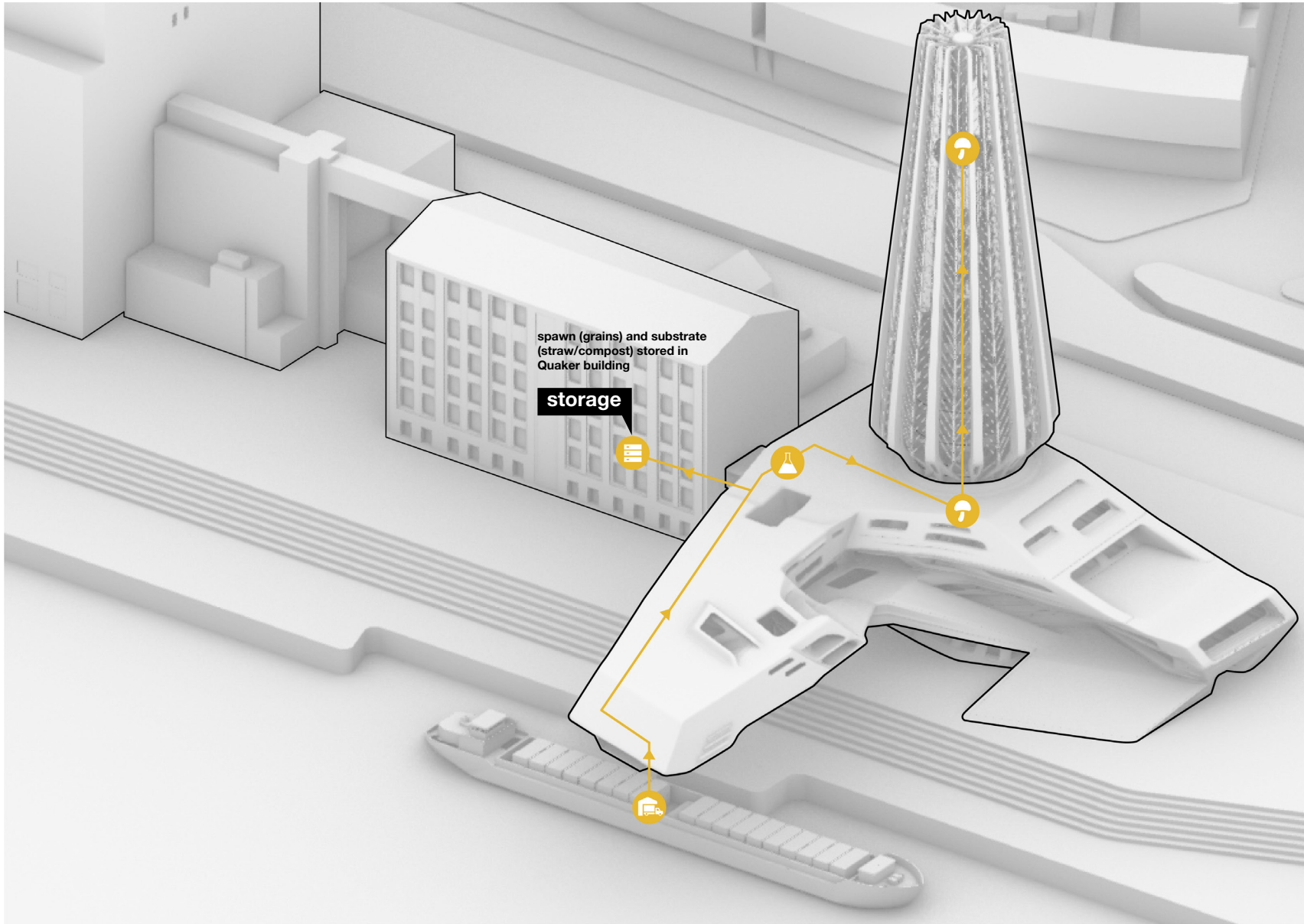
1 tower entrance



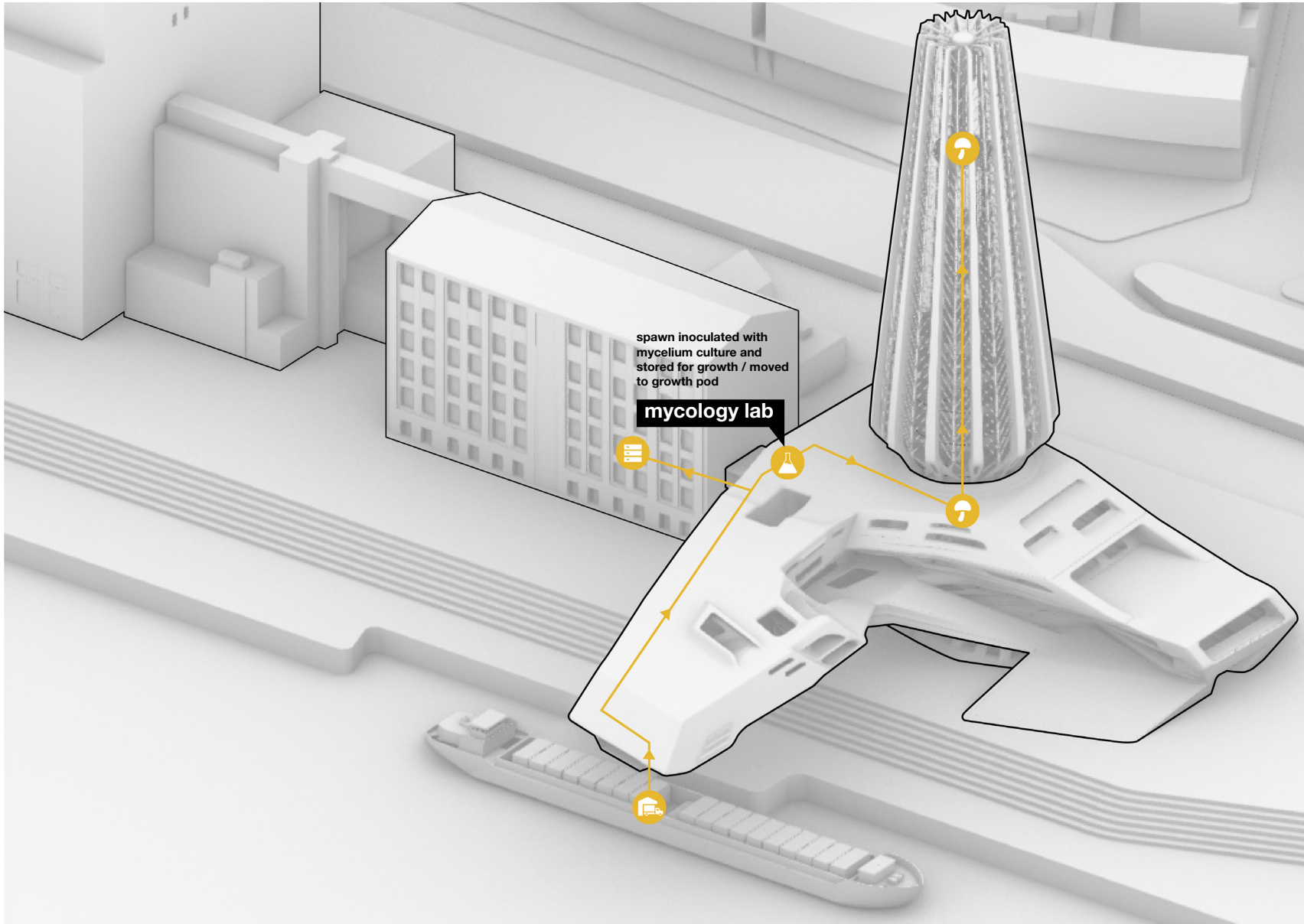


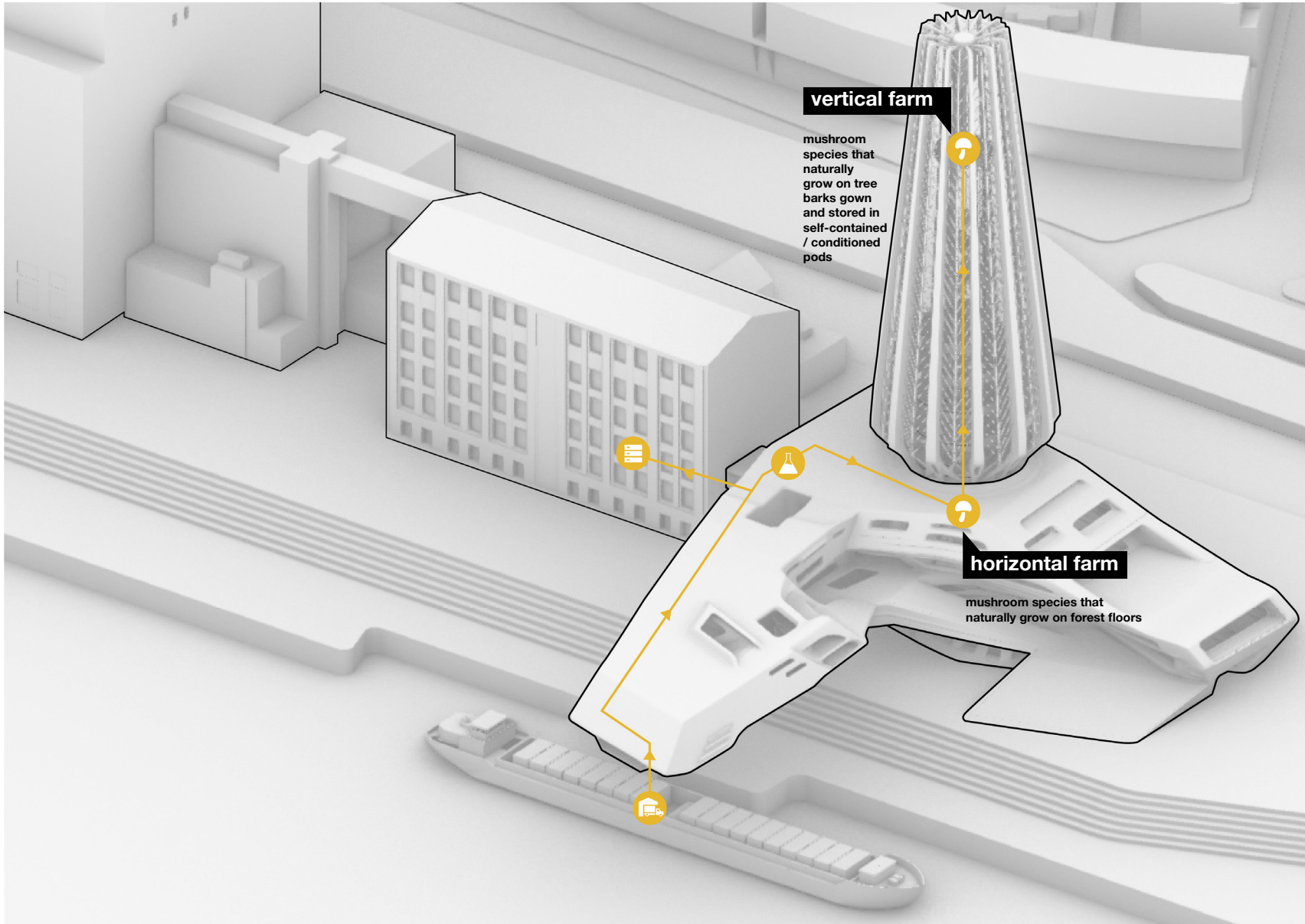


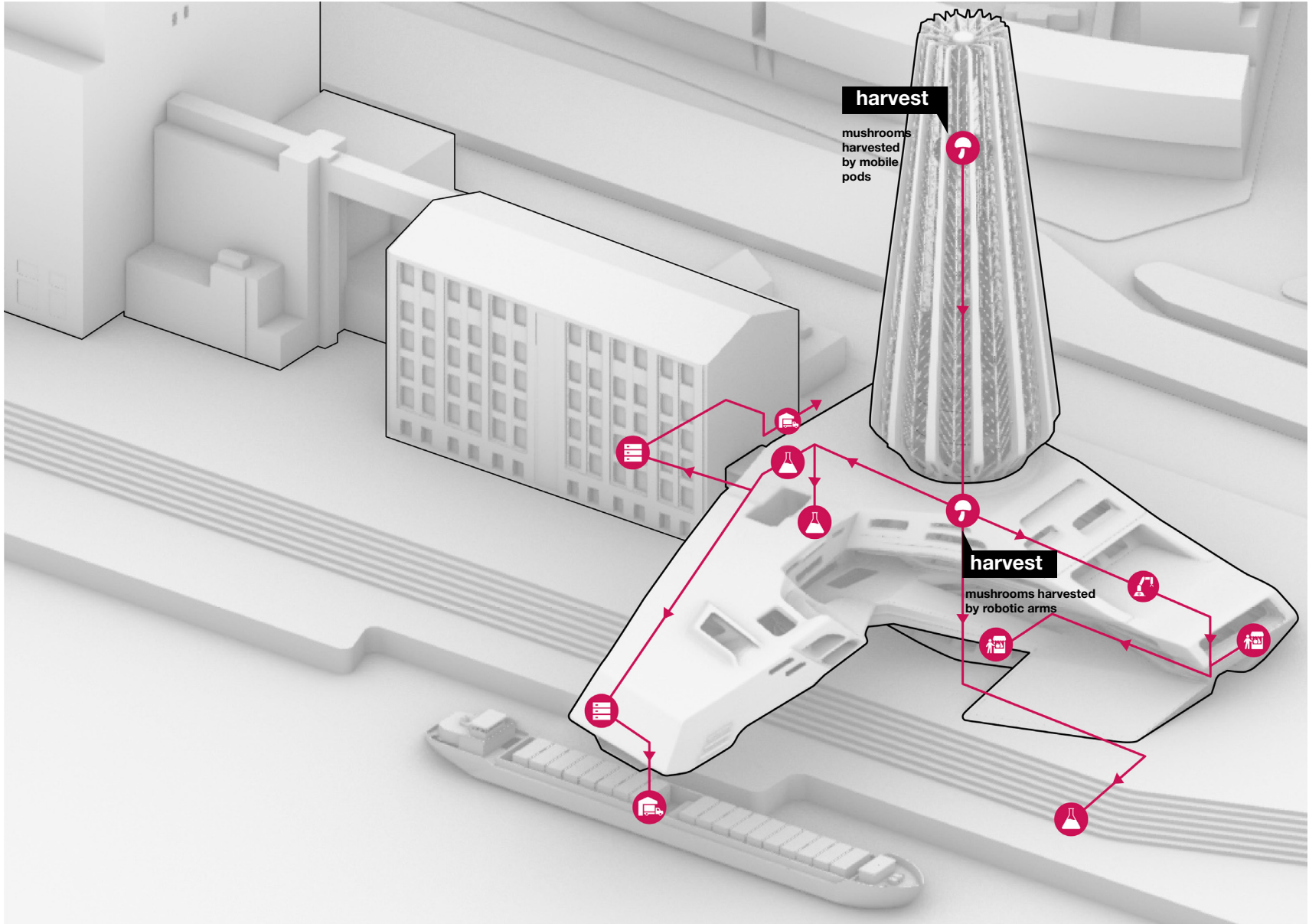


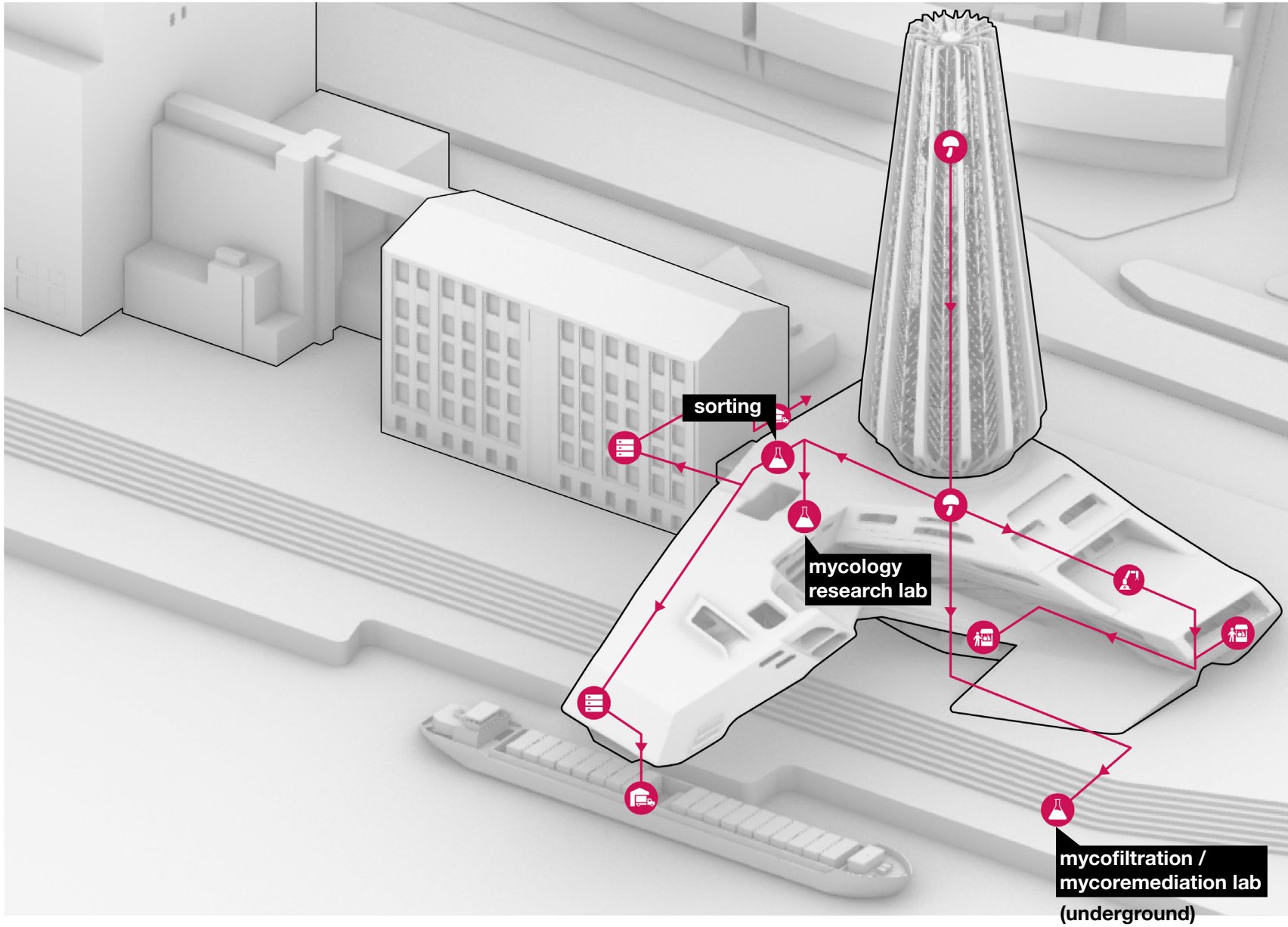


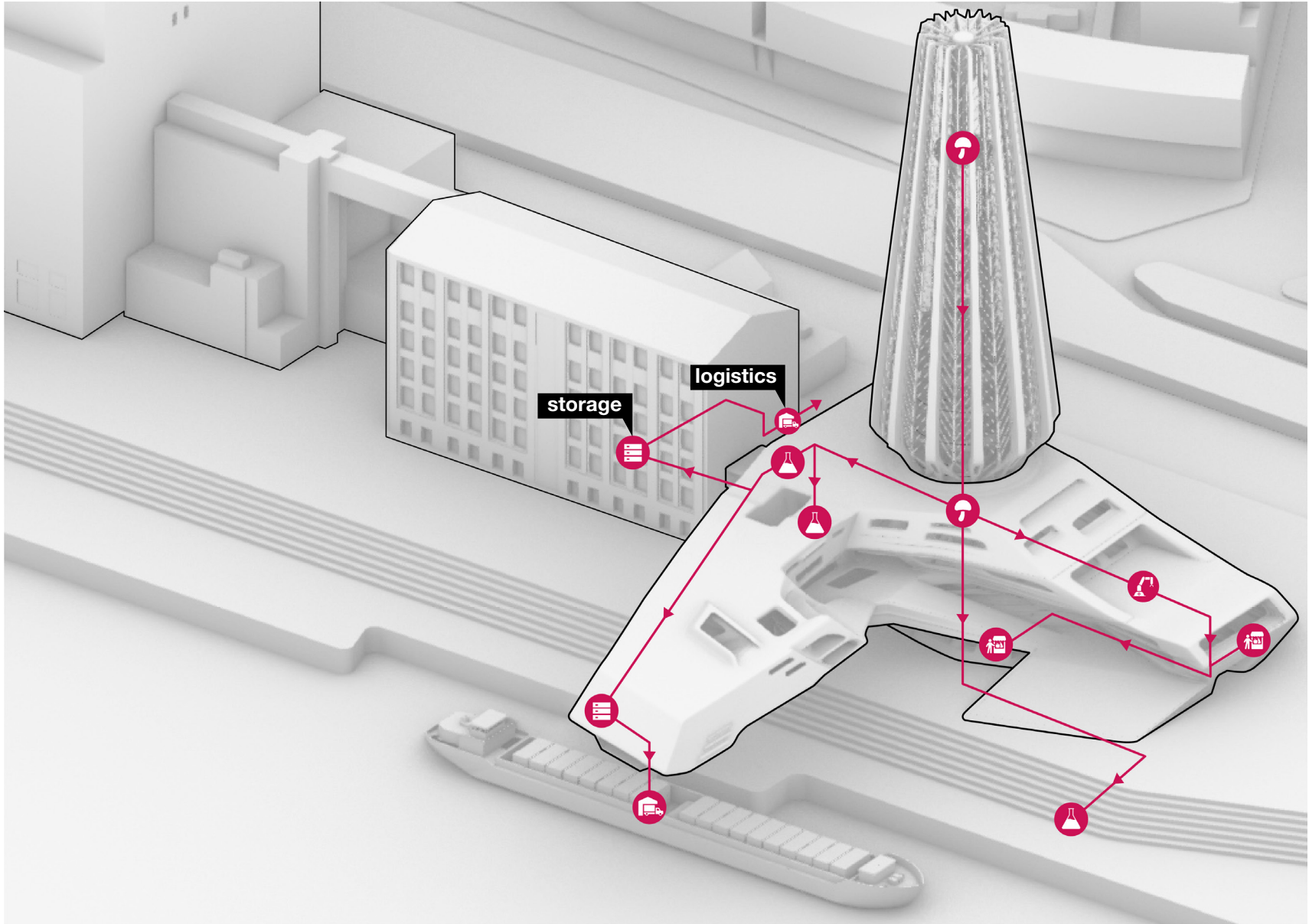


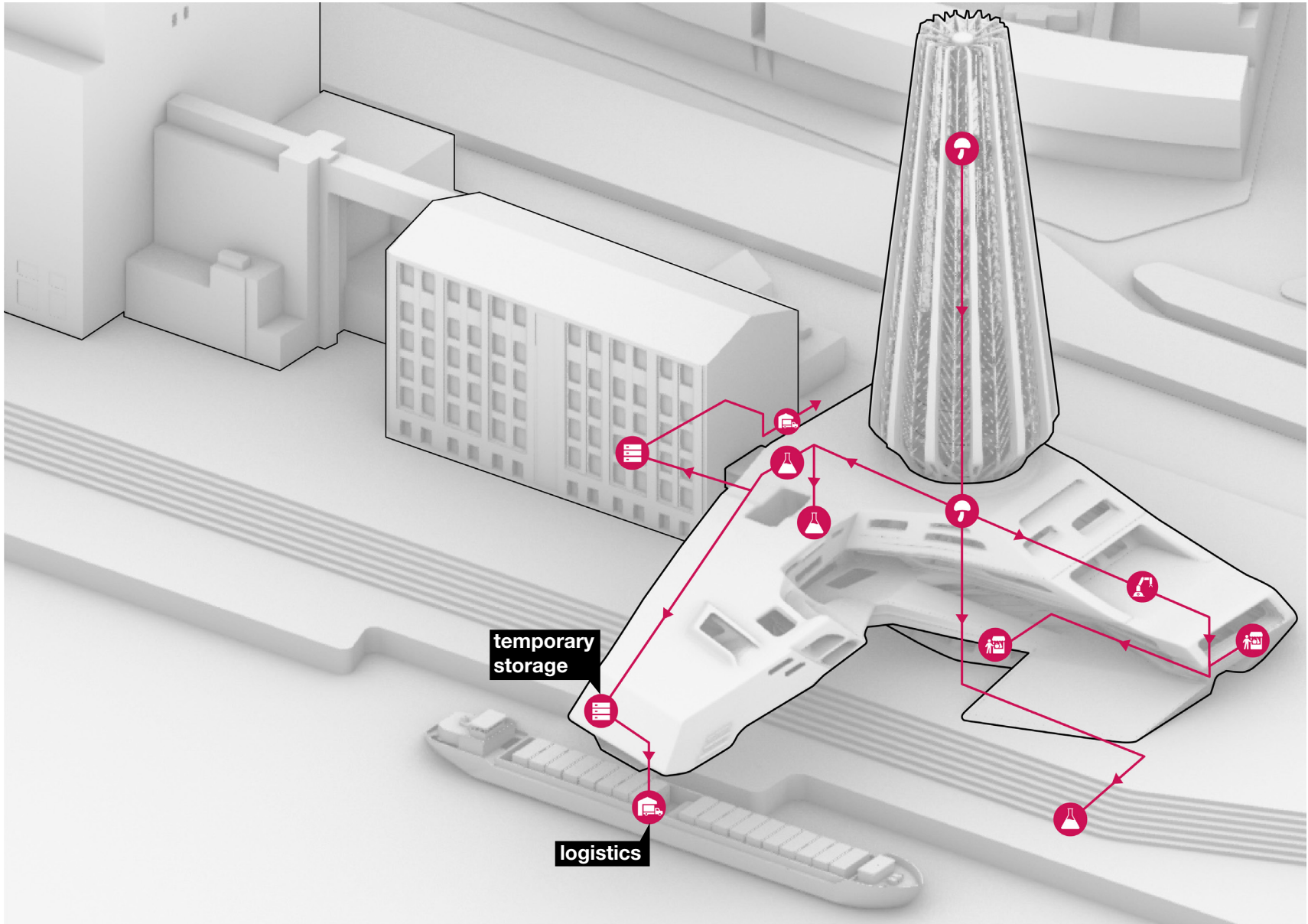


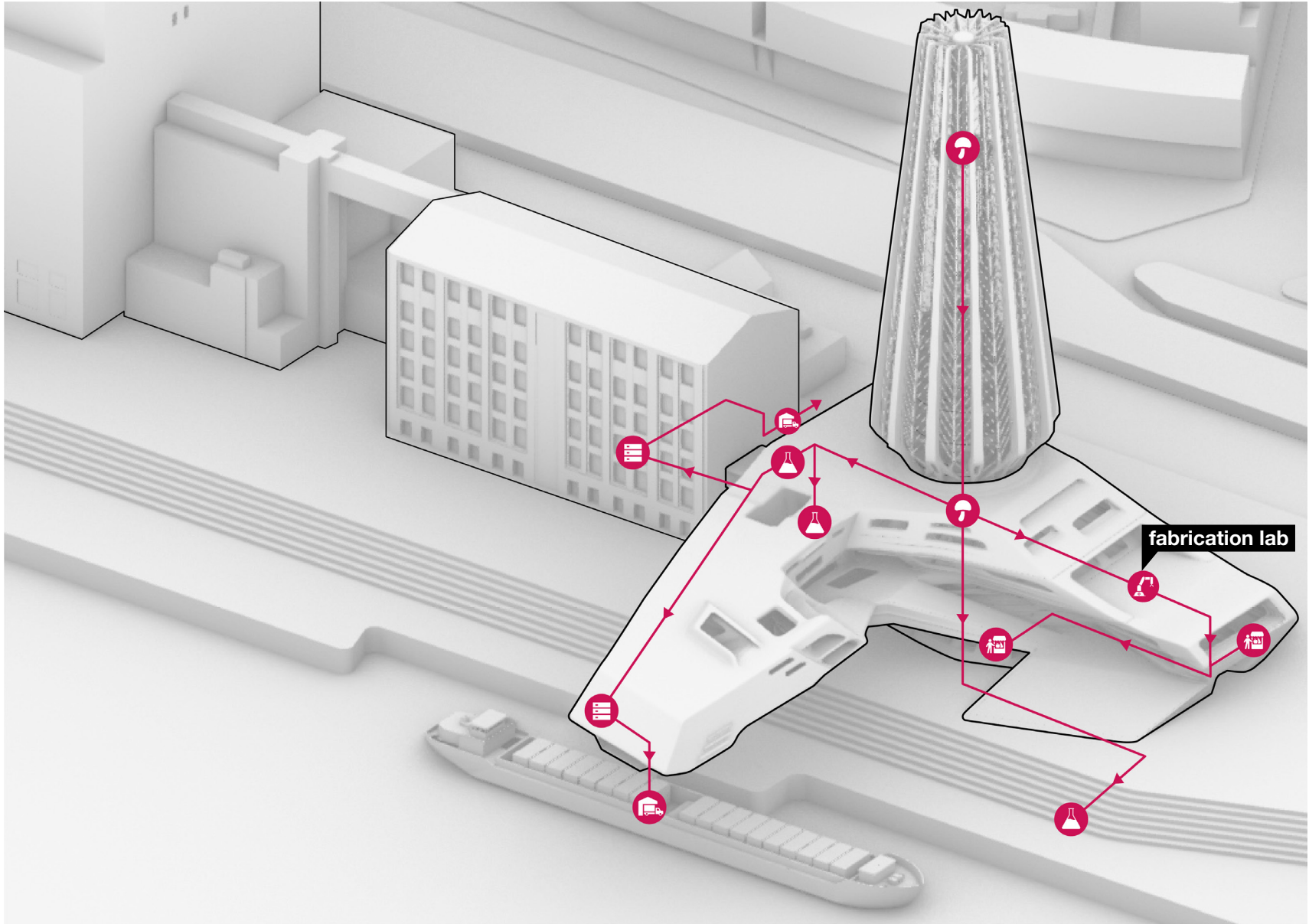


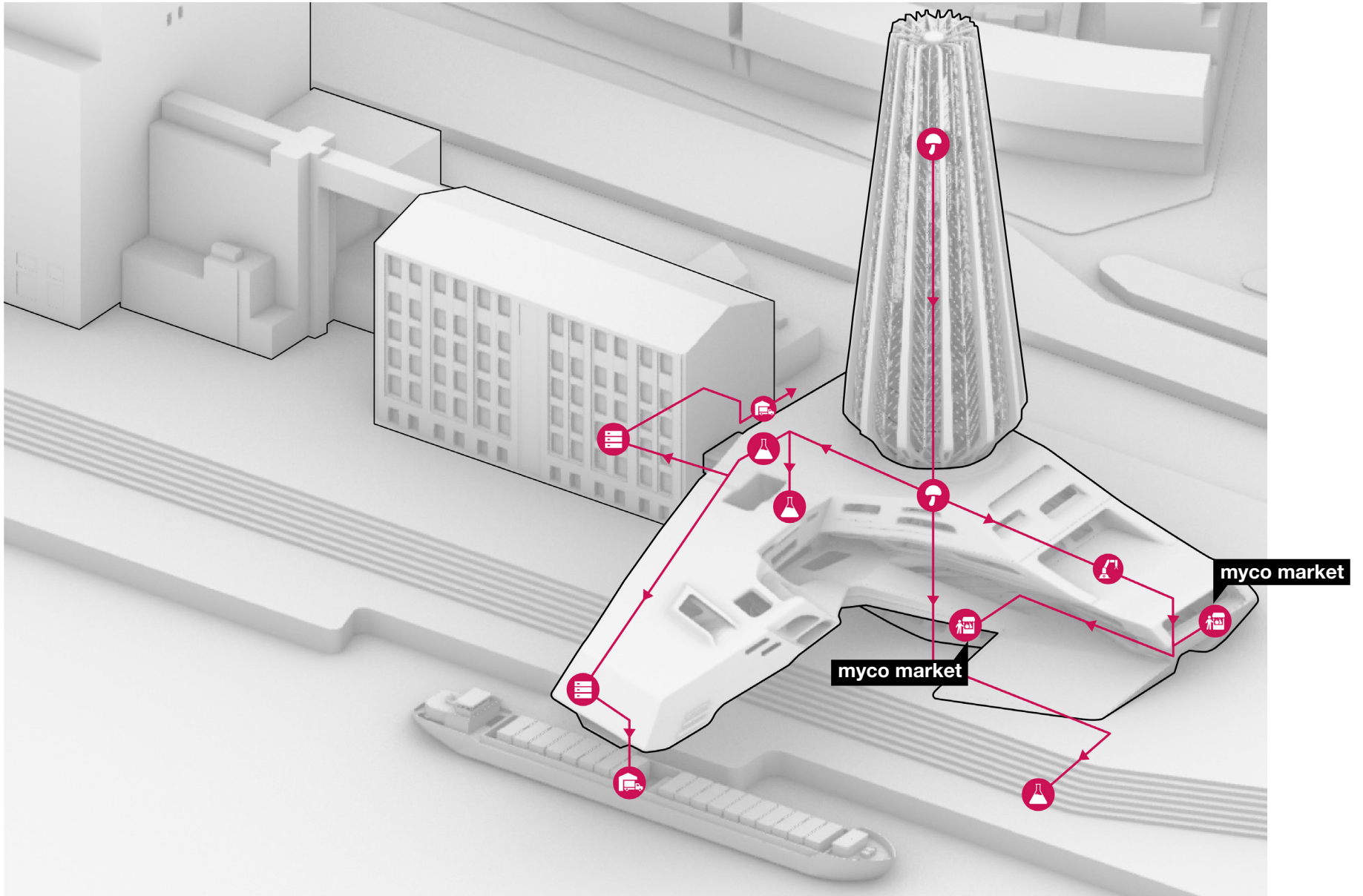




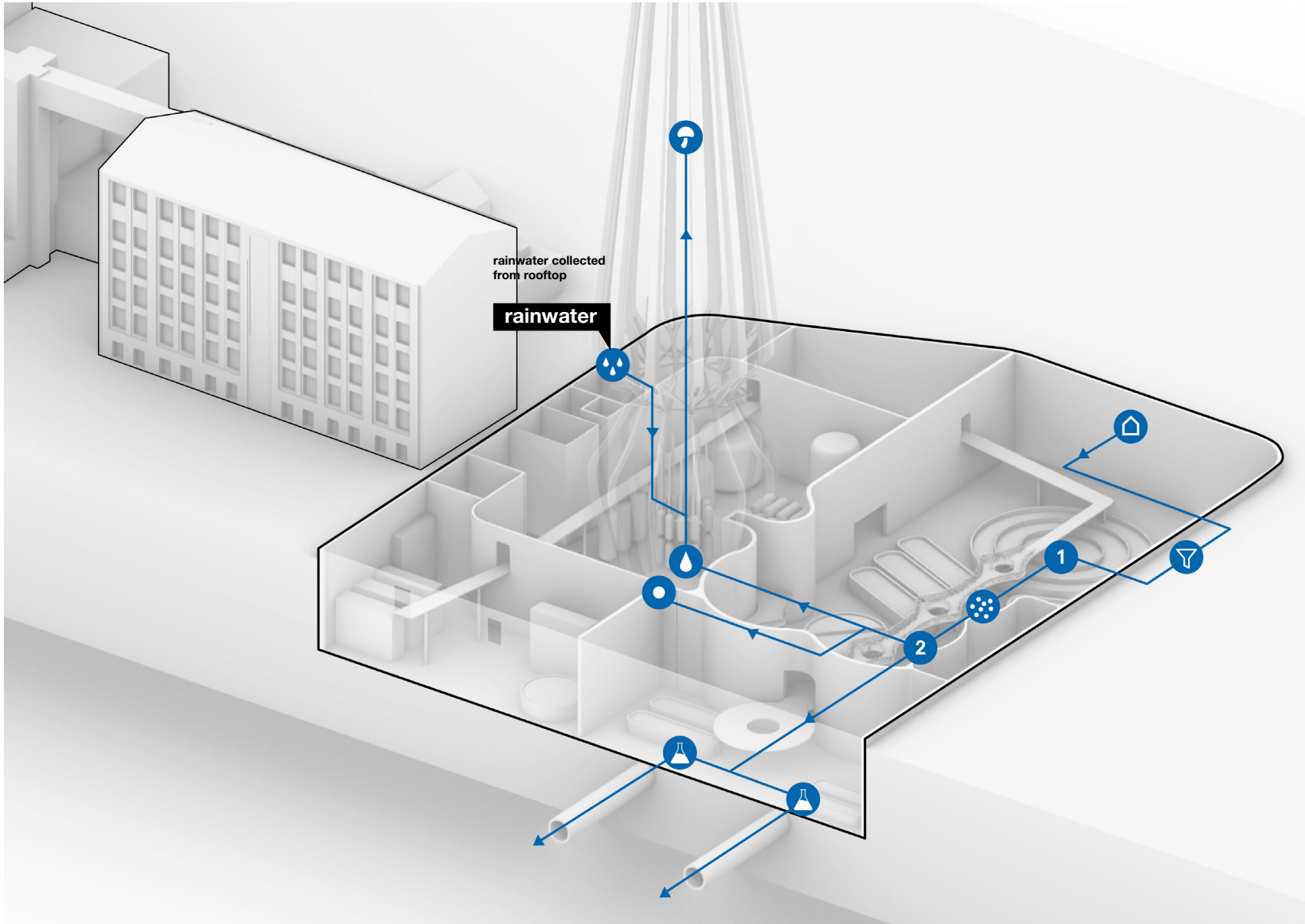


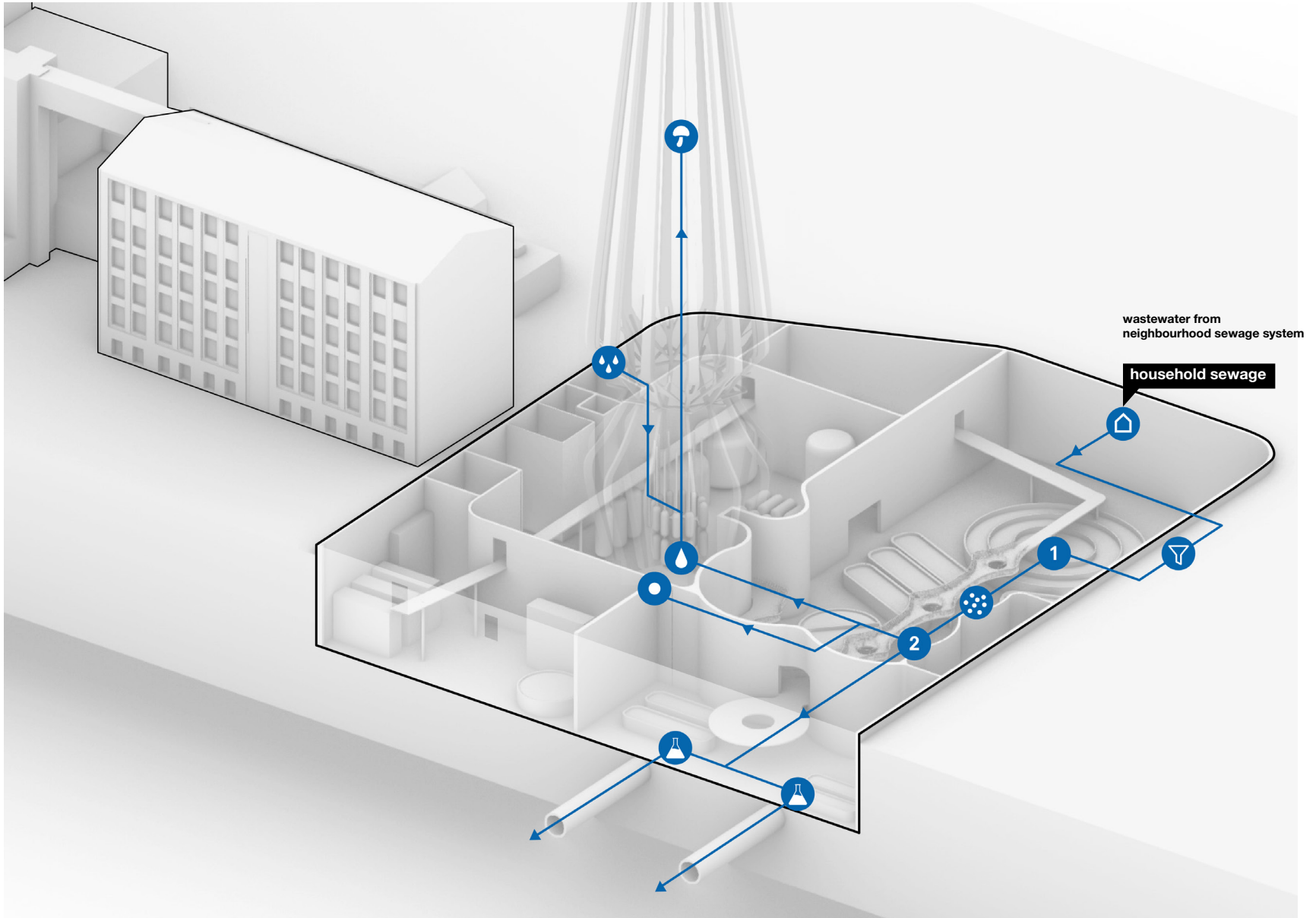


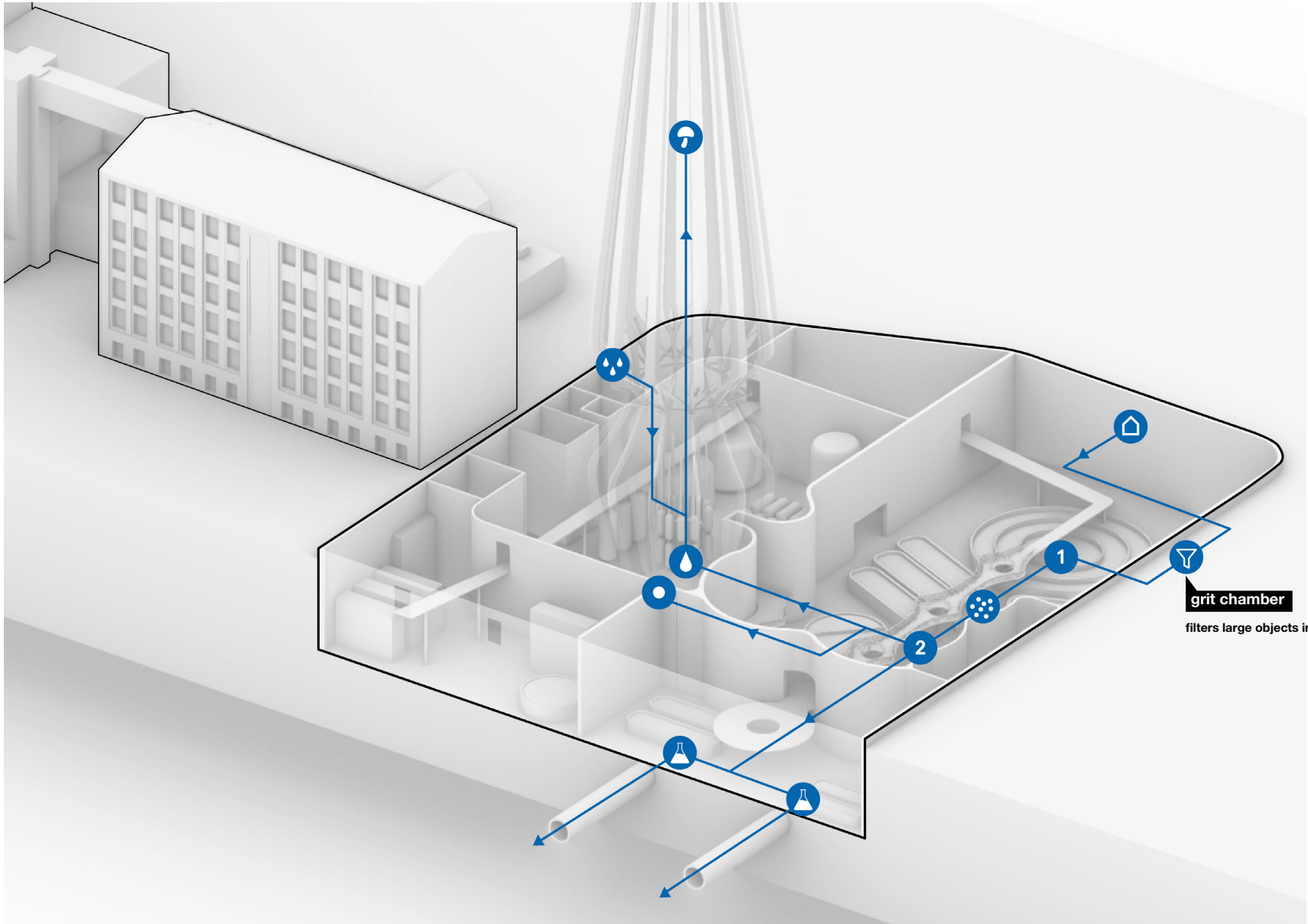


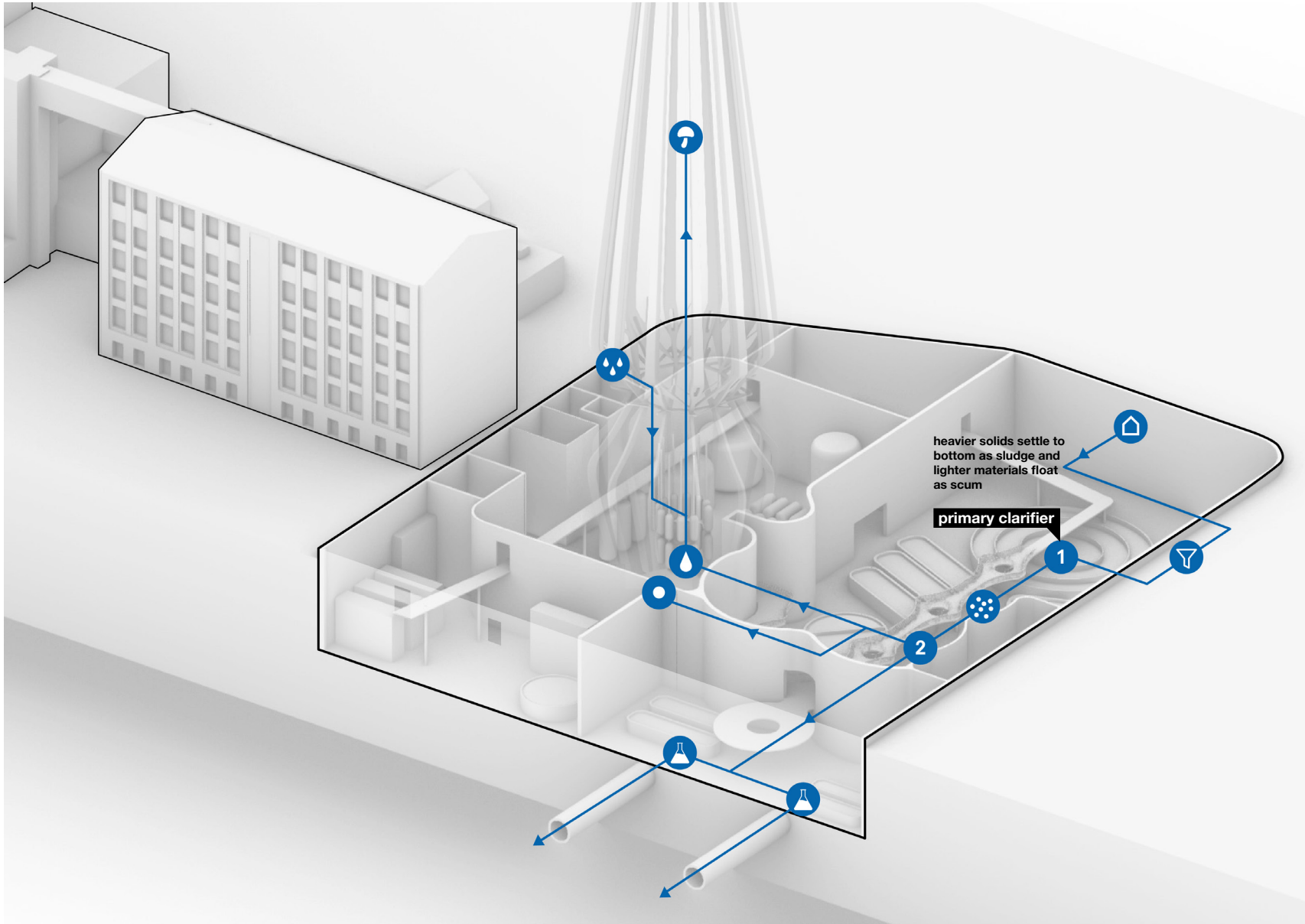


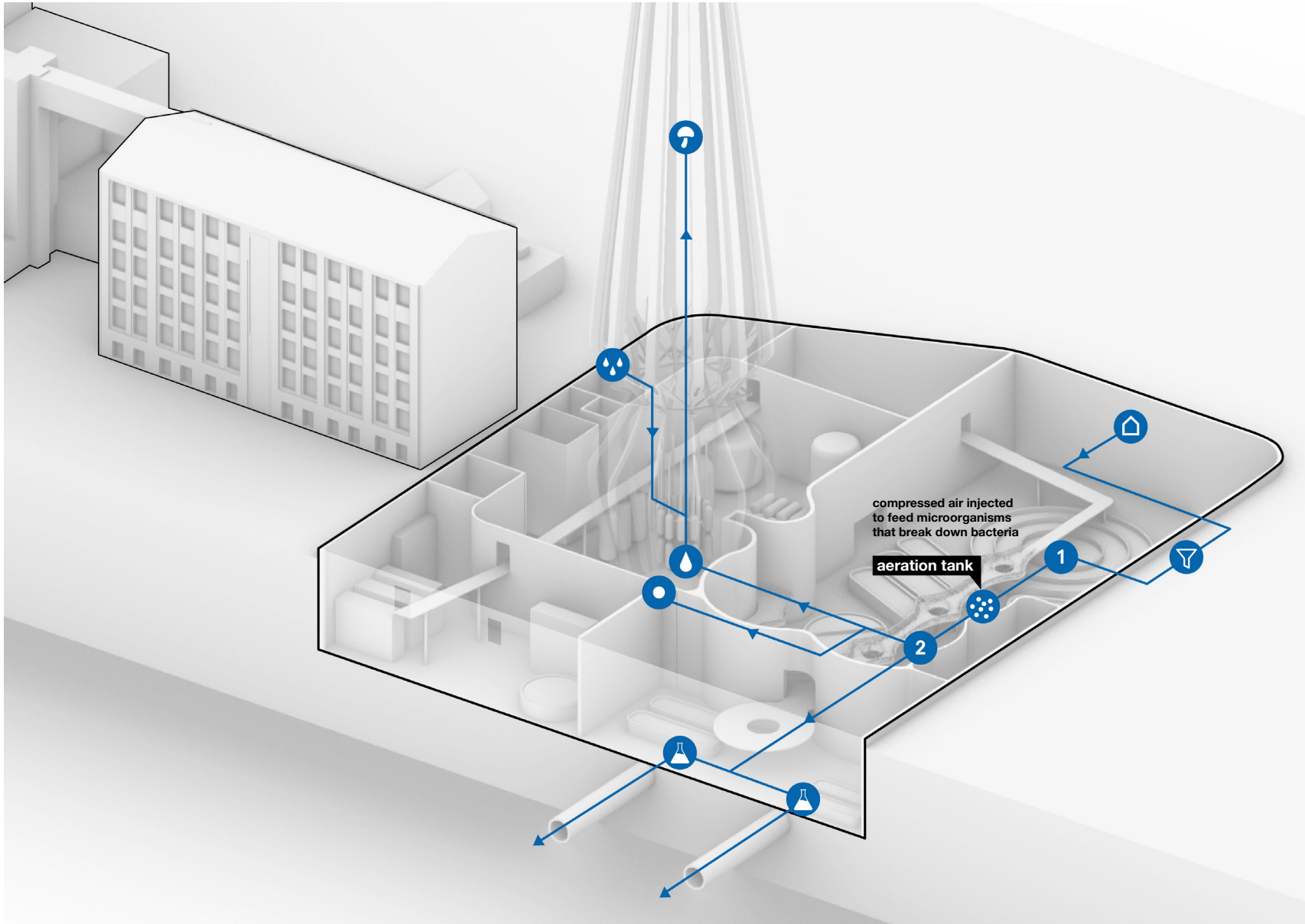


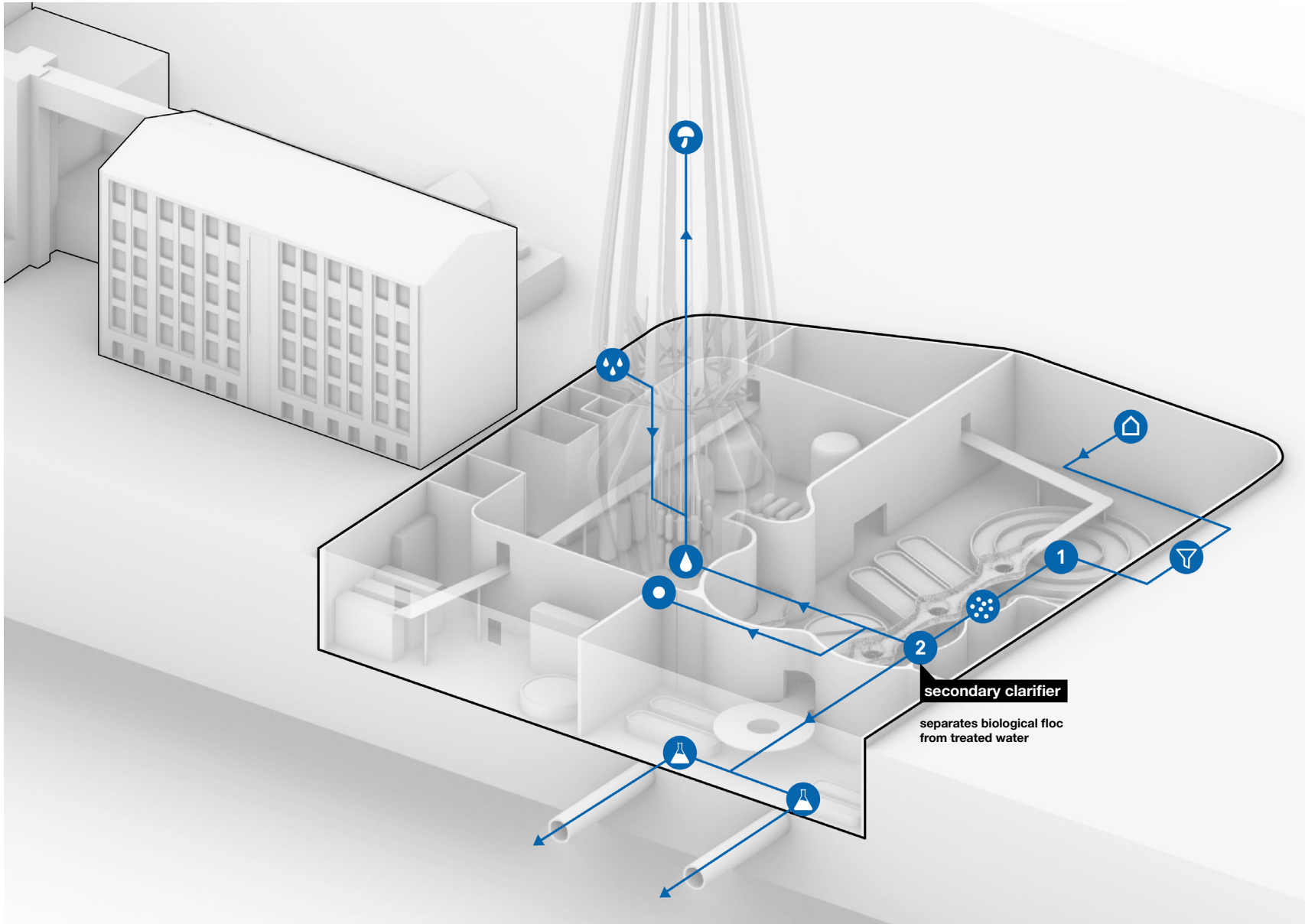


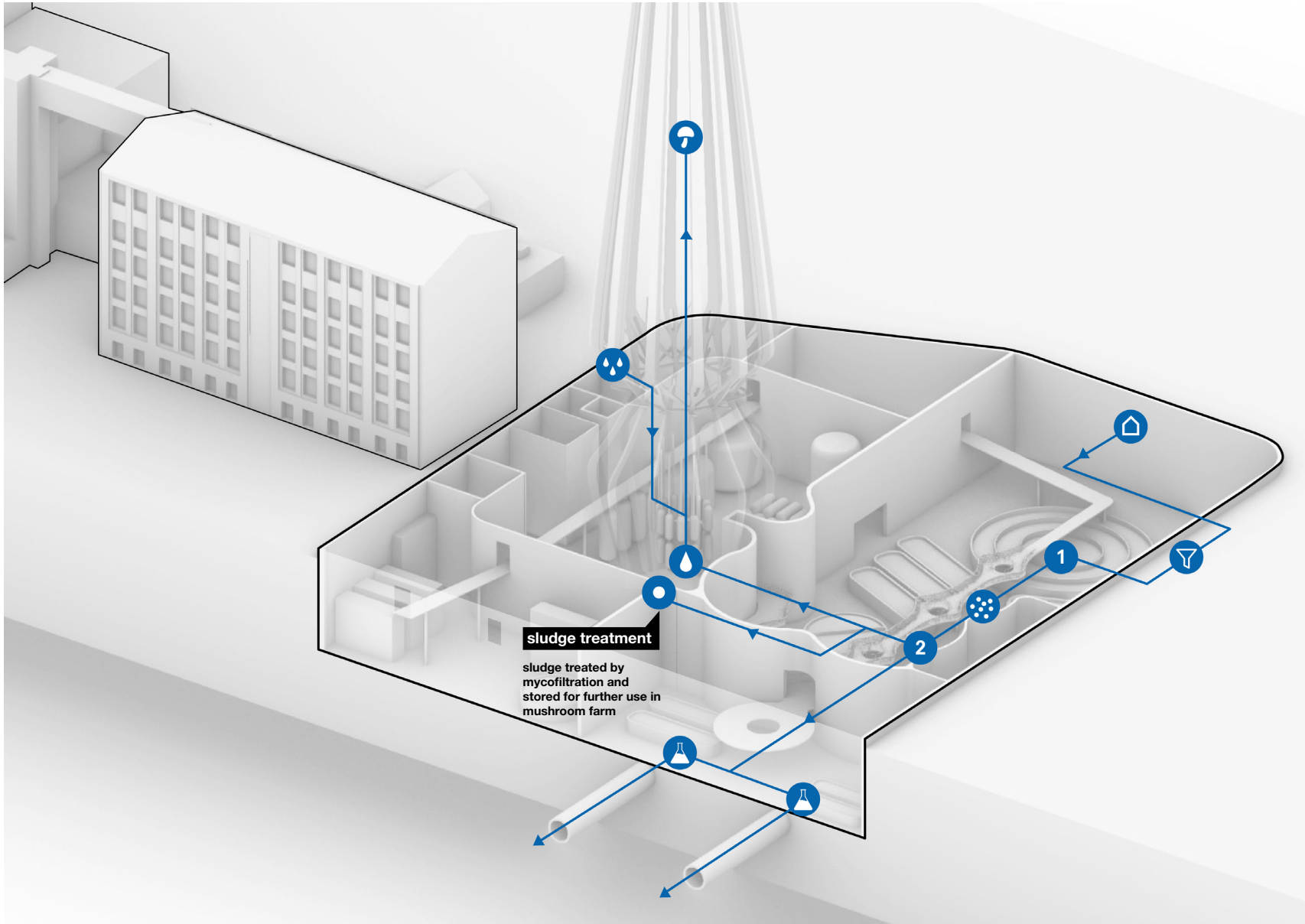


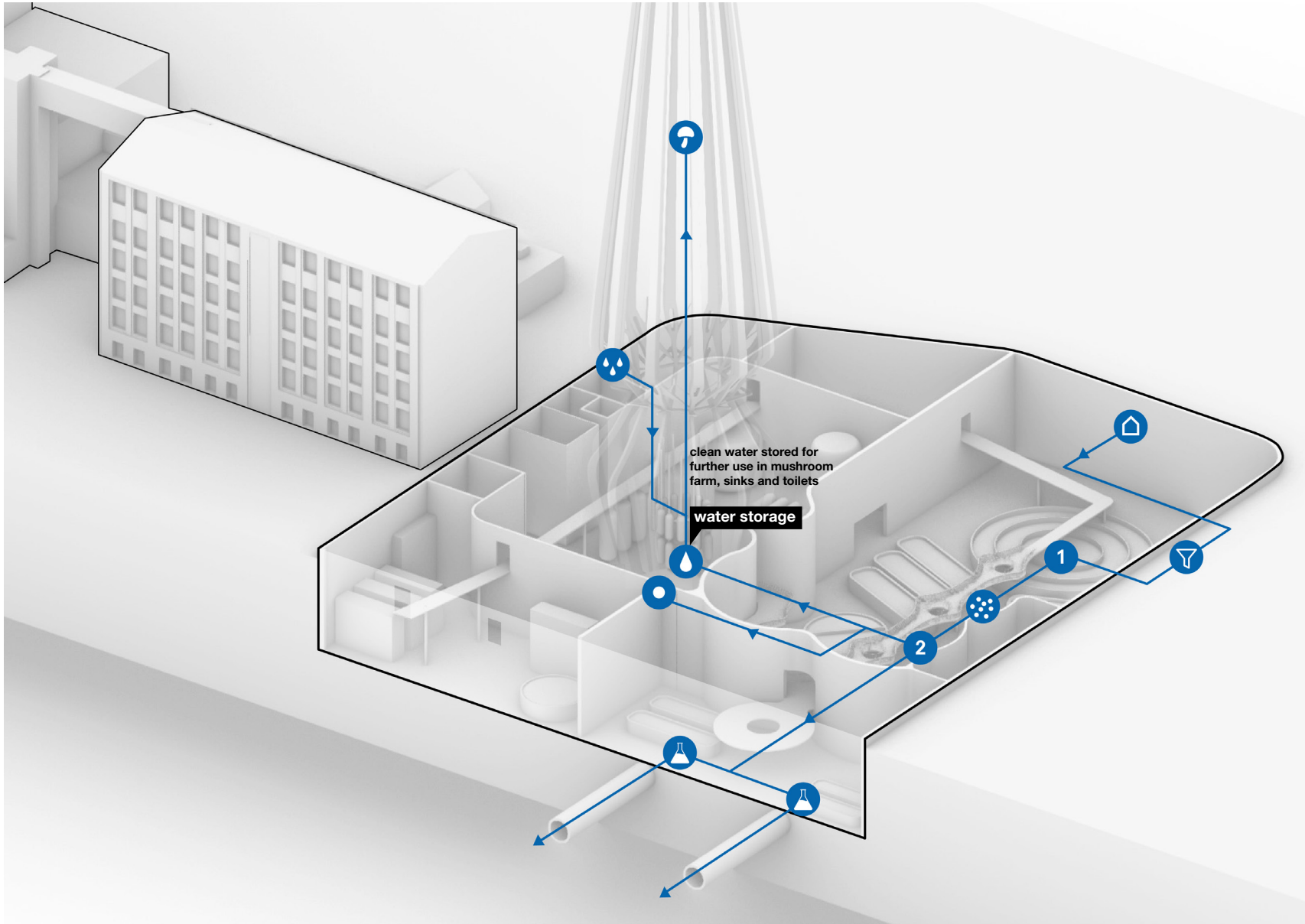




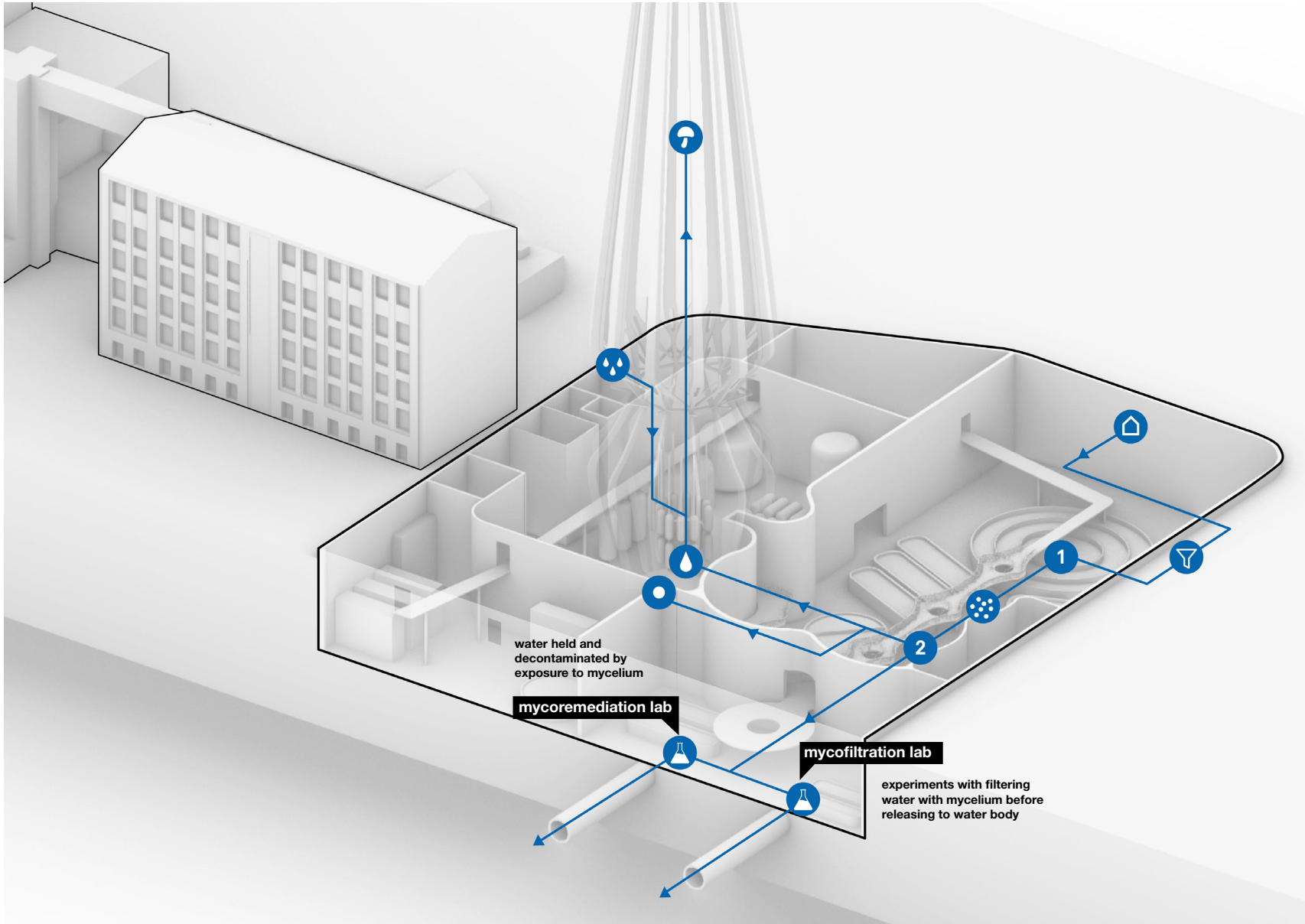


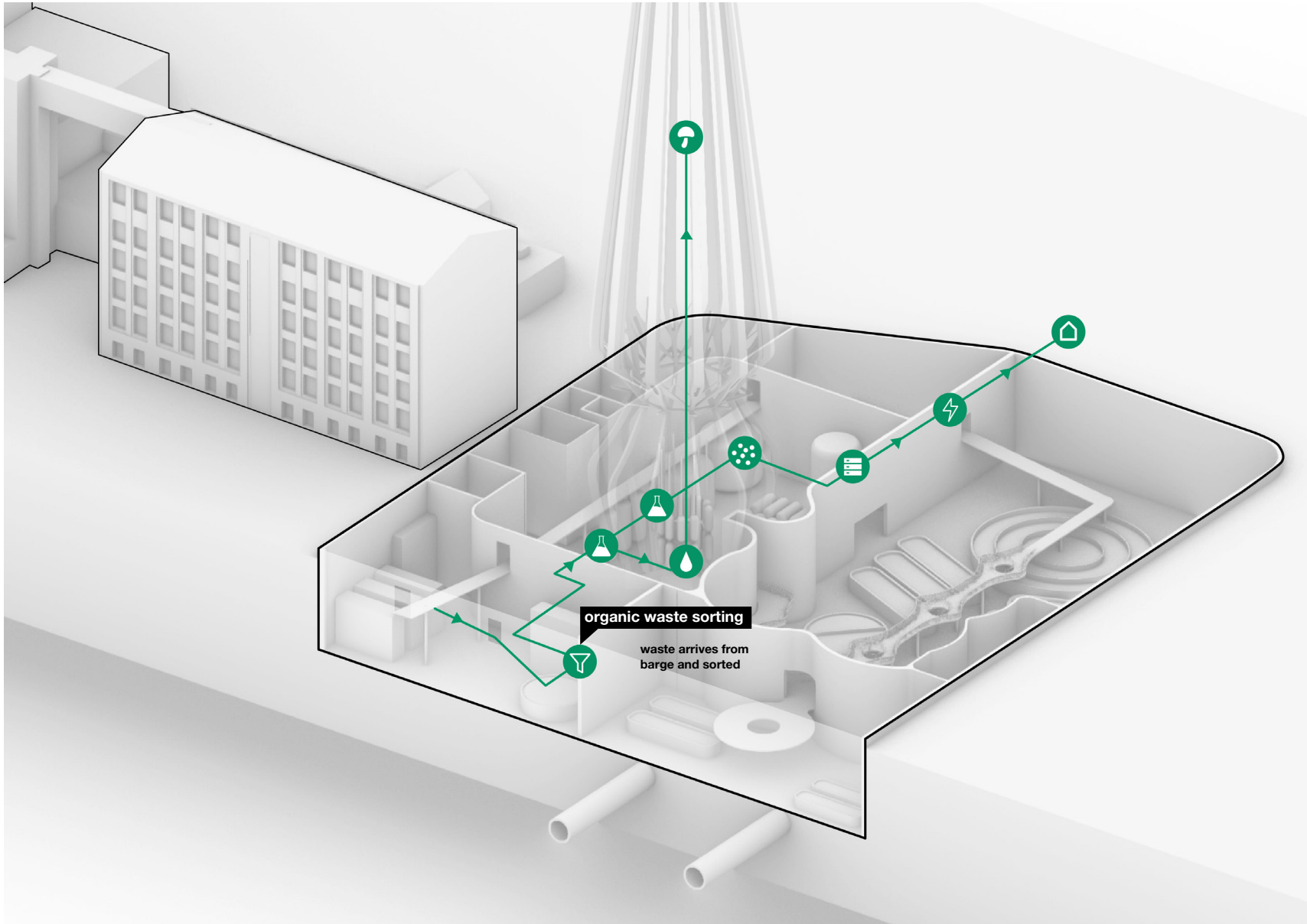


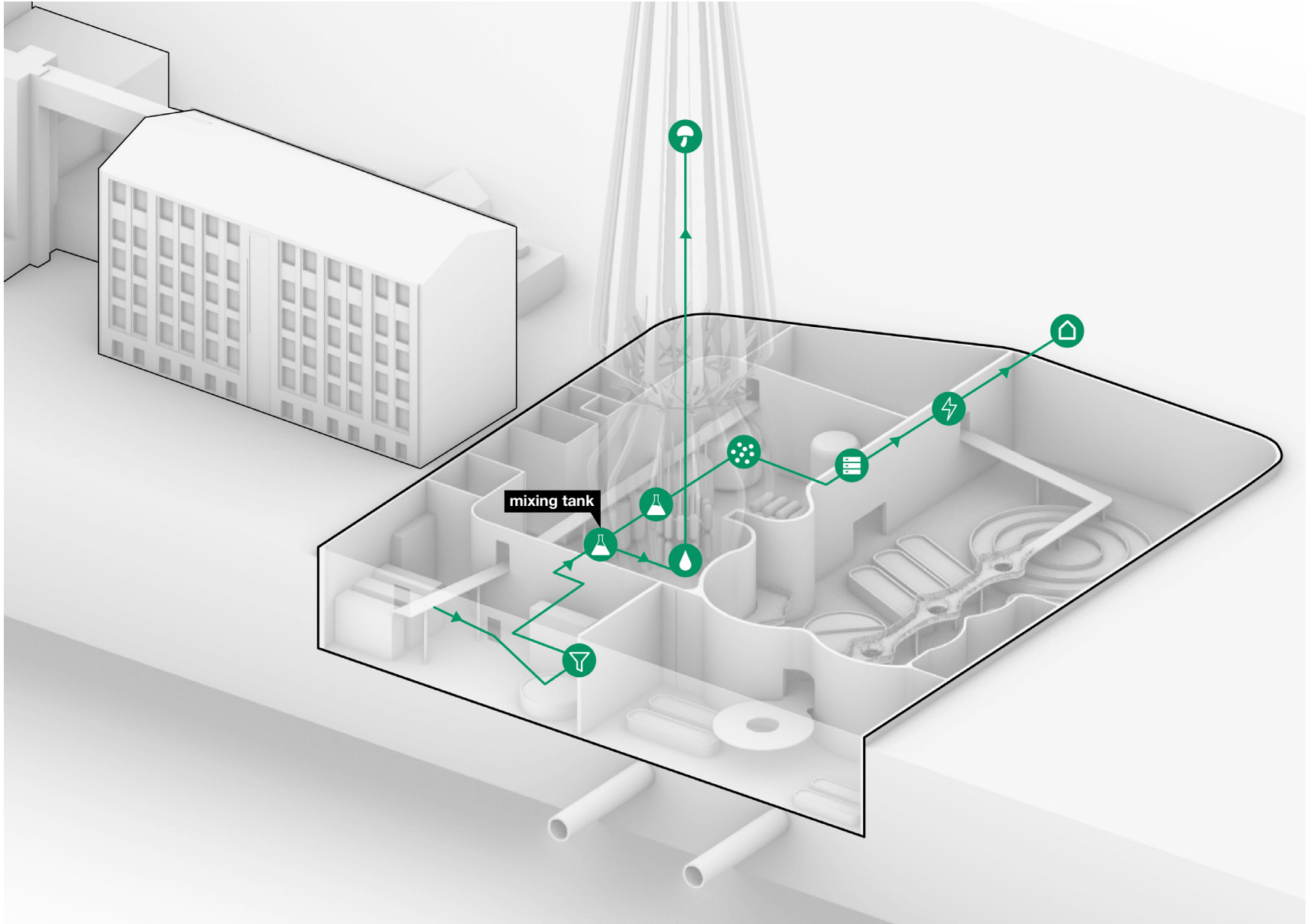


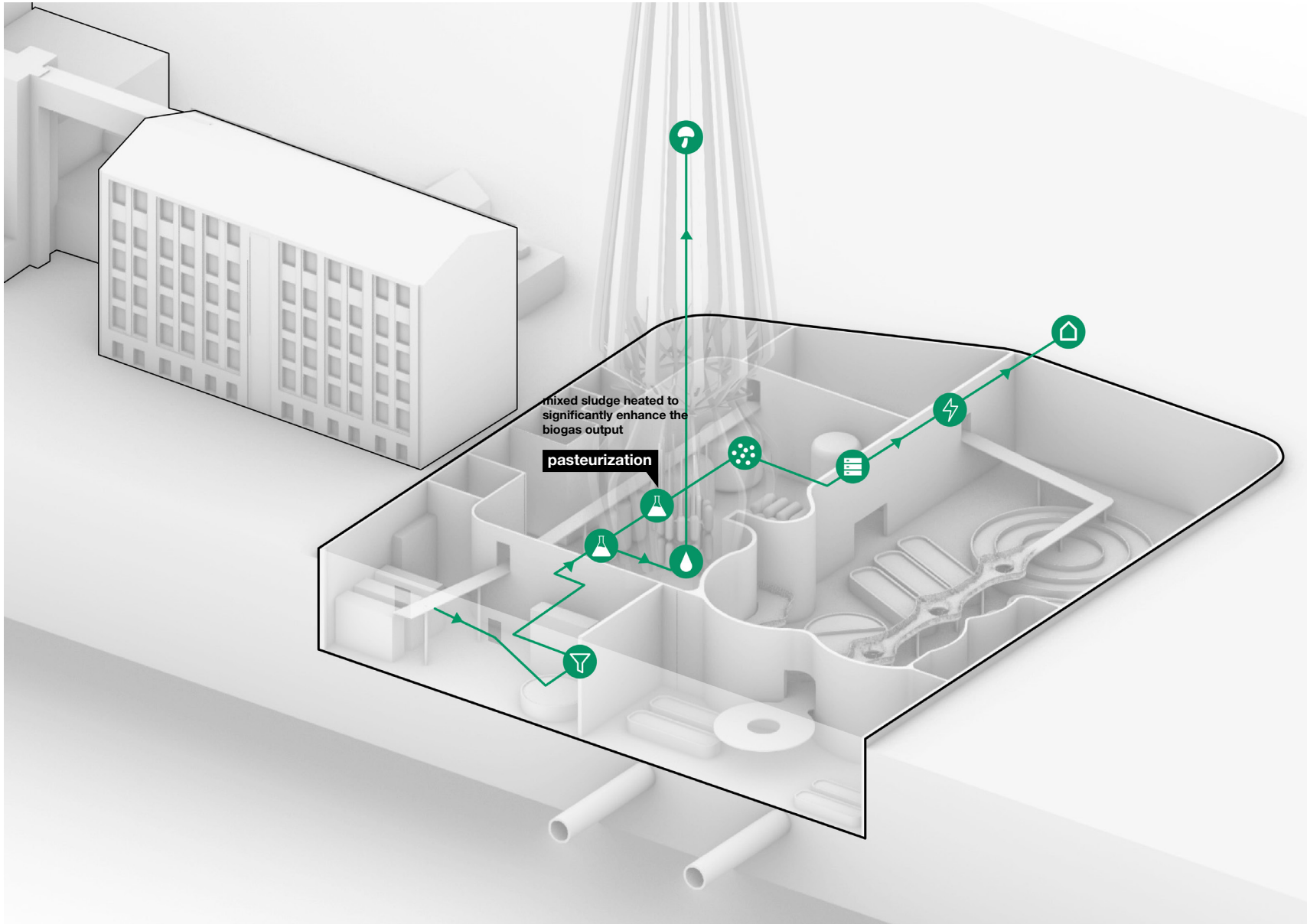


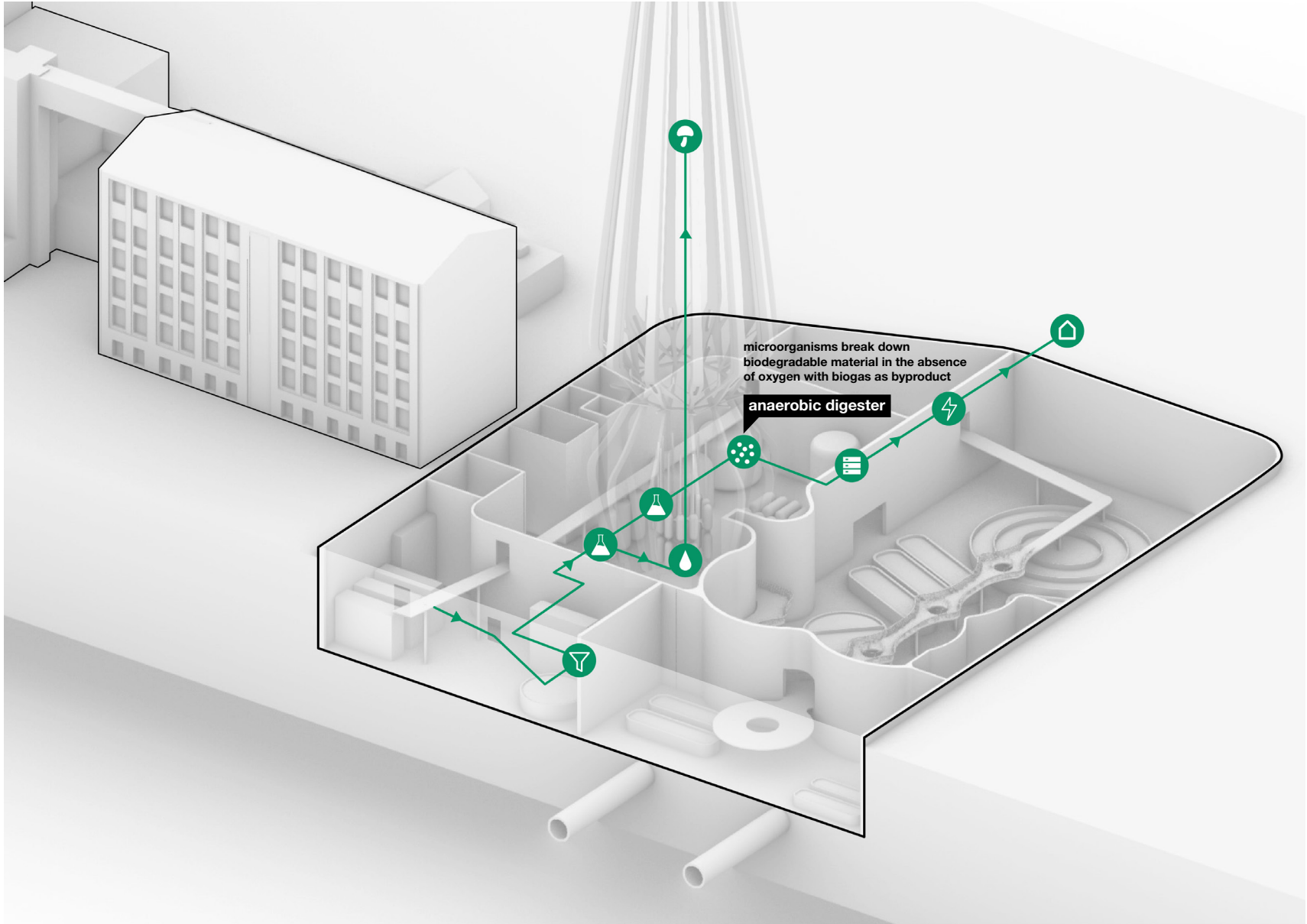


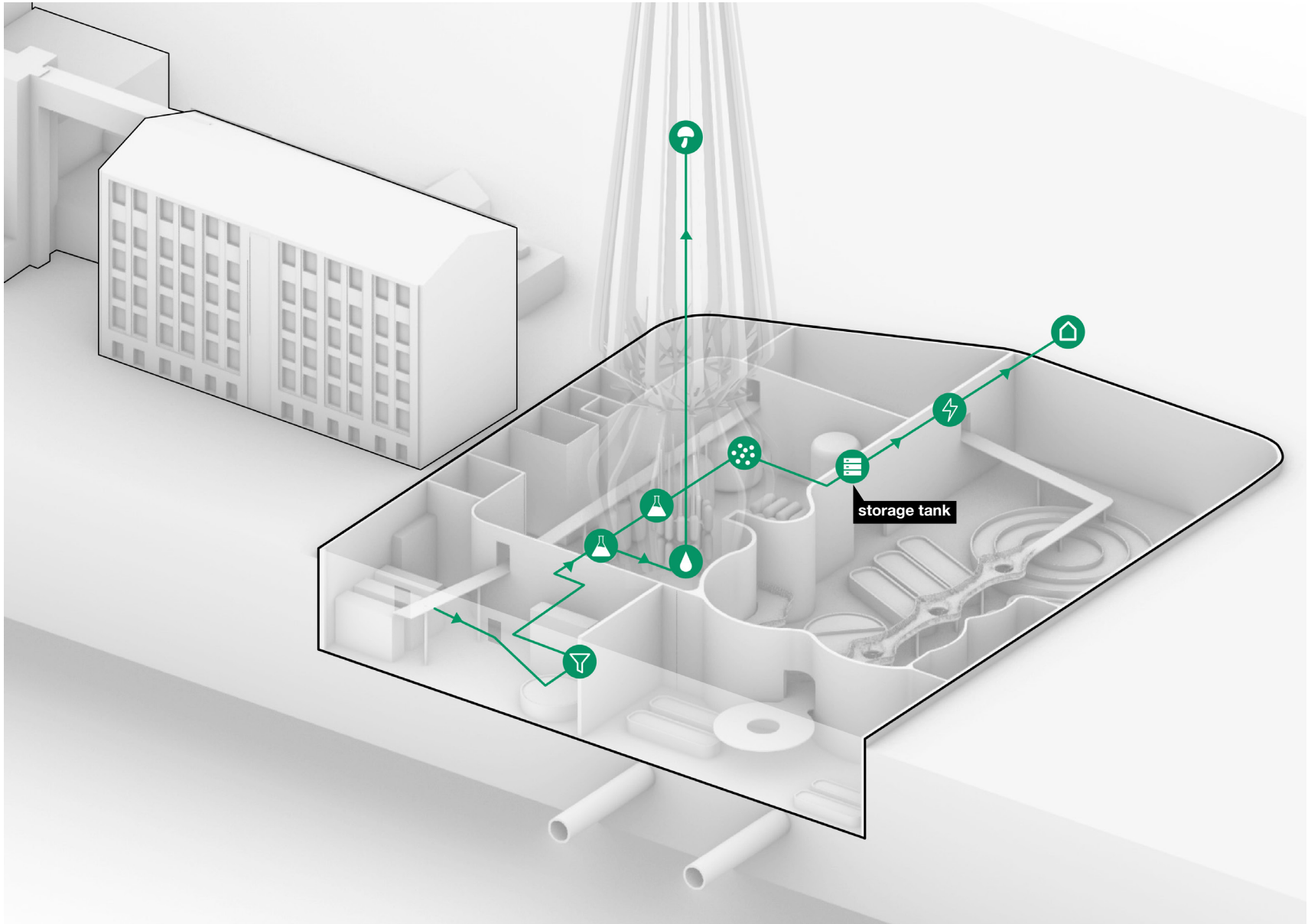


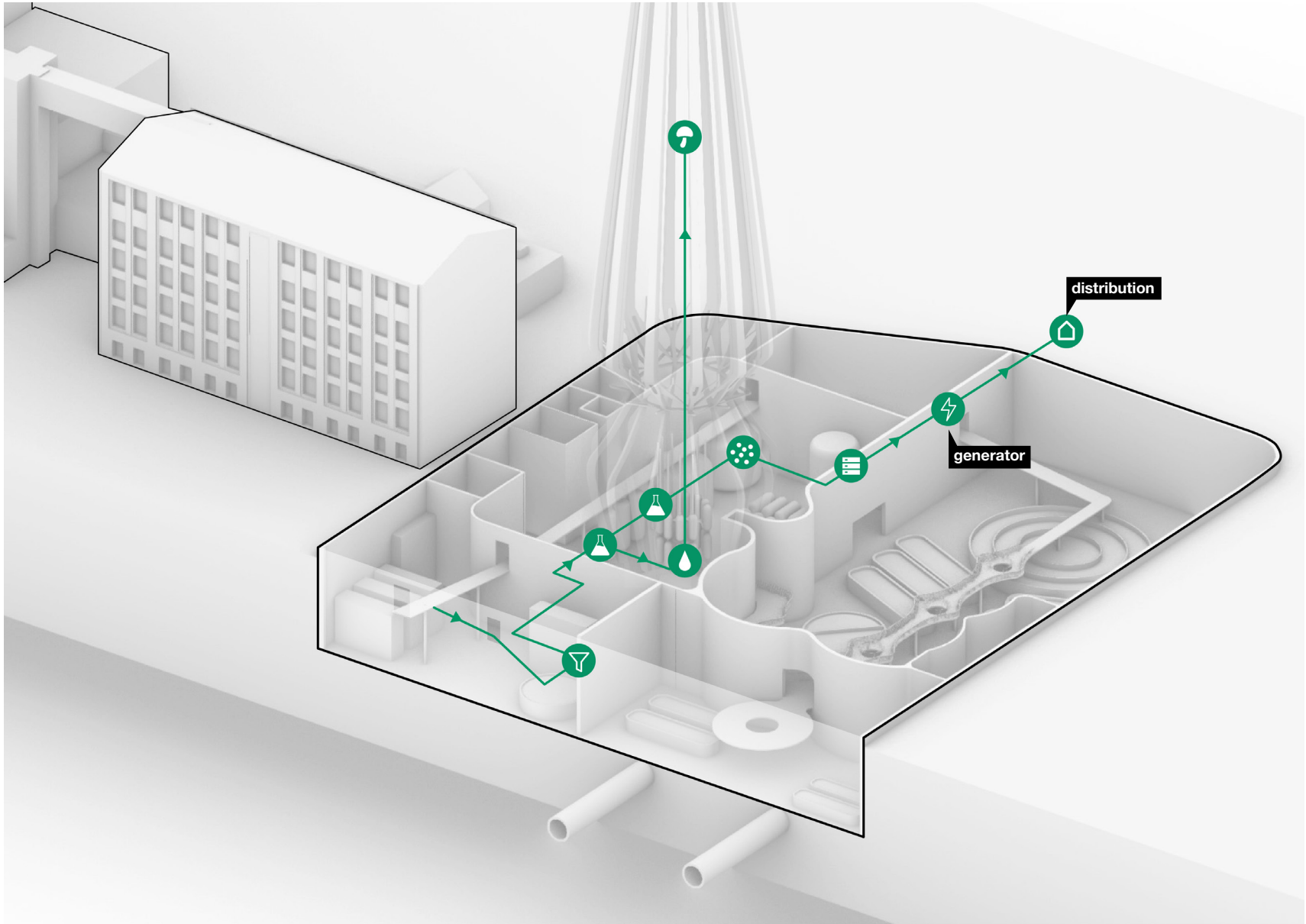












*introduction*

*research*

*design brief*

*concept*

*implementation*

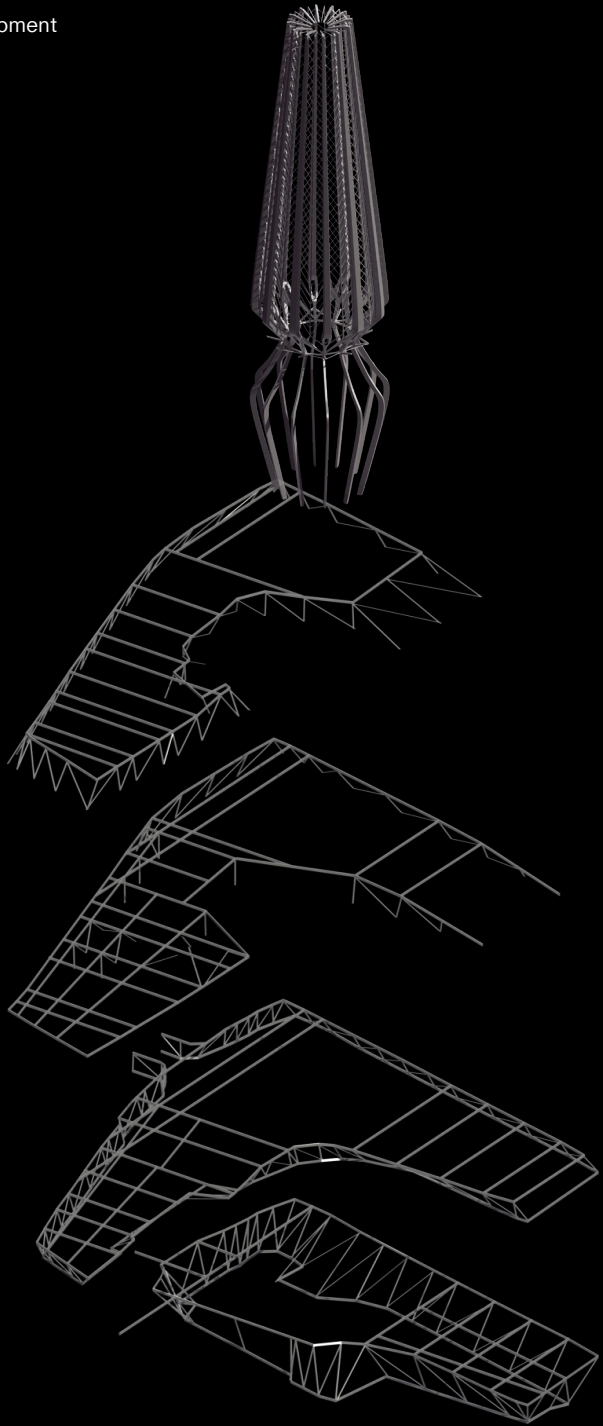
***development***

*visualisations*

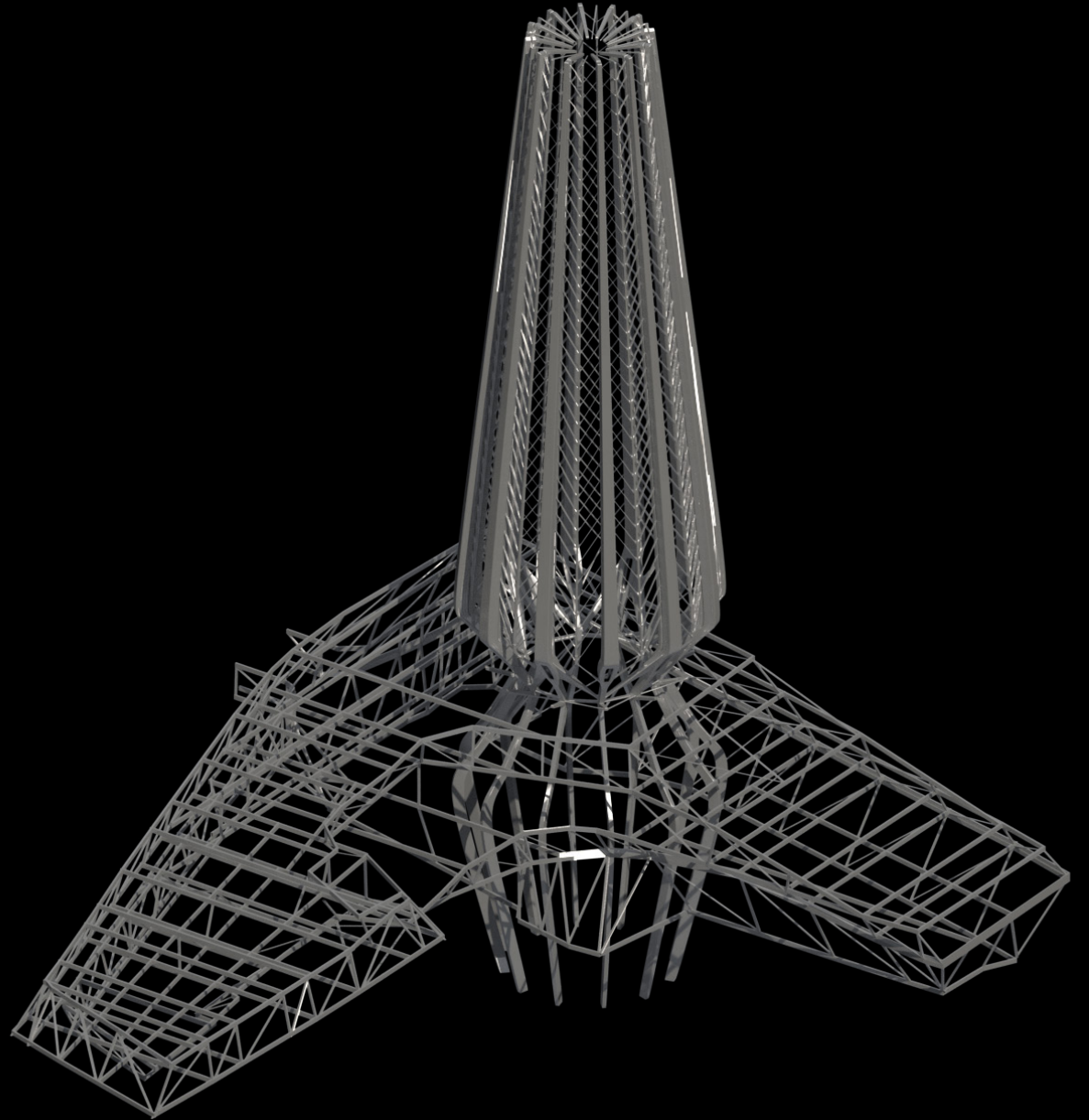
*conclusion*

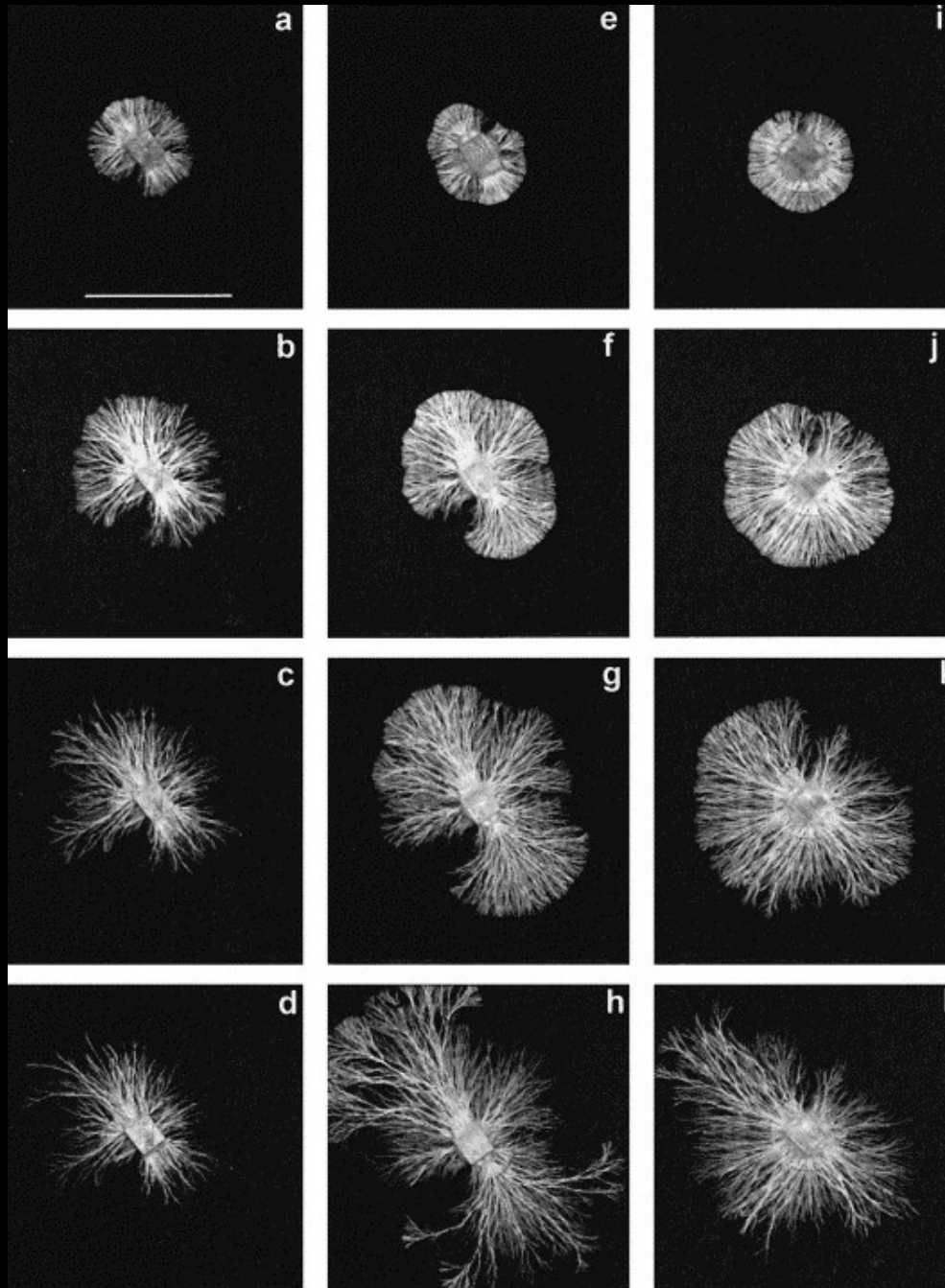


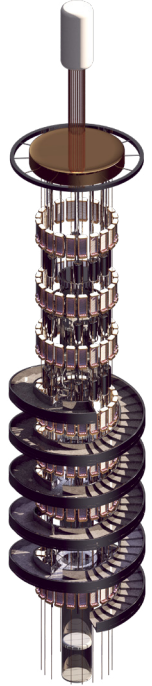
Development



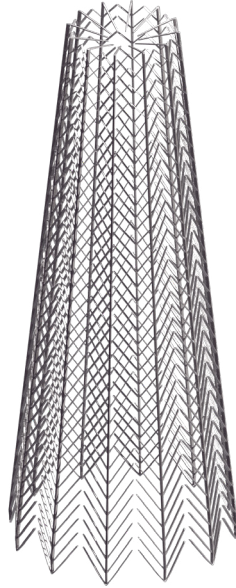
structure



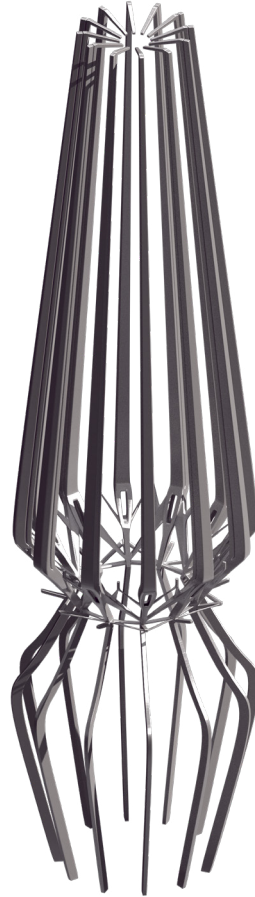




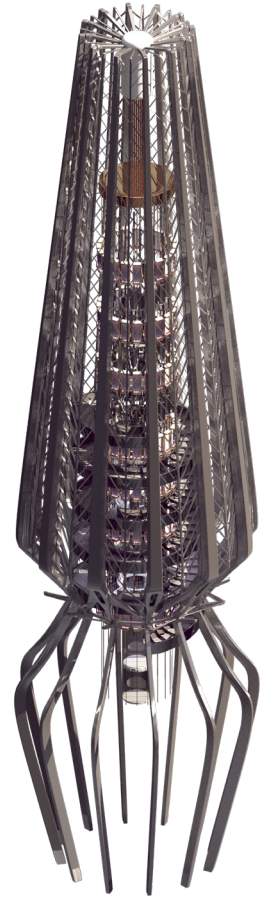
Staircase +  
mushroom farm



Secondary structure



Primary structure



Combined

**Daylight Optimization**

Daylight is maximised through the grand atrium with side openings and a large glass ceiling structure on the top floor.

**Water Cycle**

Not only is rainwater collection reused in toilets and irrigation, the underground wastewater treatment facility also cleans turn black water in the building into clean drinking water through mycofiltration and UV filter.

**Waste to Energy**

The electrical energy used in the building is provided by the underground organic waste-to-energy plant via anaerobic digestion. The excess energy produced is used to power residents in the neighbourhood.

**summer**

**Passive Ventilation**

Openings are designed to allow fresh air to enter the building while warm air exits through atriums and roof openings.

**Solar Panels**

Solar panels are placed on large roof surface and integrated into the tower facade.

**Chilled Slabs**

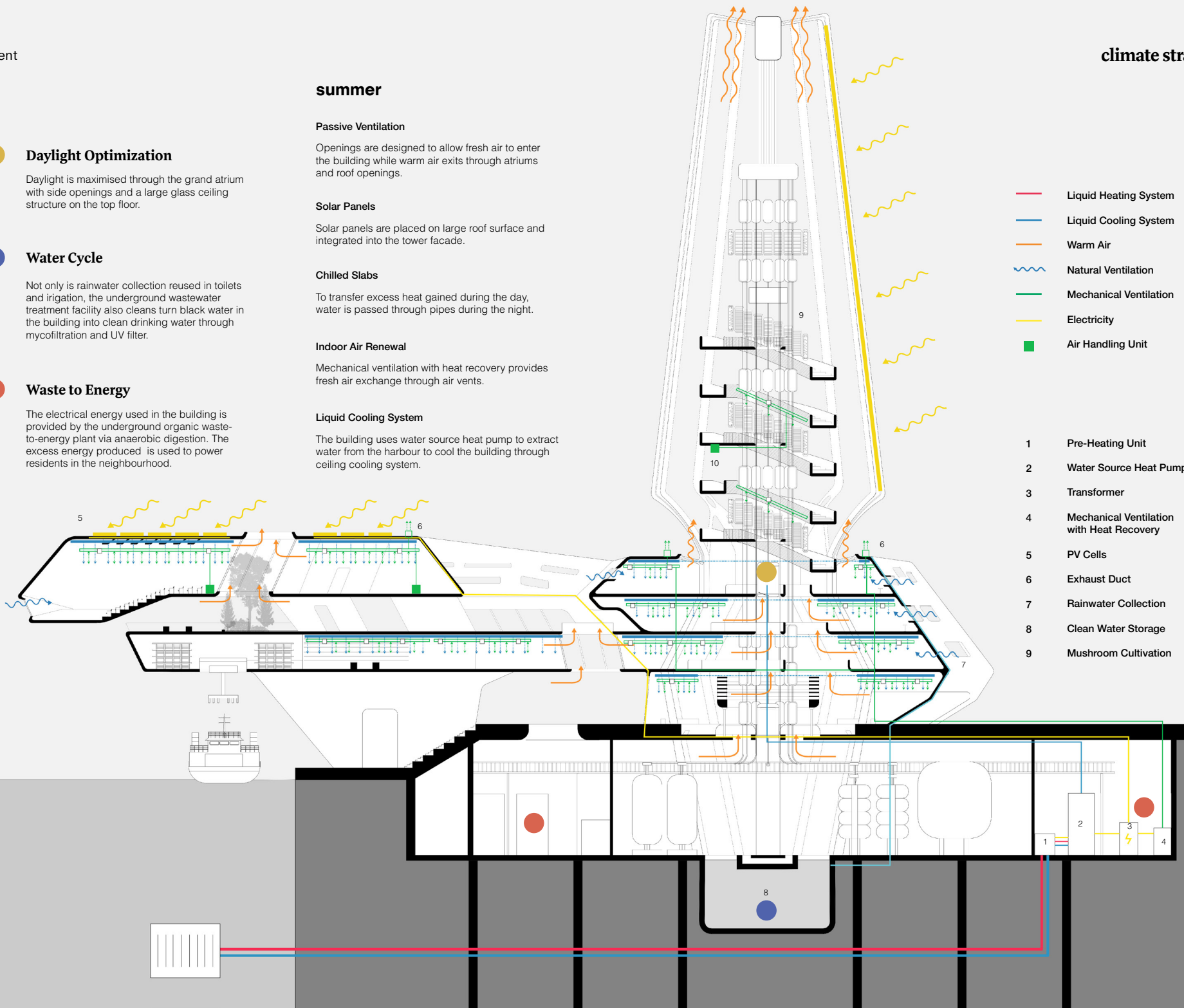
To transfer excess heat gained during the day, water is passed through pipes during the night.

**Indoor Air Renewal**

Mechanical ventilation with heat recovery provides fresh air exchange through air vents.

**Liquid Cooling System**

The building uses water source heat pump to extract water from the harbour to cool the building through ceiling cooling system.



- Liquid Heating System
- Liquid Cooling System
- Warm Air
- ~ Natural Ventilation
- Mechanical Ventilation
- Electricity
- Air Handling Unit

- 1 Pre-Heating Unit
- 2 Water Source Heat Pump
- 3 Transformer
- 4 Mechanical Ventilation with Heat Recovery
- 5 PV Cells
- 6 Exhaust Duct
- 7 Rainwater Collection
- 8 Clean Water Storage
- 9 Mushroom Cultivation

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The electrical energy used in the building is provided by the underground organic waste-to-energy plant via anaerobic digestion. The excess energy produced is used to power residents in the neighbourhood.

**winter**

**Moisture Control**

During winter days, moisture is mechanically extracted and reused in the vertical mushroom farm.

**Mycelium Thermal Insulation**

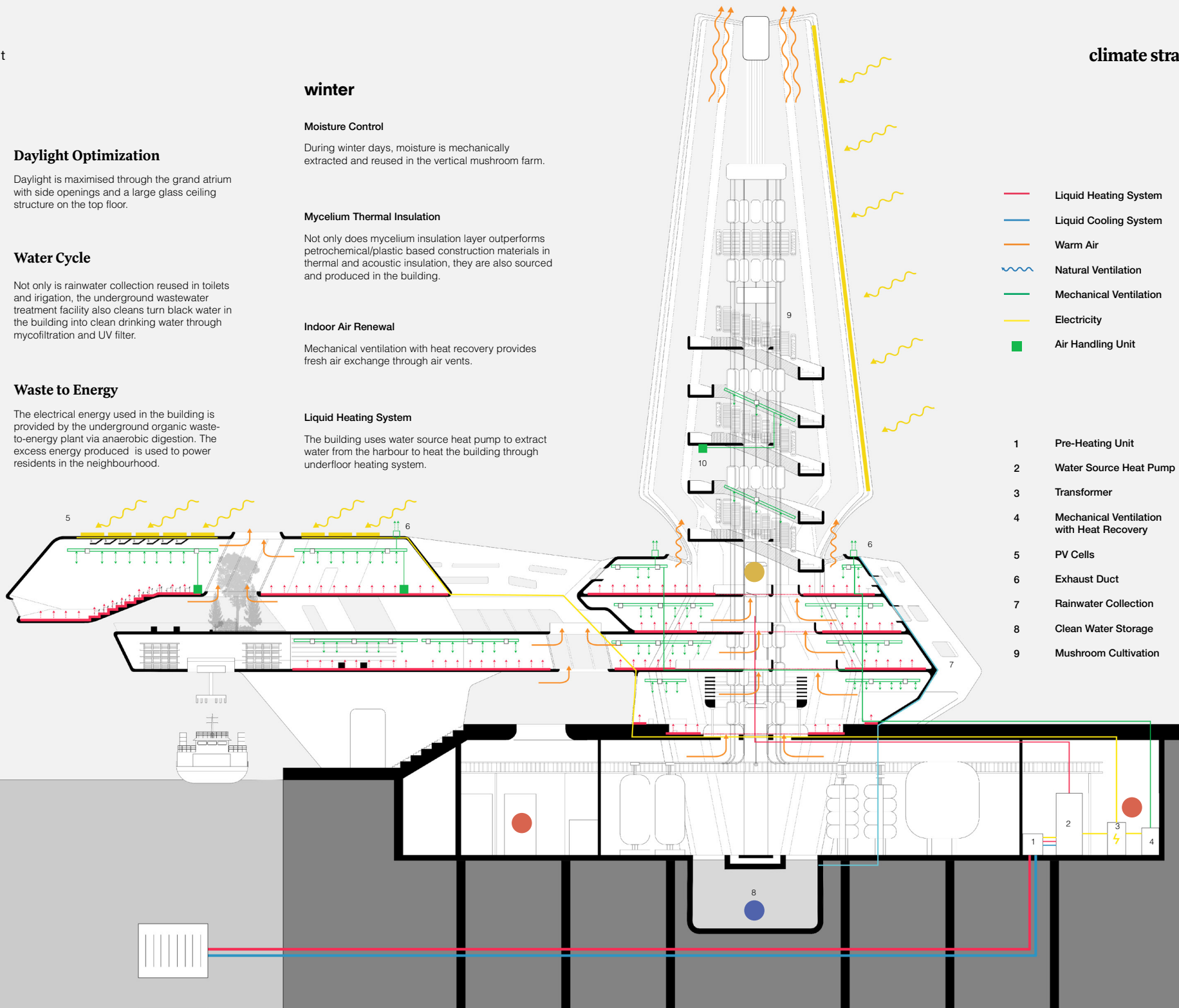
Not only does mycelium insulation layer outperforms petrochemical/plastic based construction materials in thermal and acoustic insulation, they are also sourced and produced in the building.

**Indoor Air Renewal**

Mechanical ventilation with heat recovery provides fresh air exchange through air vents.

**Liquid Heating System**

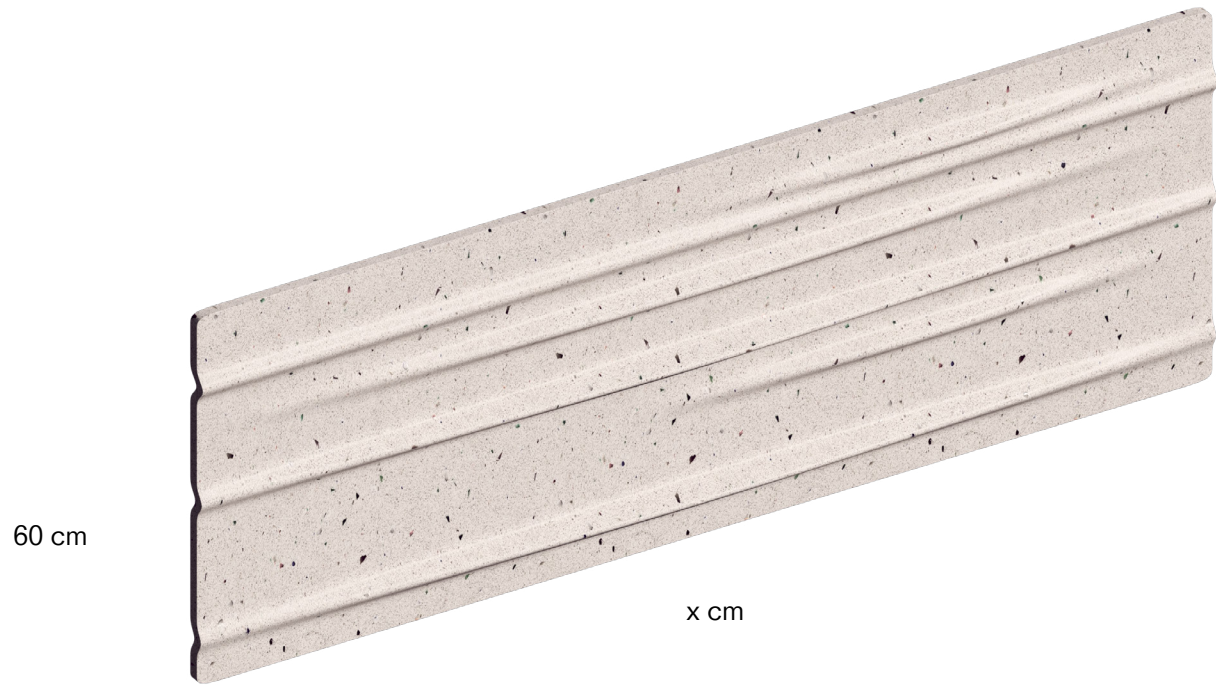
The building uses water source heat pump to extract water from the harbour to heat the building through underfloor heating system.



- Liquid Heating System
- Liquid Cooling System
- Warm Air
- ~ Natural Ventilation
- Mechanical Ventilation
- Electricity
- Air Handling Unit

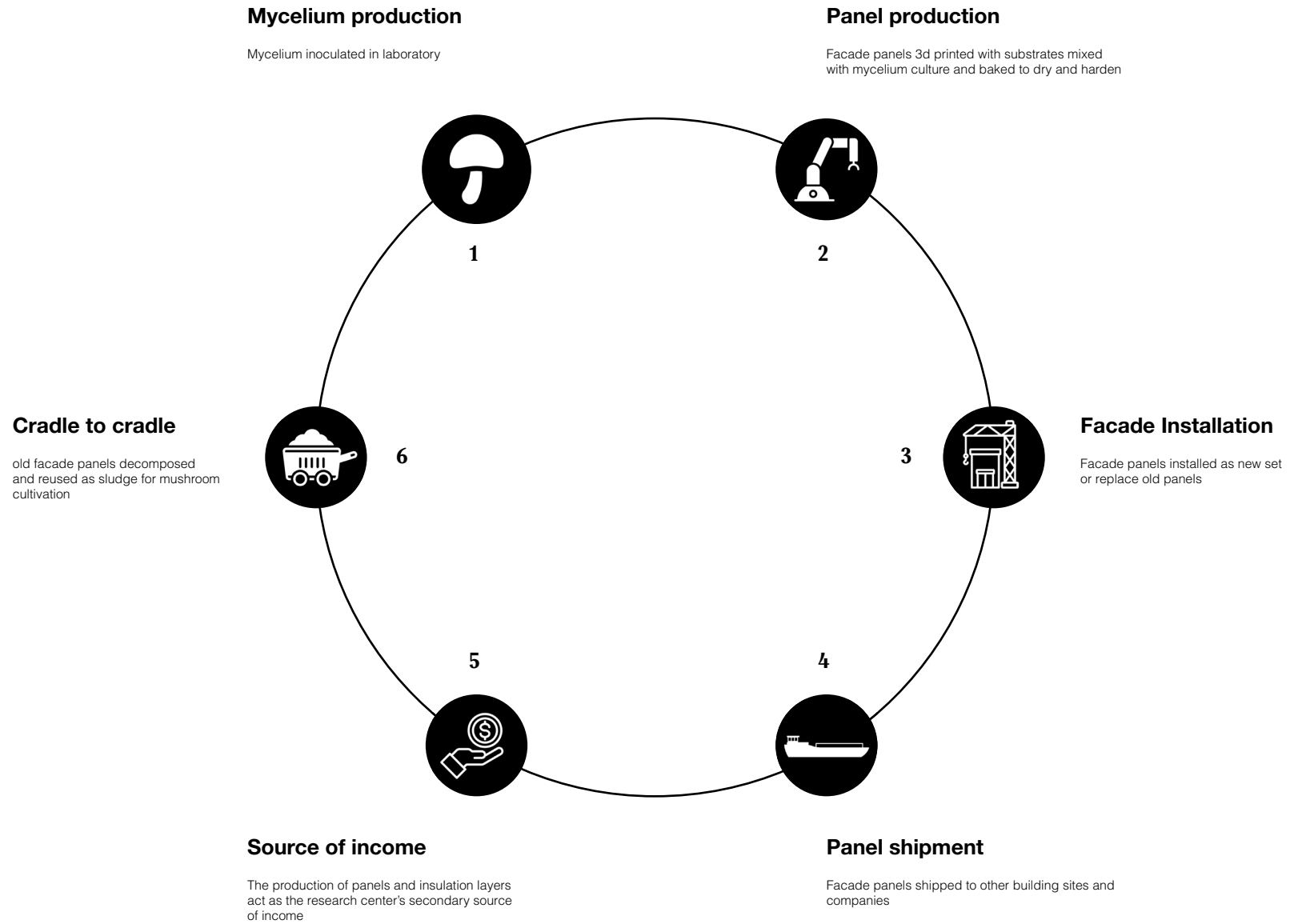
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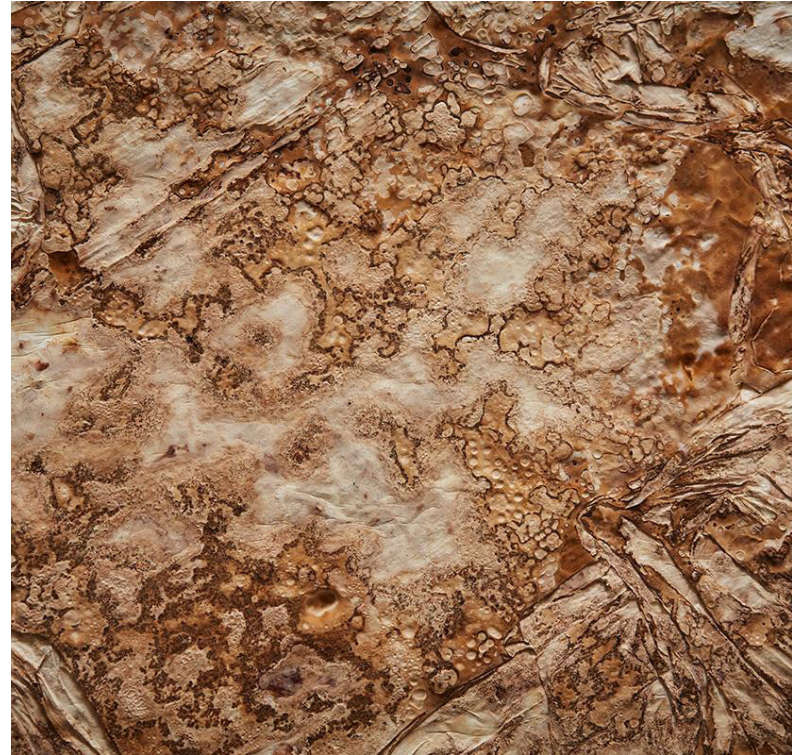
**Mycelium composite facade panel**



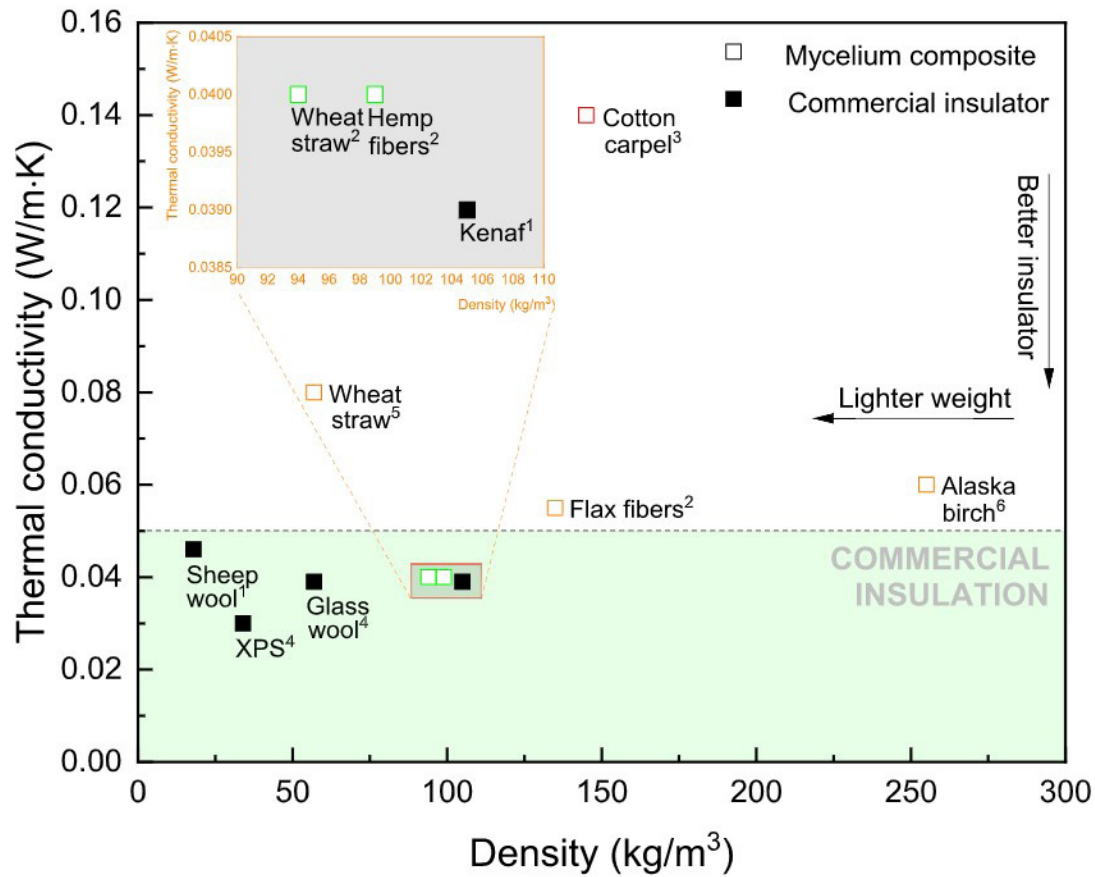
60 cm

x cm





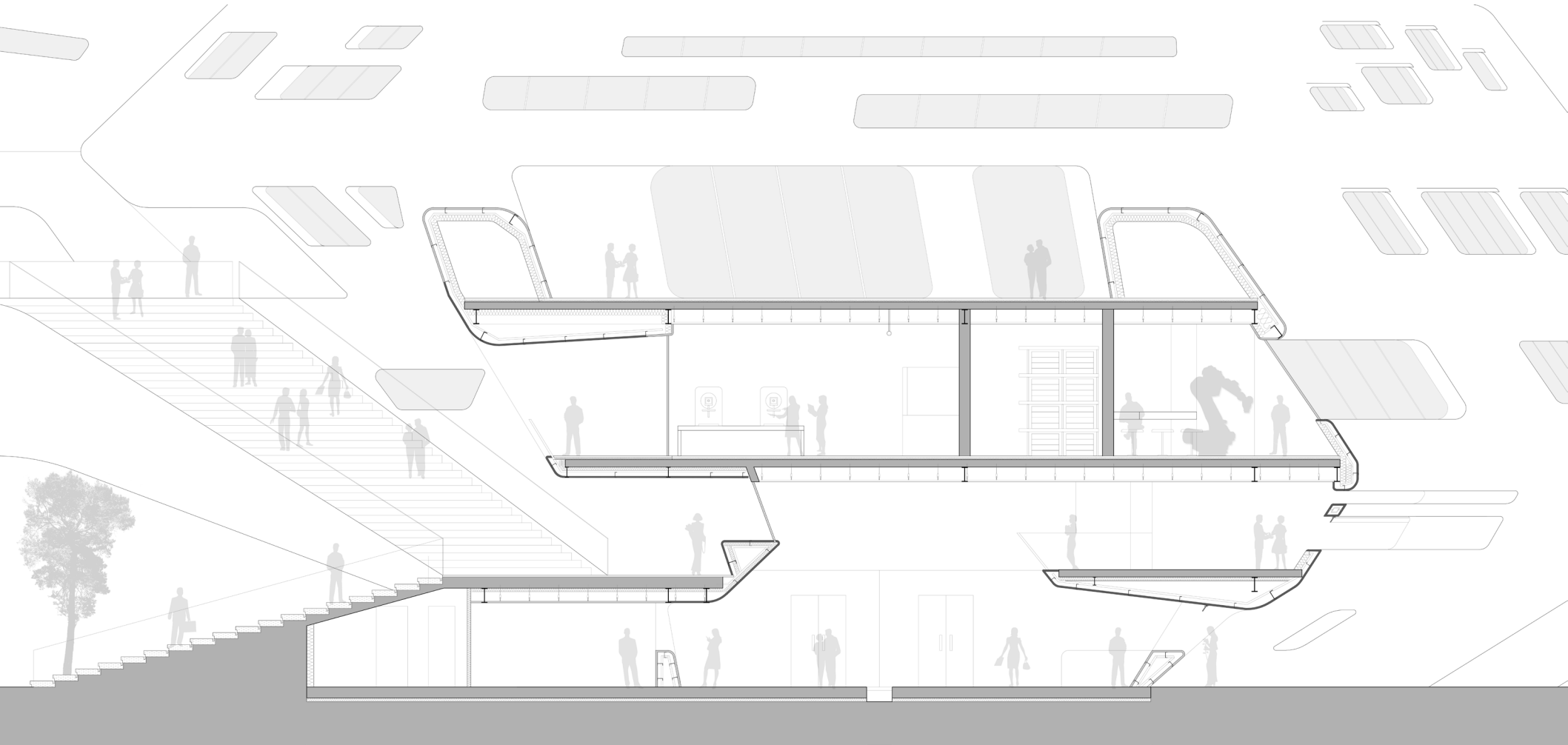


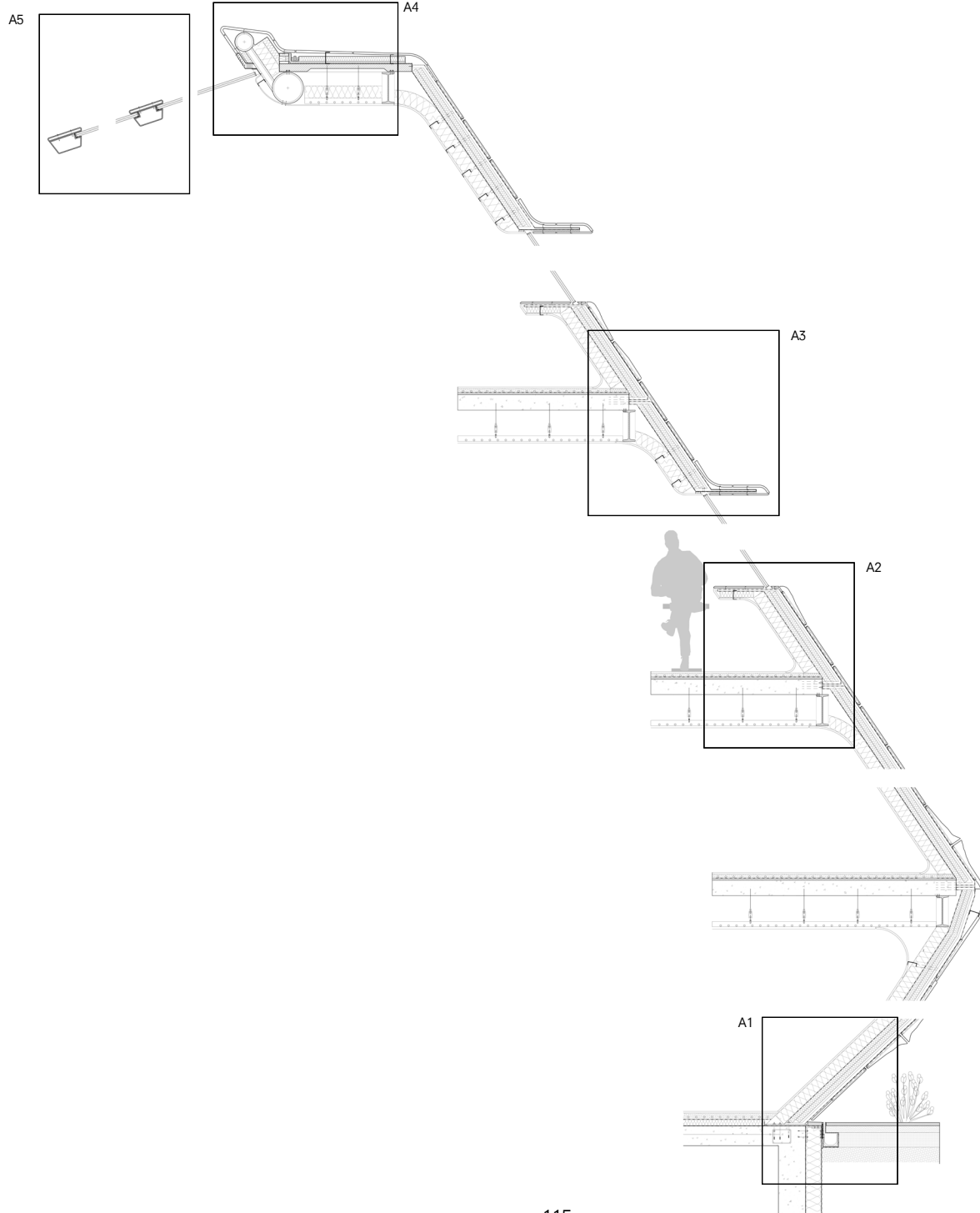


Engineered mycelium composite construction materials from fungal biorefineries (Jones Et Al. 2019)



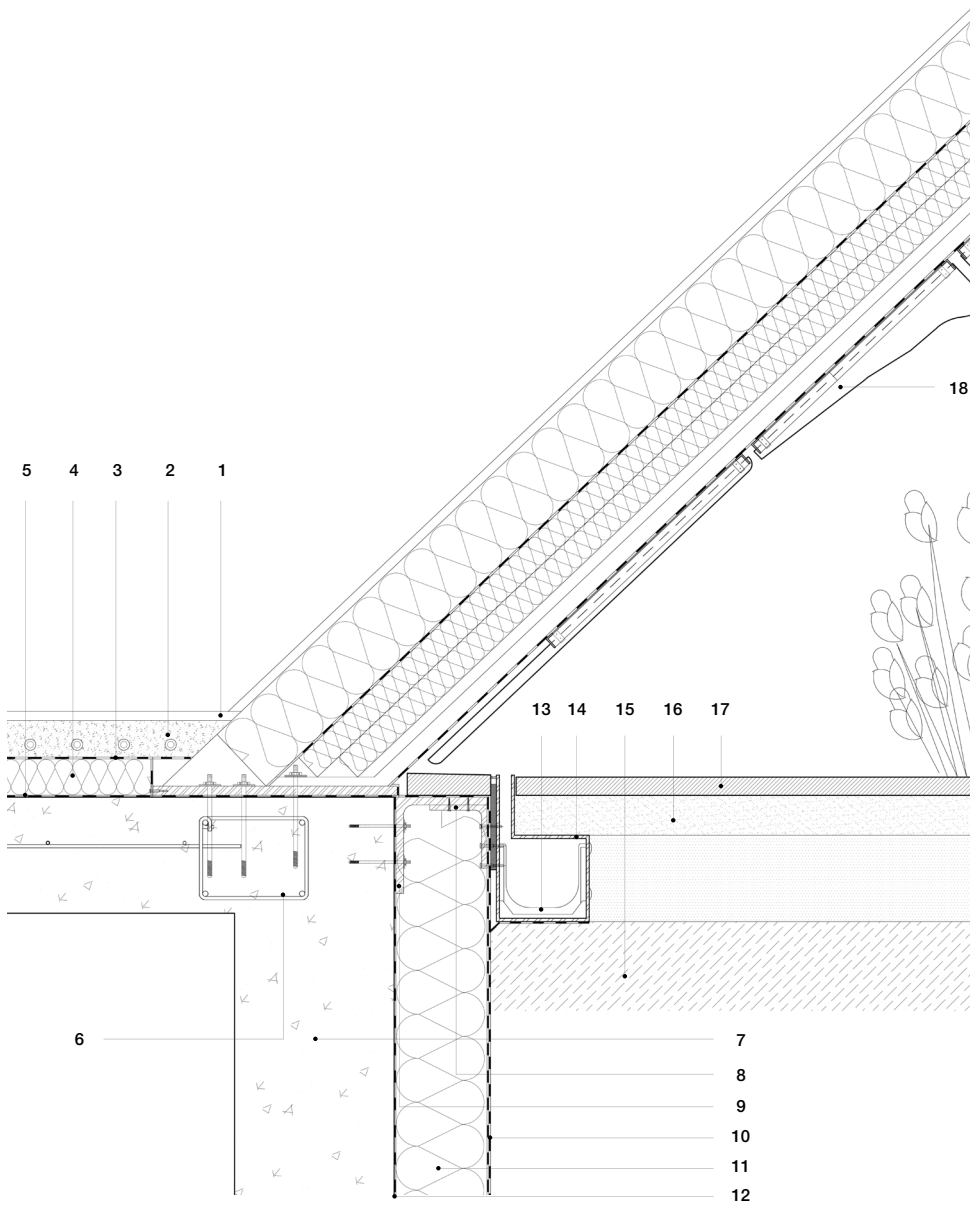
Ecovative Mushroom



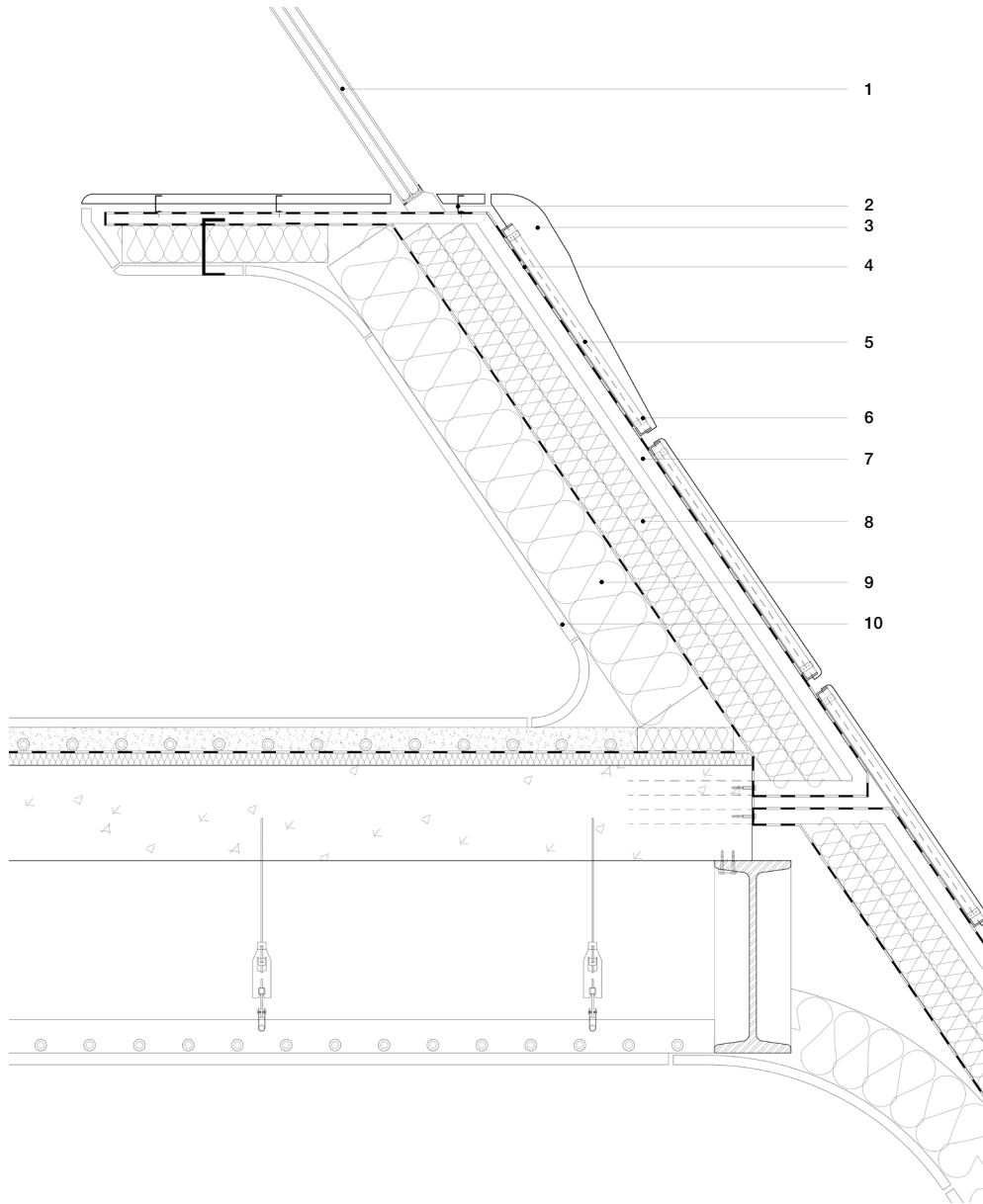


**detail A1**

1. 20 mm Floor panel
2. 80 mm Floor screed with integrated underfloor heating
3. Water membrane
4. 80 mm Mycelium composite sound insulation
5. Vapour control layer
6. Steel rod
7. 350 mm Concrete
8. Steel gutter support L profile
9. Facade support L profile
10. Bitumen layer
11. 220 mm Mycelium composite insulation
12. Water membrane
13. Floor gutter
14. Steel gutter support structure
15. Soil
16. Sand layer
17. Exterior stone flooring
18. 3D printed mycelium facade

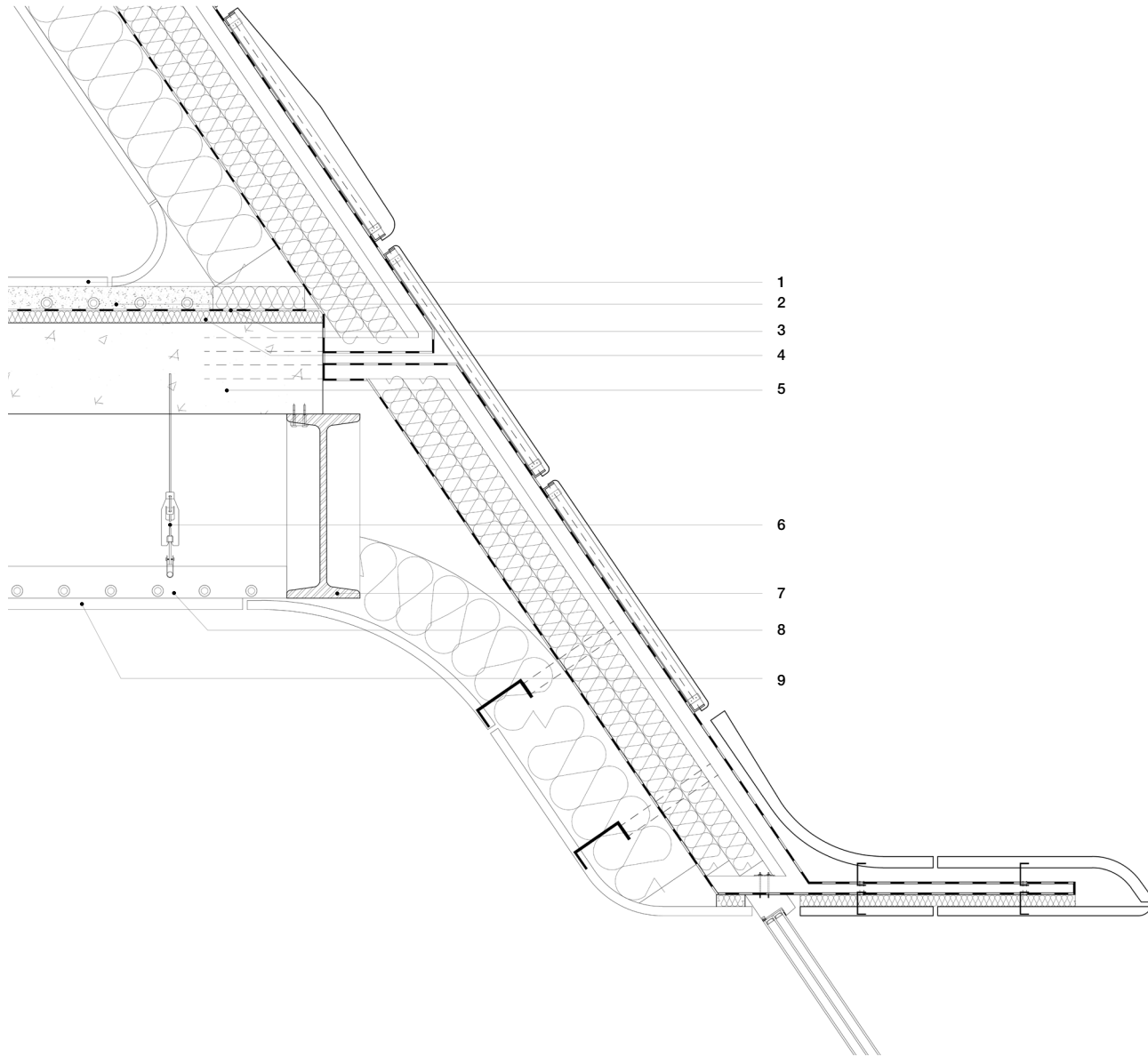


**detail A2**



1. Triple glazed low-e glass wall system
2. Steel clipping
3. Stone cladding
4. 4 mm Waterproof membrane
5. 10 mm Cavity
6. Supporting steel stud
7. Secondary supporting steel frame
8. 60 mm Mycelium composite insulation layer
9. 160 mm Mycelium composite insulation layer
10. 20 mm wall panel

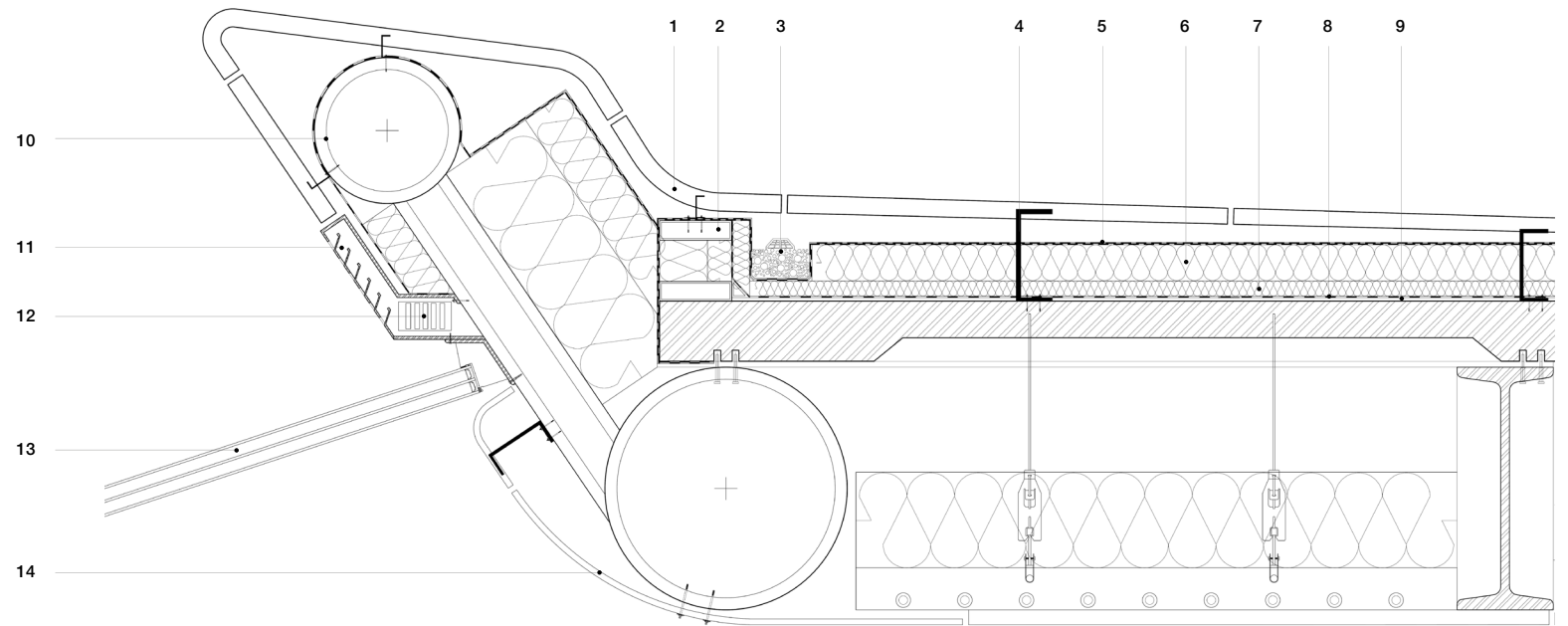
**detail A3**



1. 20 mm Floor panel
2. 50 mm Floor screed with integrated underfloor heating
3. 4 mm Vapour control layer
4. 25 mm Mycelium composite sound insulation
5. 200 mm Reinforced concrete slab
  
6. **Suspended ceiling**  
Explosive bolt  
Suspension rod  
Service gap
  
7. Steel beam HEB 400
8. Cooling ceiling with expanded glass granulate
9. 25 mm Plaster board

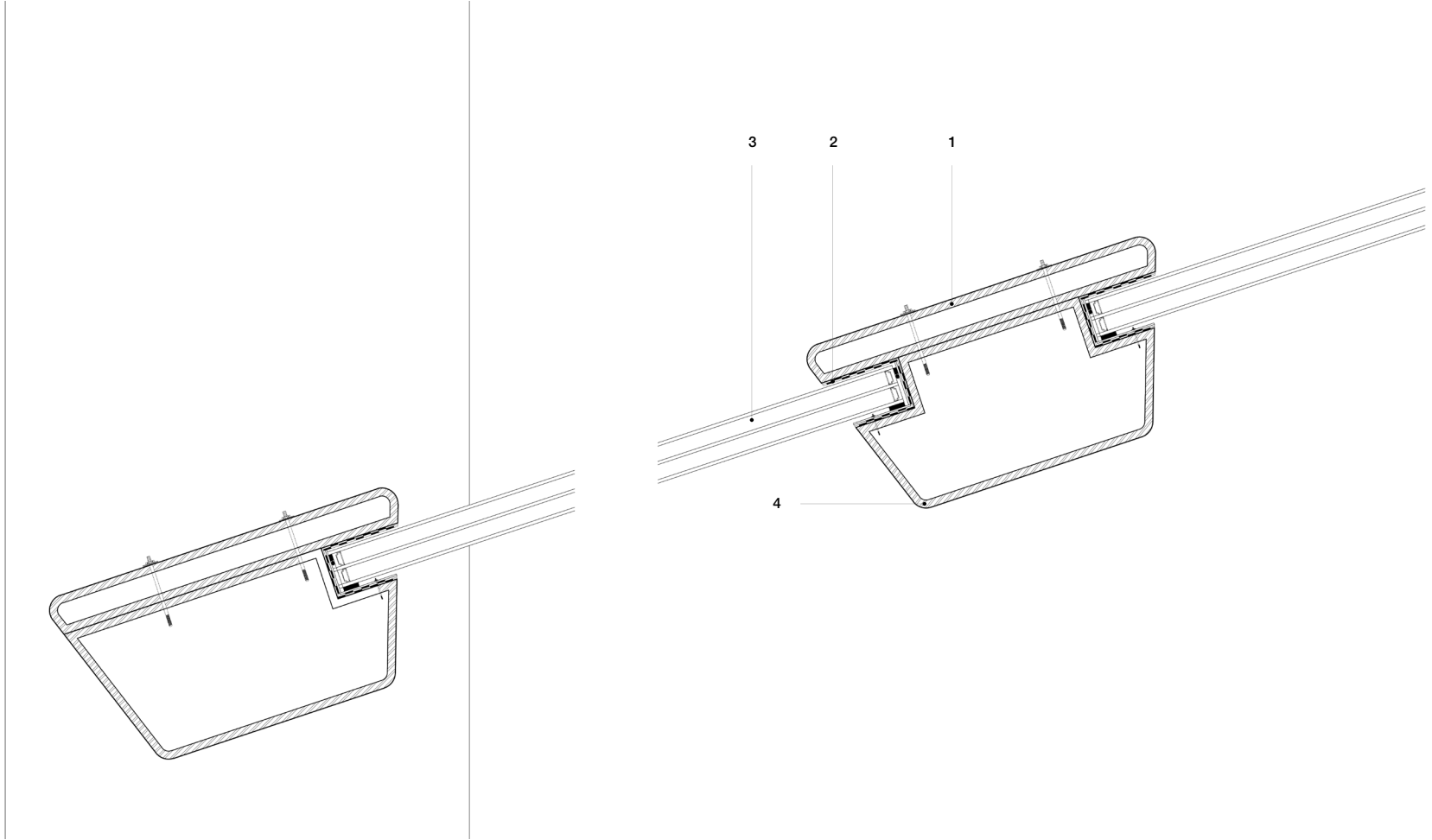
**detail A4**

1. 20 mm Stone cladding
2. Light steel rectangular profile
3. Gutter for rainwater collection
4. Steel clipping
5. Water membrane
6. 60 mm Mycelium composite insulation layer
7. 30 mm Mycelium composite sound insulation
8. Vapour control layer
9. Screed
10. Steel ring beam
11. Integrated trickle ventilation
12. Fan ventilation Unit
13. Triple glazed low-e glass rooflight
14. Interior aluminium ceiling cladding



**detail A5**

- 1. Steel roof cap
- 2. 4 mm Vapour control layer
- 3. Triple glazed low-e glass rooflight
- 4. Steel tower structure





*introduction*

*research*

*design brief*

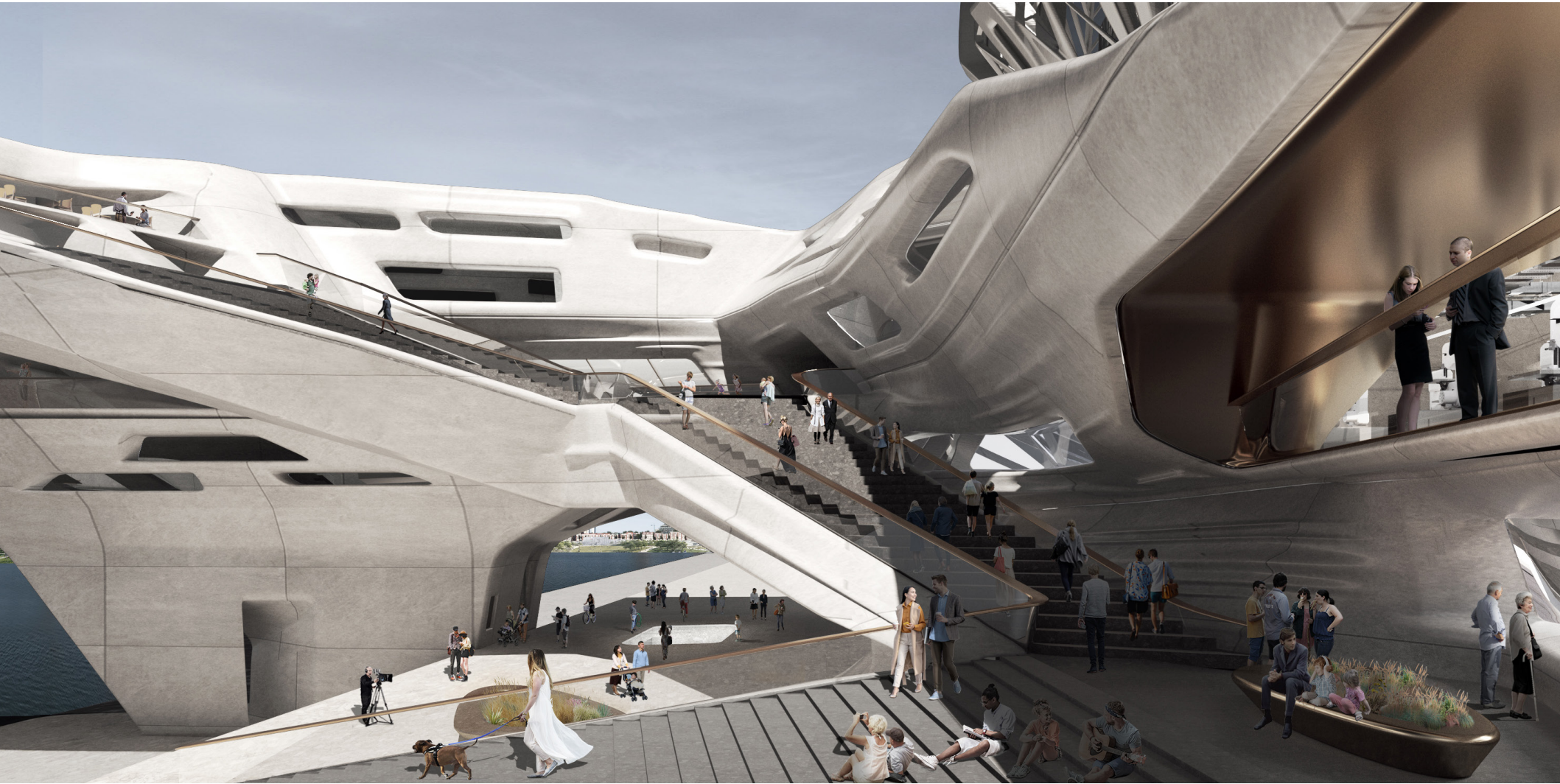
*concept*

*implementation*

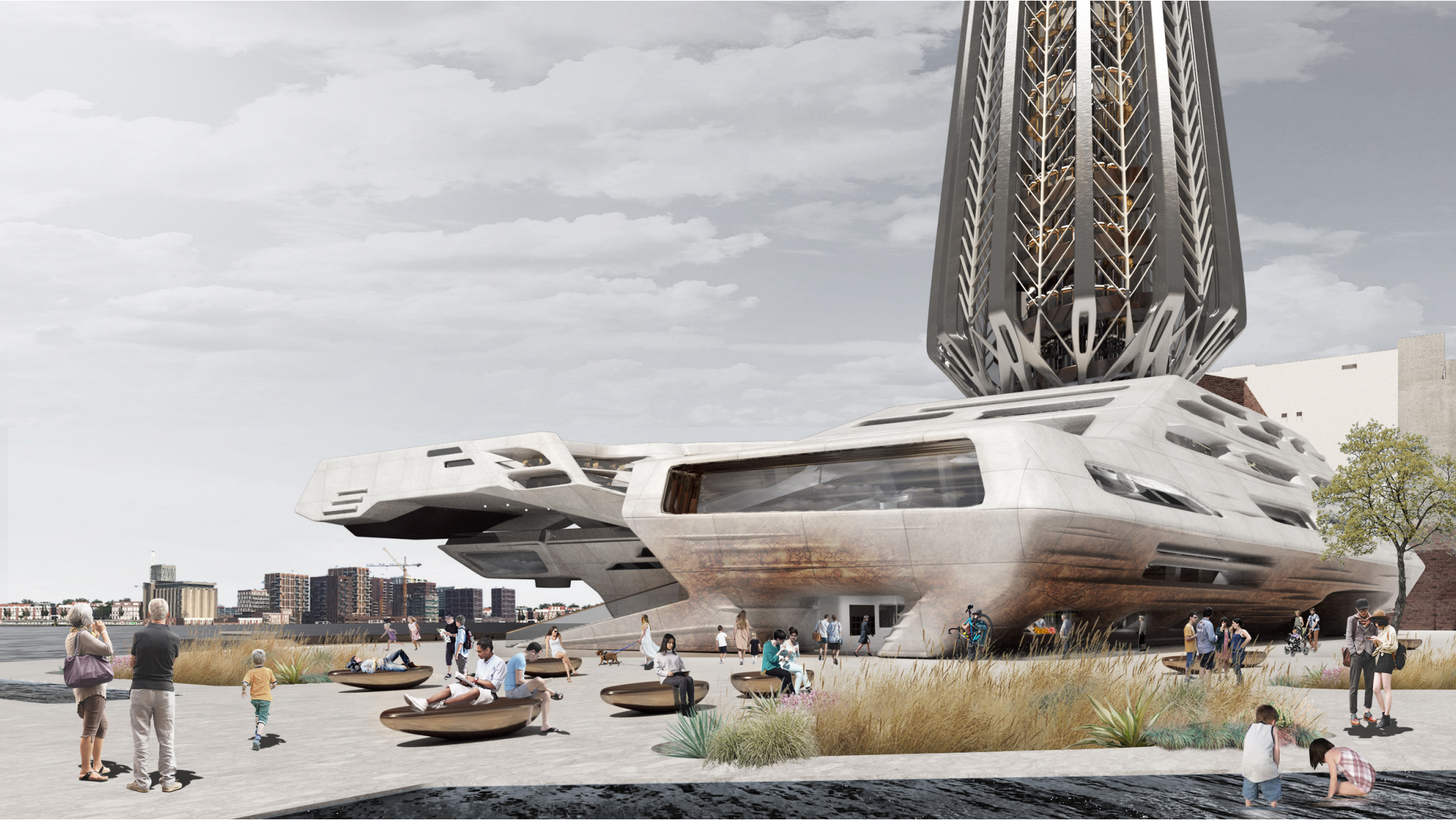
*development*

***visualisations***

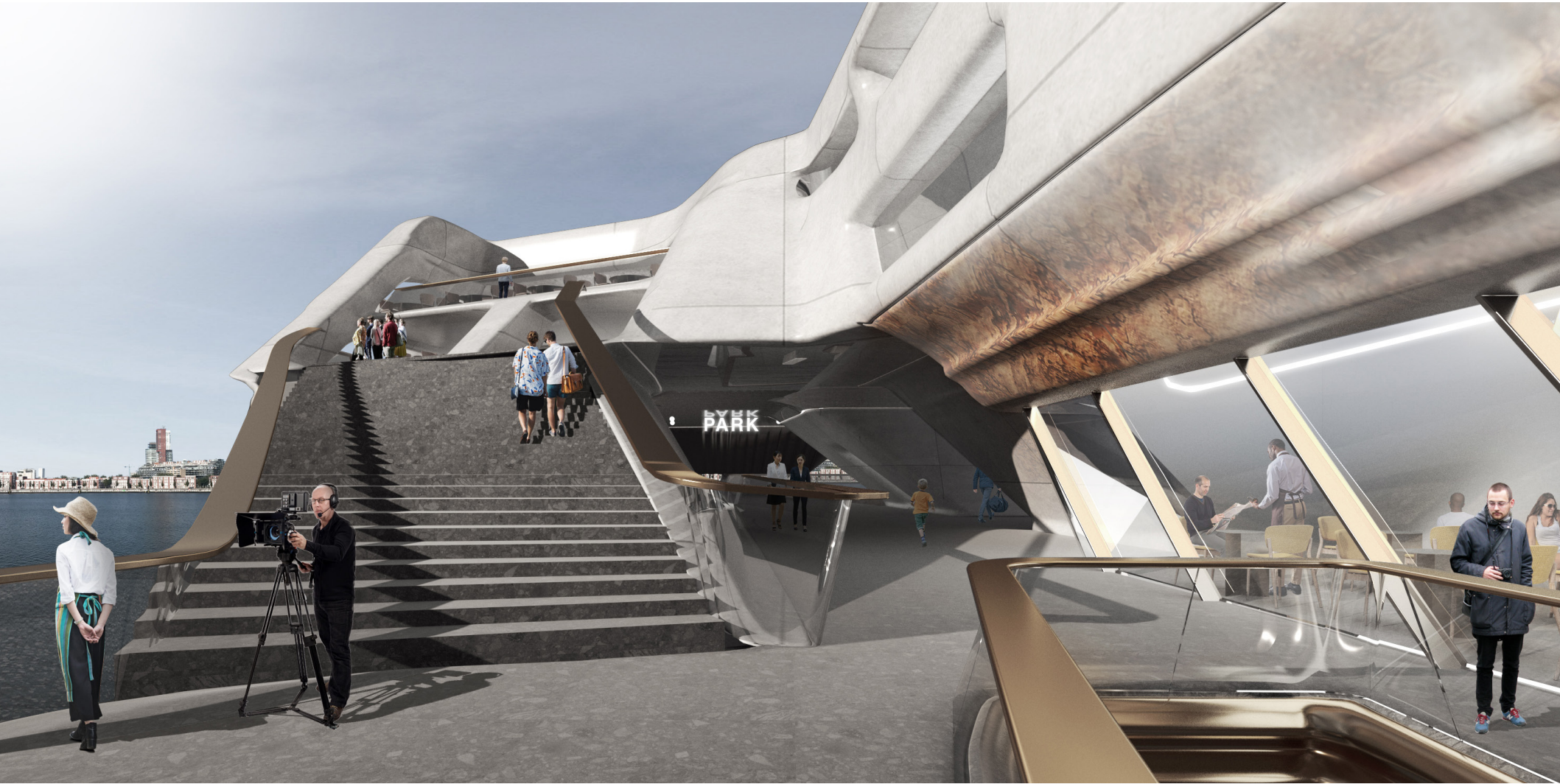
*conclusion*



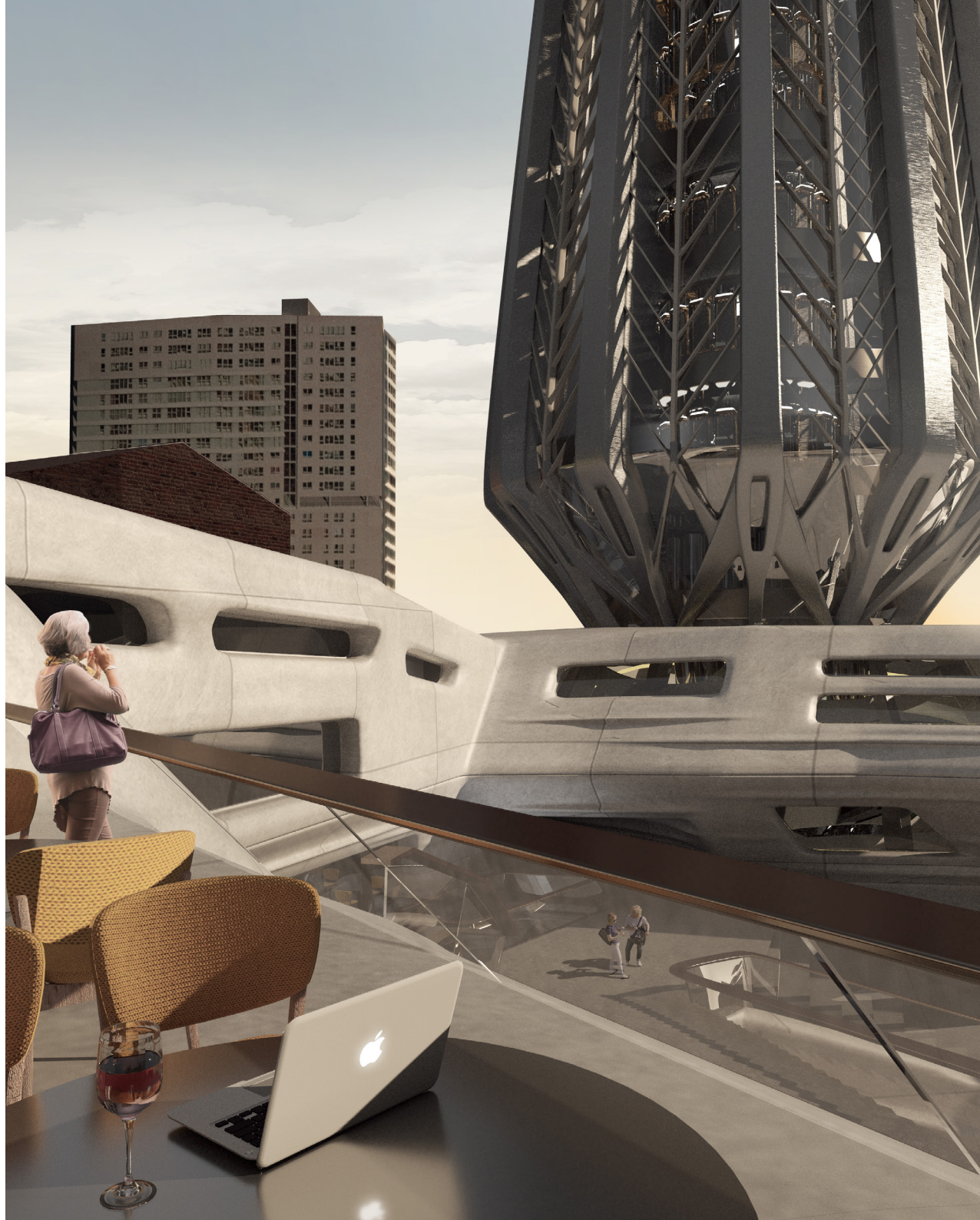






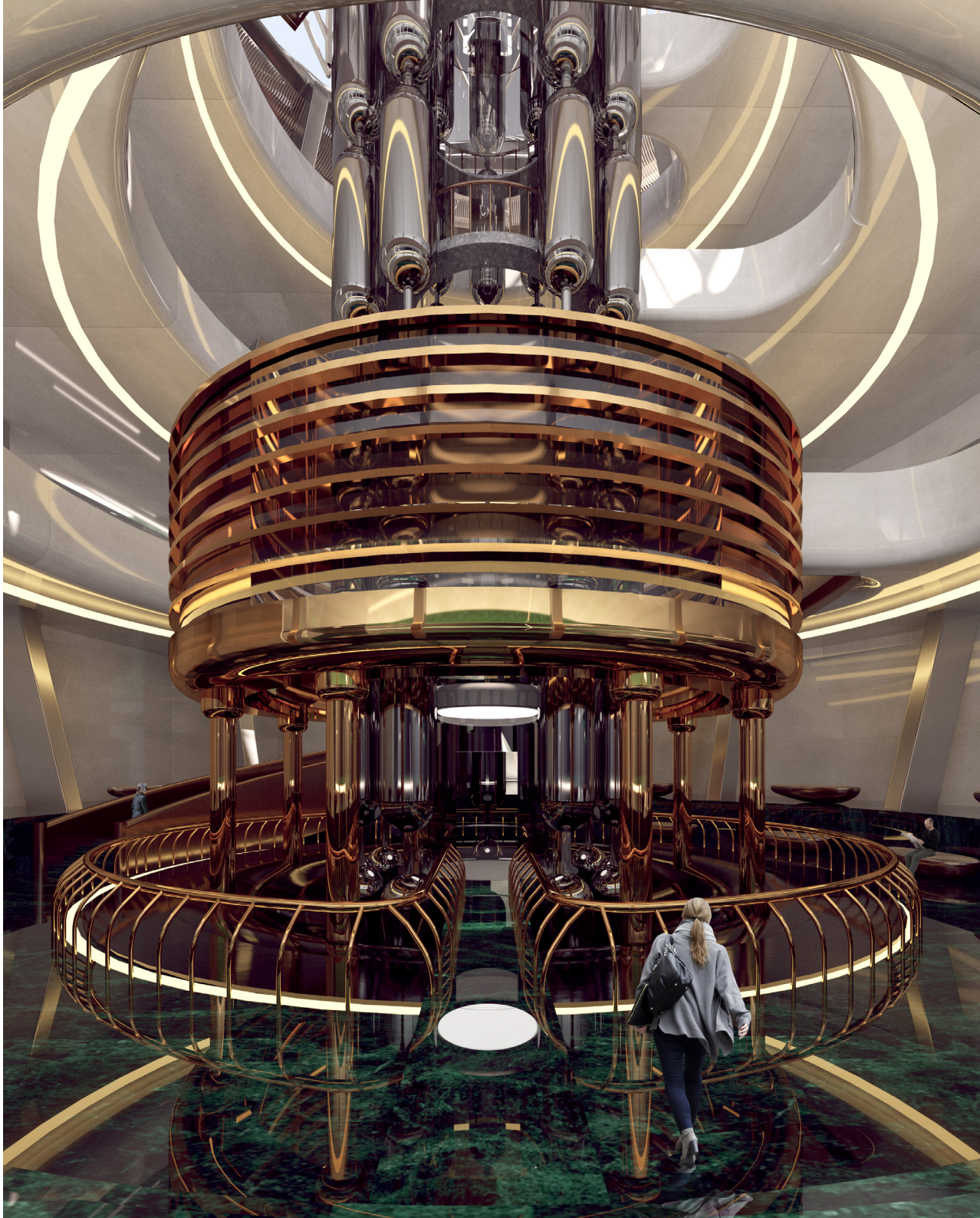








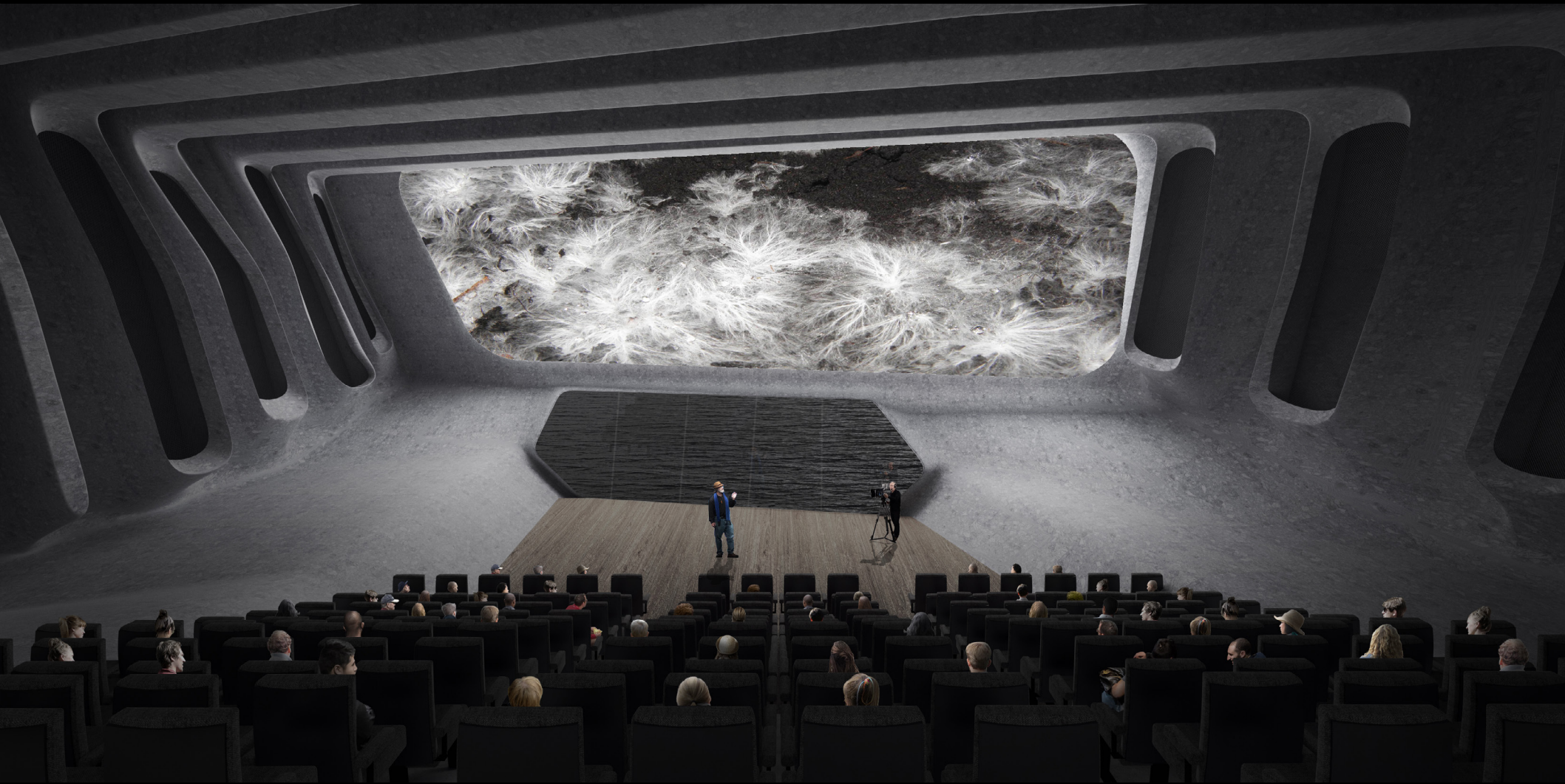










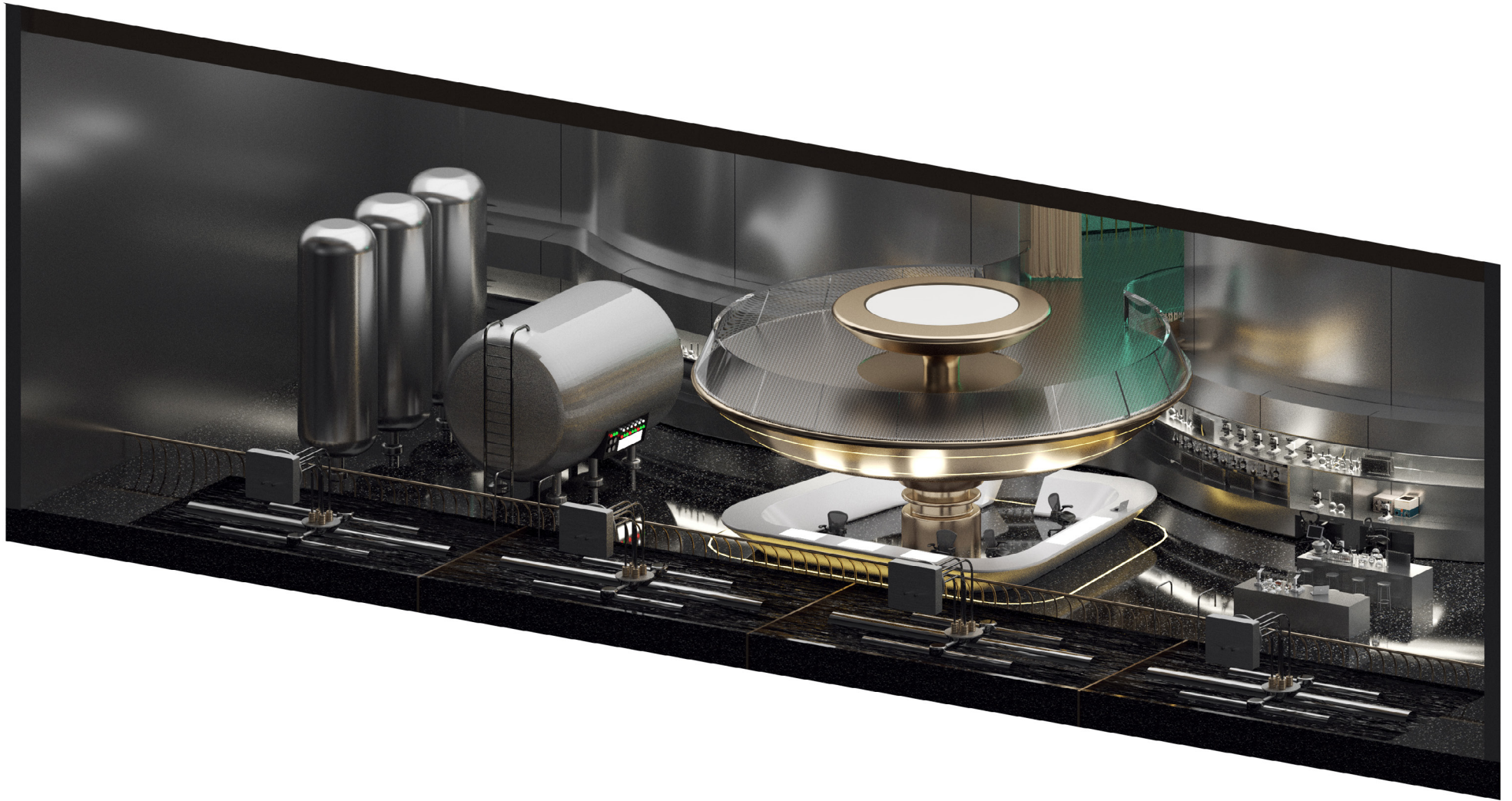


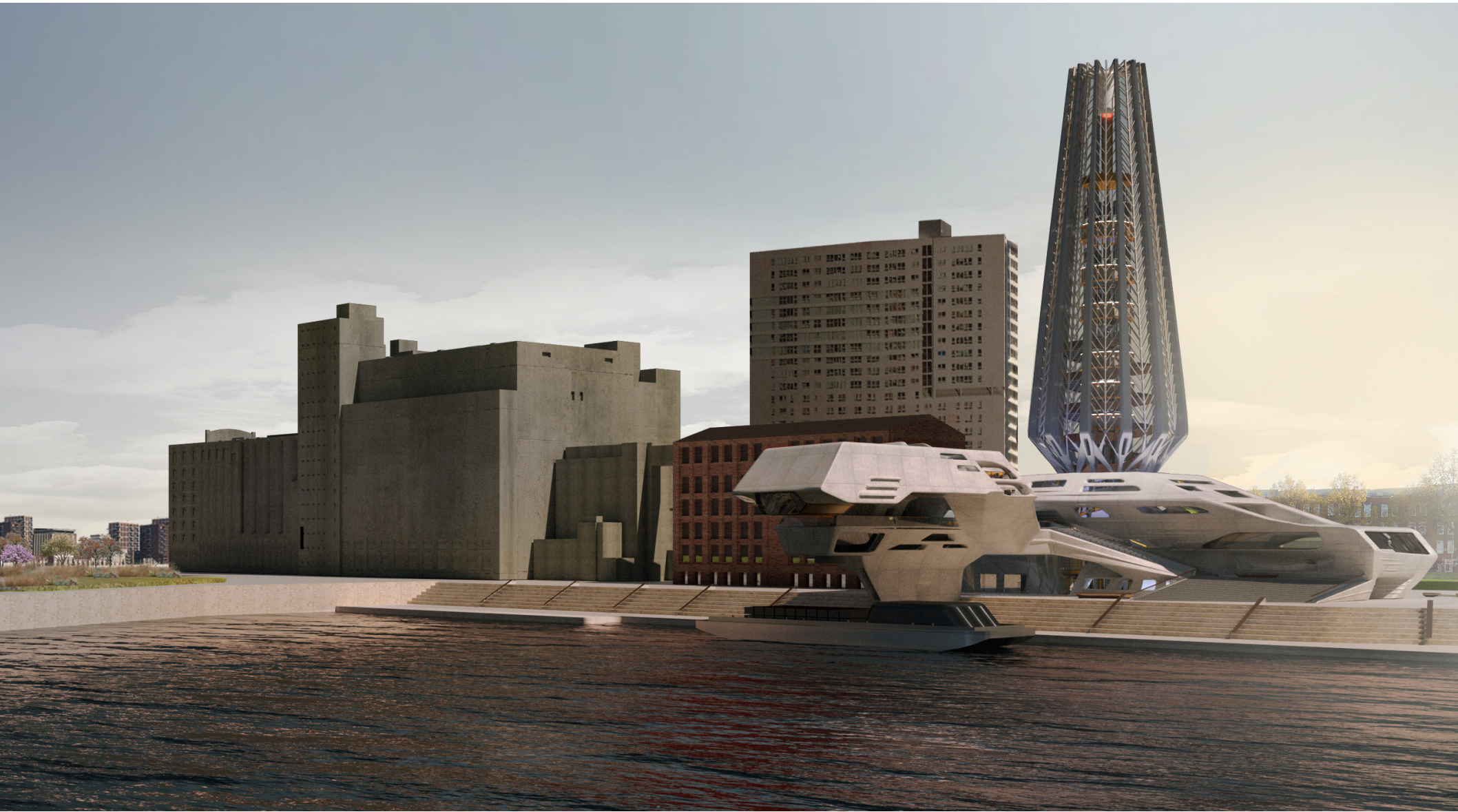








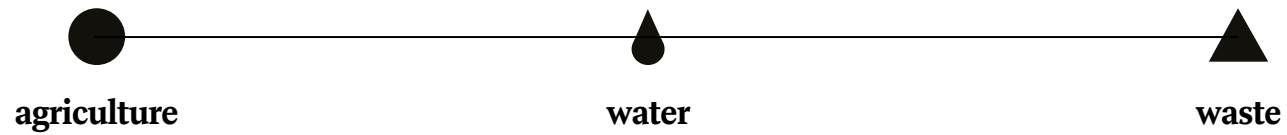
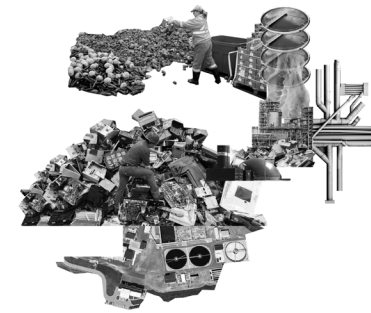




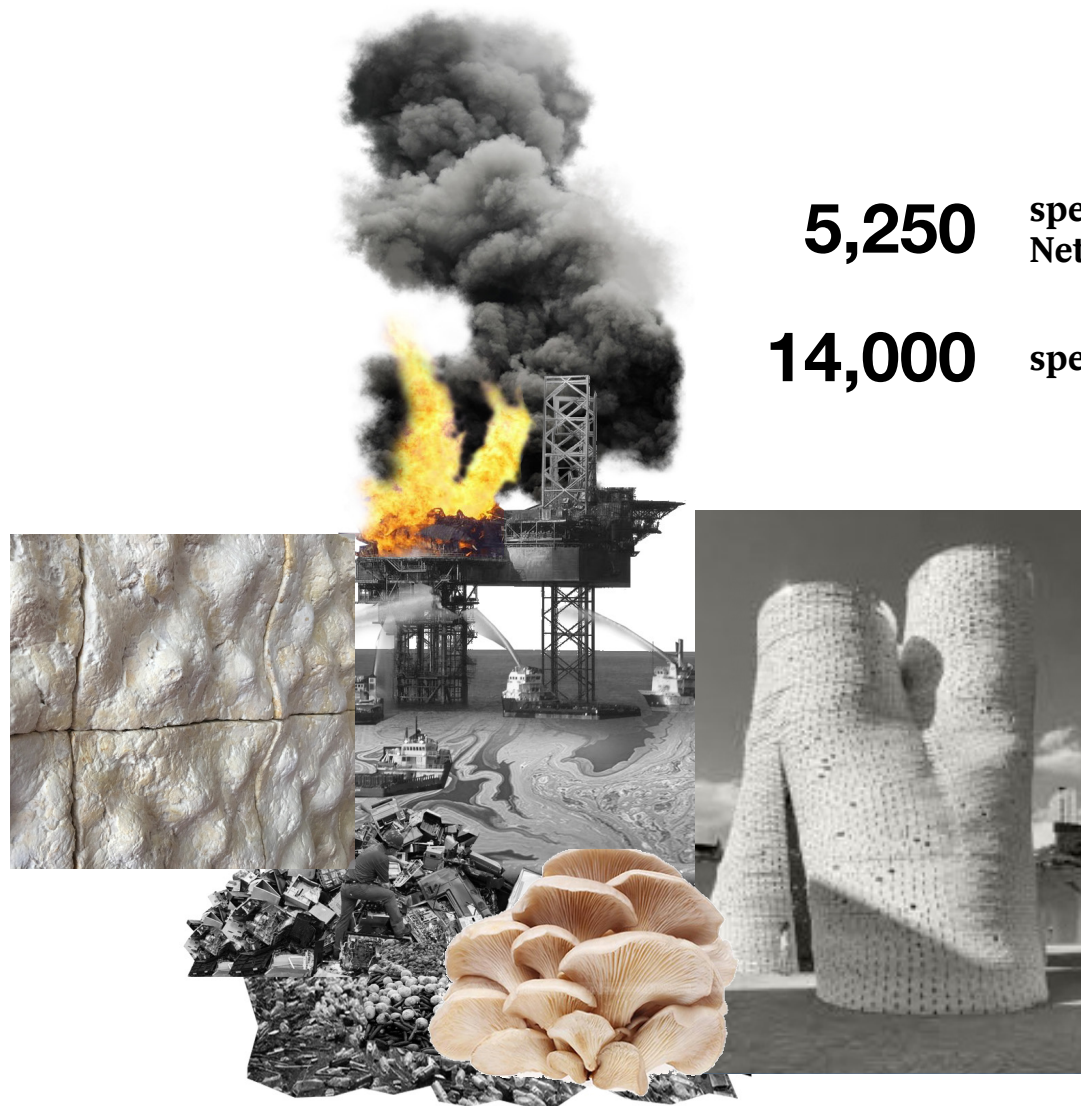
*introduction*  
*research*  
*design brief*  
*concept*  
*implementation*  
*development*  
*visualisations*  
***conclusion***

**How can urban agriculture act as a catalyst for  
confrontation against urban waste flows?**

**Through encouraging education and novel research by intertwining multiple flows within the public interventions.**



## Global Relevance



**5,250** species of mushroom in the Netherlands.

**14,000** species in the world

## Mushroom Production, Quantified



**200** Pods

**3-4** Weeks / Harvest

**2-3** kg/ Pod / Harvest

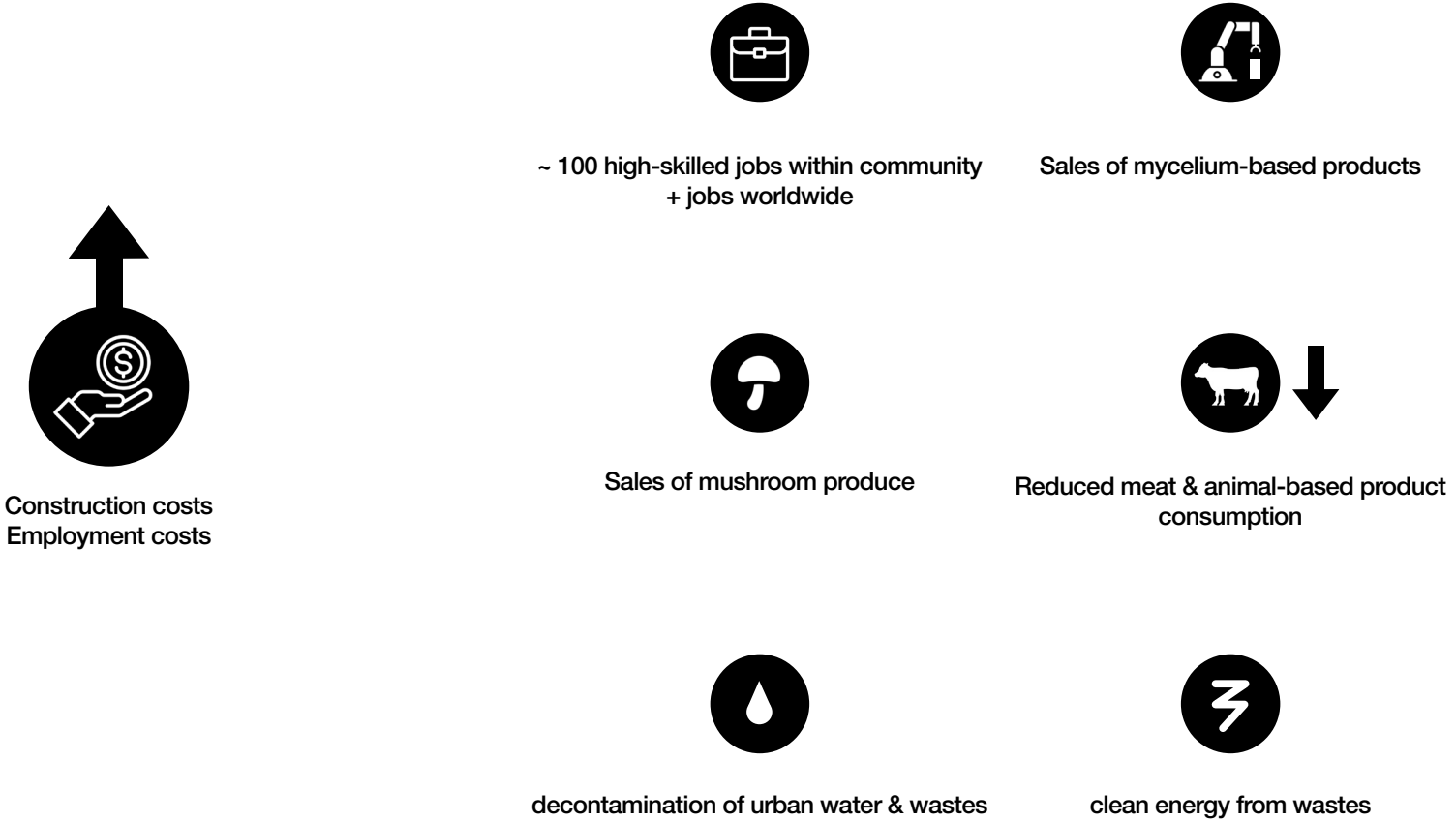
**3-40** € / kg

**3-80** € / Pod / Harvest

**100-150k** € / Year



# Reflection - Cost



Initial Investment

Long-term Profit

**If Earth = Spaceship**

**Architecture = Fuel?**



