HYPERBODY GRADUATION PROJECT
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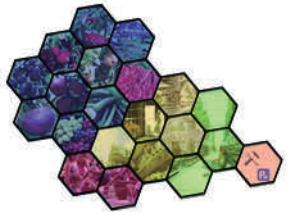
TUTORS: HENRIETTE BIER,  NIMISH BILORIA, KAREL VOLLERS



# Urban Vertical Agriculture

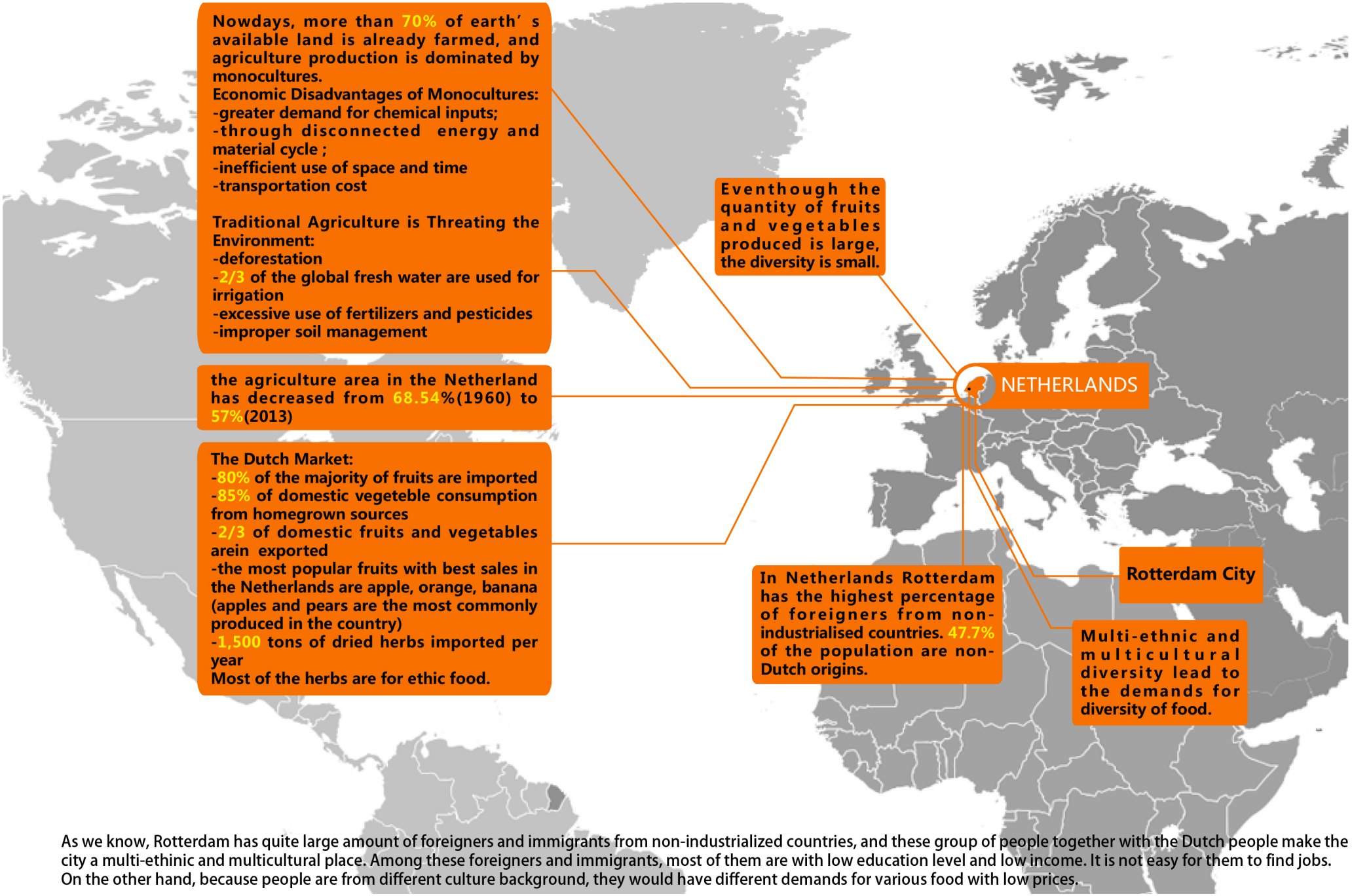
# Contents

# Part 1 Interchange of Kleinpolder, Rotterdam

# Location

The site is located on the northern part of Rotterdam city.

source from google earth

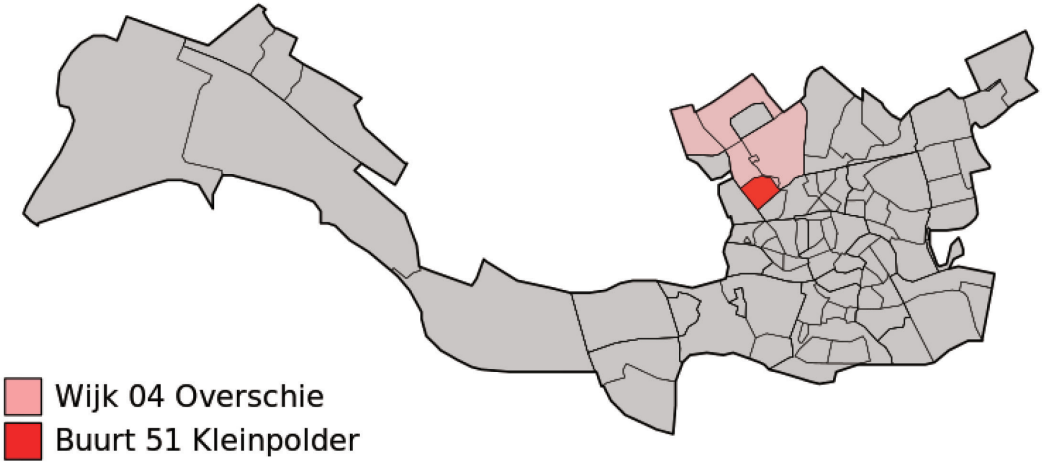


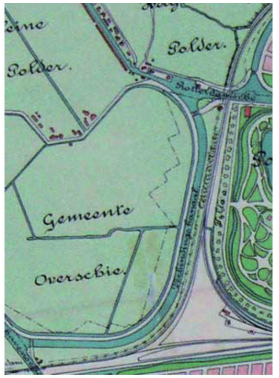

As we know, Rotterdam has quite large amount of foreigners and immigrants from non-industrialized countries, and these group of people together with the Dutch people make the city a multi-ethinic and multicultural place. Among these foreigners and immigrants, most of them are with low education level and low income. It is not easy for them to find jobs. On the other hand, because people are from different culture background, they would have different demands for various food with low prices.

# History of The Site

The interchange(the site i choose) is the largest 3D interchange in Netherlands, and it was built in the 60′ s. The interchange is surrounded by houses which were built in 30′ s. Both of the interchange and the surrounding houses are the results of sophisticated urban planning. It emerges from the disagreement between the large highways logic and the traditional urban fabric.

For this Kleinpolder district, the interchange, on one hand separates Overschie from Rotterdam; on the other hand, it has already become a sculpture, an identity for the district.




source from http://www.engelfriet.net/

## centralization of vehicles (>150,000vehicles/day)

The interchange mainly joins highway A13 and A20. Both of the highways are two of the busiest ones in Netherlands. And this centralized traffic system brings air pollution to the surrounding areas.

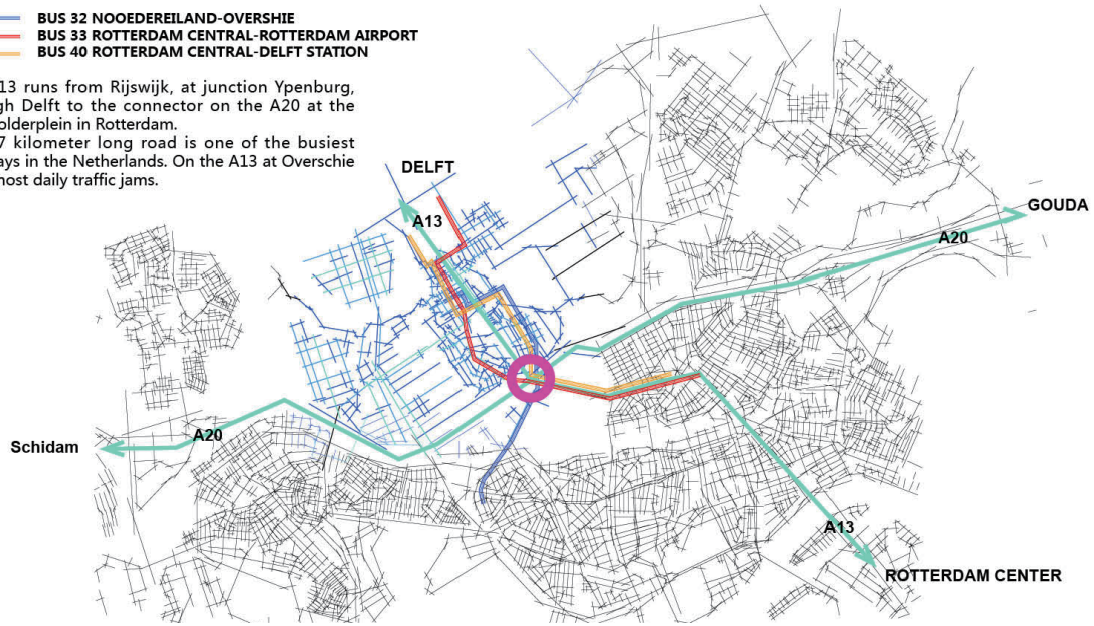
| HIGHWAY | DIRECTION | AVERAGE SPEED (km/h) |
|---|---|---|
| A20 | NORTH | 77-95 |
| | SOUTH | 68-82 |
| A13 | EAST | 70-93 |
| | WEST | 72-89 |

| average speed v=40km/h<br>POLLUSTION FROM AUTOMO- | EMISSION FACTOR kg(1000 vehicles/d) |
|---|---|
| CO | 1.89 |
| NO2 | 0.09 |
| SO2 | 0.07 |
| PM | 0.01 |

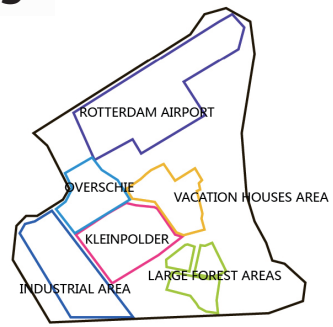
| EMISSION OF CAR | NEUTRAL GEAR | LOW SPEED | HIGH SPEED |
|---|---|---|---|
| $NO_X$ | 0-50PPm | 1000PPm | 4000PPm |
| $CO_2$ | 6.5-8% | 7-11% | 12-13% |
| $H_2O$ | 7-8% | 9-11% | 10-11% |
| $O_2$ | 1-1.5% | 0.5-2% | 0.1-0.4% |
| CO | 3-10% | 3-8% | 1-5% |

BUS 32 NOOEDEREILAND-OVERSHIE
BUS 33 ROTTERDAM CENTRAL-ROTTERDAM AIRPORT
BUS 40 ROTTERDAM CENTRAL-DELFT STATION

The A13 runs from Rijswijk, at junction Ypenburg, through Delft to the connector on the A20 at the Kleinpolderplein in Rotterdam.
The 17 kilometer long road is one of the busiest highways in the Netherlands. On the A13 at Overschie are almost daily traffic jams.

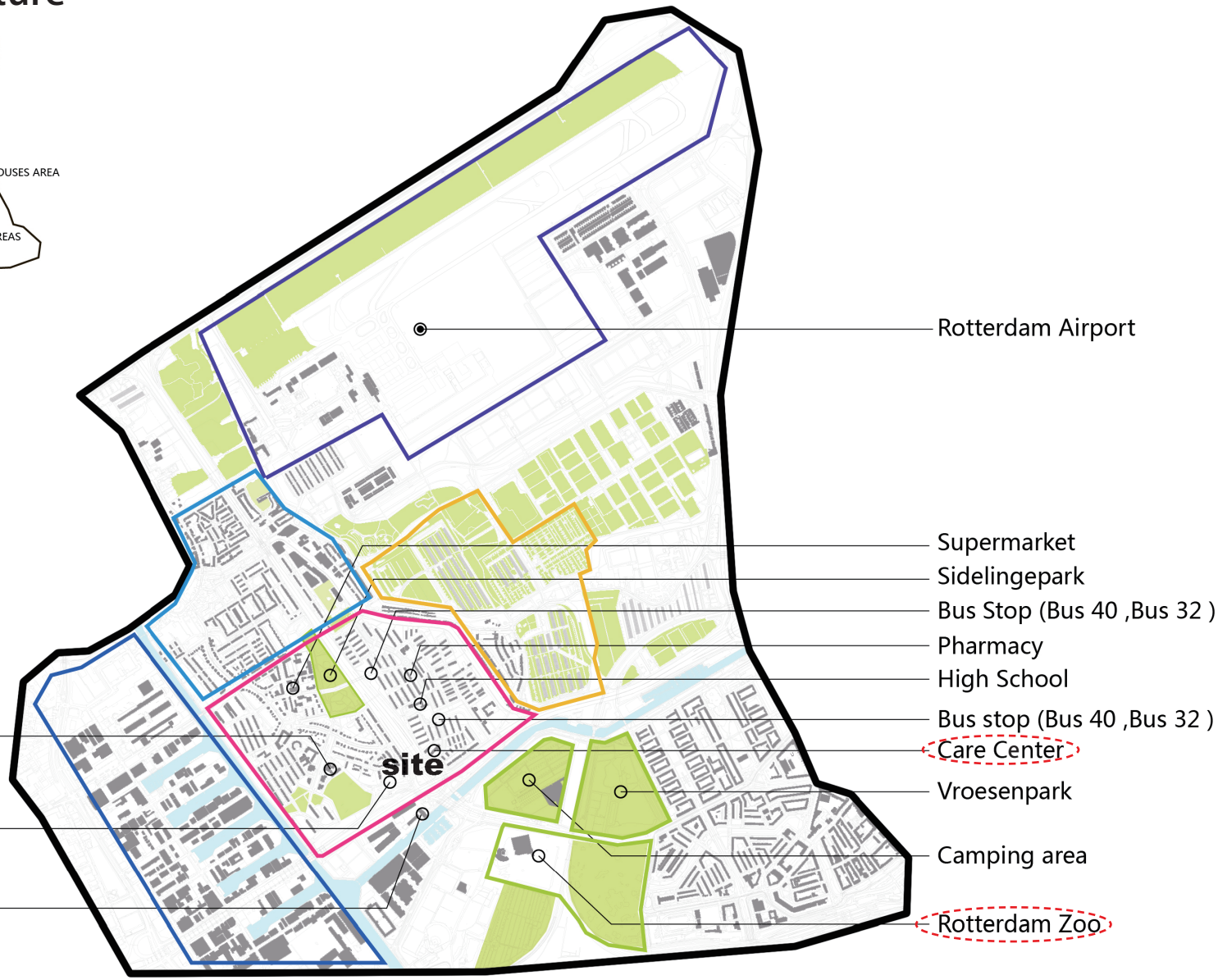


# Surrounding Infrastructure




The interchange is mainly surrounded by residential areas(on the north side ) and the tourism area (on the south side).
For the residential area, a care center for the aged people is just next to the interchange.

The tourism part includes the Rotterdam zoo and the park.
The Rotterdam zoo is one of the most attractions in Netherlands, with daily visitors of 1,500.



# Population

percentage of apartments in Kleinpolder: 48%

population density in Kleinpolder: >4947 people/km$^2$

population density in Roterdam: >1234 people/km$^2$

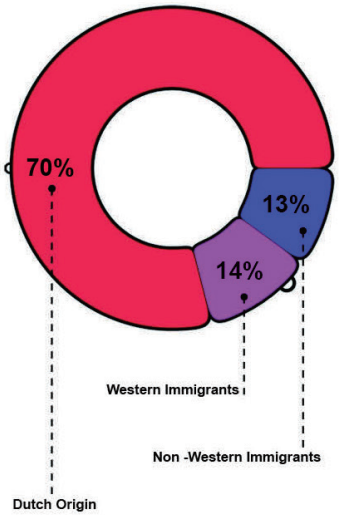
per capita income in Kleinpolder: <18,200 euro/year

per capita income in Rotterdam: 22,100 euro/year

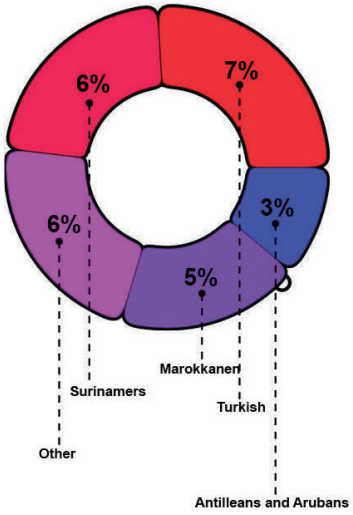
~24,600euro/year

number of cars per household in Kleinpolder: <0.92

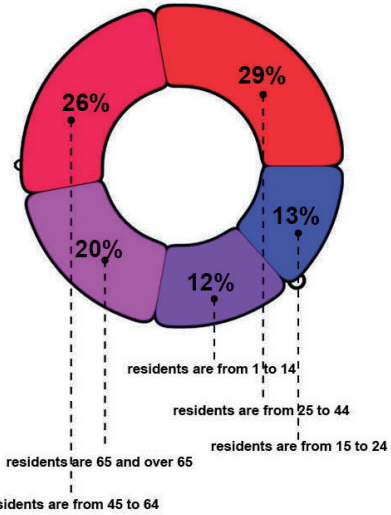

total population in KLEINPOLDER: 7500




population composition




immigrants composition




age composition

The population density in Kleinpolder is much high than the average level of Rotterdam, and the number of immigrant population takes up 27% of the total.

Compared with the average income level of the city, the income level of this district is lower.

People aged from 46 to 65( and over 65) accounts for almost half of the total population in this district.

## Global Problem

-We are having  less and less agricultural-capability land to supply the fast growing population and agricultural product’ s diversity.

-Traditional 2D agriculture causes serious pollution problems.

## Existing Problems on Site

**Problem 3: centralized traffic system leads to large amount of vehicle emission and noise**

**Problem 2: lack of consideration of pedestrian traffic**

**Problem 1: waste of urban resources (land, money, rainwater)**

## Advantages of the site

-There is no  high-rise building around it.

-It provides abundant water resource.

## Design Strategy

-a harmonious design that fits into the site, which can transform the interchange in a vertical green farm without losing the interchange′ s characters

-provide more job opportunities for the low-education residents

- reconnect the seperate parts for pedestrians, and recover the ecological footprint lost by the growth in transportation construction in big city

- solving controdiction situation between decreasing farm land and growing food demand

# Part 2 Agriculture Research

- considering load the floor can bear, clusters of crops should be with short roots no longer than 40cm

- the food' s popularity among people from different cultural backgrounds

- crops do not accupy too much space

# What could be planted in the building?

From the end of October daylength is shorter than 10 hours, winter time

October
November
December
January

During these periods, due to the low temperature, crops such as beans, carrots cucumbers potatoes zucchini, garlic prefer warm temperature need heating system to keep the enviroment in a stable warm condition.

Crops like broccoli, lettuce which prefer low temperture coule be cultivated in the normal winter condition.

From the mid of February daylength is longer than 10 hours, spring time

February
March
April
May
June
July
August
September

During these periods, beans, carrots cucumbers potatoes zucchini, garlic could be sow straight into the ground.

Brocooli, lettuce, tomatoes, onion, peppers need to be grown seedlings, and be kept in a stable cool temperature.

| crop types | daylight demand |
|---|---|
| | |
| perannial crop 1 (preferede chilled hours <100h or 450 hours per year) | |
| Rosemary | high |
| Asparagus | medium to low |
| Grape | high |
| Borage | high |
| Thyme | medium |
| Strawberry | high |
| Marigold | high |
| Comfrey | medium |
| Hyssop | medium |
| | |
| perannial crop 2 (prefered chilled hours 900h) | |
| | |
| Sorrel | medium |
| Currant | medium |
| | |
| Annual crop (chilled annually) | |
| Nasturtium | high |
| Zucchini | high |
| Bean | high |
| Carrot | high |
| Cucumber | high |
| Dill | high |
| Garlic | medium |
| Onion | high |
| Peas | high |
| Peppers | medium |
| Tomato | medium |

# the solutions for in and out door cultivation

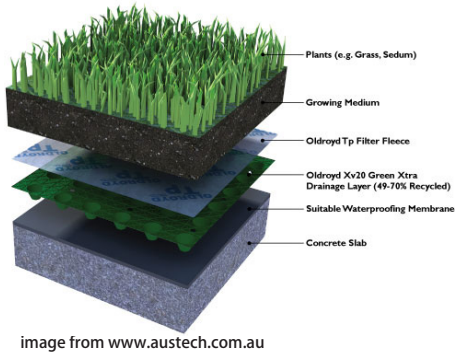



image from www.austech.com.au

solution indicate how cultivation works on concrete slab

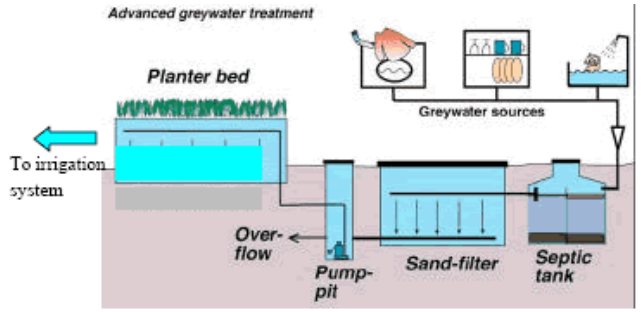
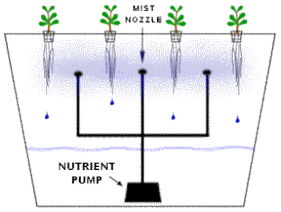


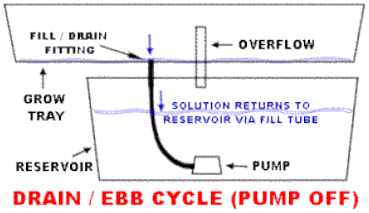

image from http://fra-dab810.blogspot.nl/

the image above indicate how used water is filtered through agriculture cultivation system

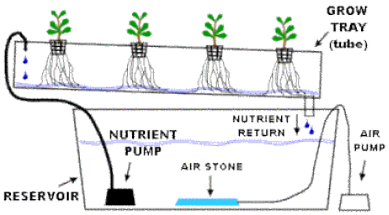
6 basic types of hydroponic systems:



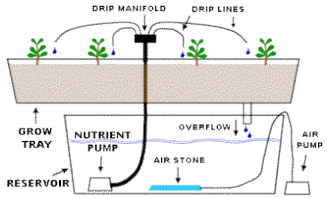

aeroponic system is the most high tech one



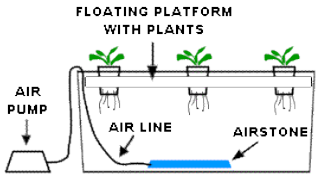

EBB & FLOW system



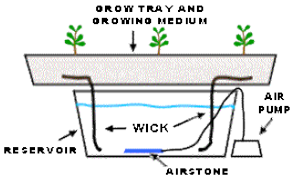

N. F. T. (nutrient film technique) system




drip system




water culture




wick system

information from http://www.simplyhydro.com/system.htm

Through the comparison in these 6 types of hydroponics systems, the final choice systems are aeroponic system and drip system.

# the solution for in and out door cultivation

image from http://www.ledinside.com/news/2014/7/japanese_farmer_partners_with_ge_to_develop_world_largest_led_indoor_farm

## LED indoor farming

The weather in Netherlands is usually rainy. When the amount of natural daylight can not reach the demanded level, the building need to use artificial lights.

Actually, the dominant type of chlorophyll in plants only needs purple  light for working. When growing the crops, red and blue LEDs could create this special light and reduce the energy used in indoor cultivation.

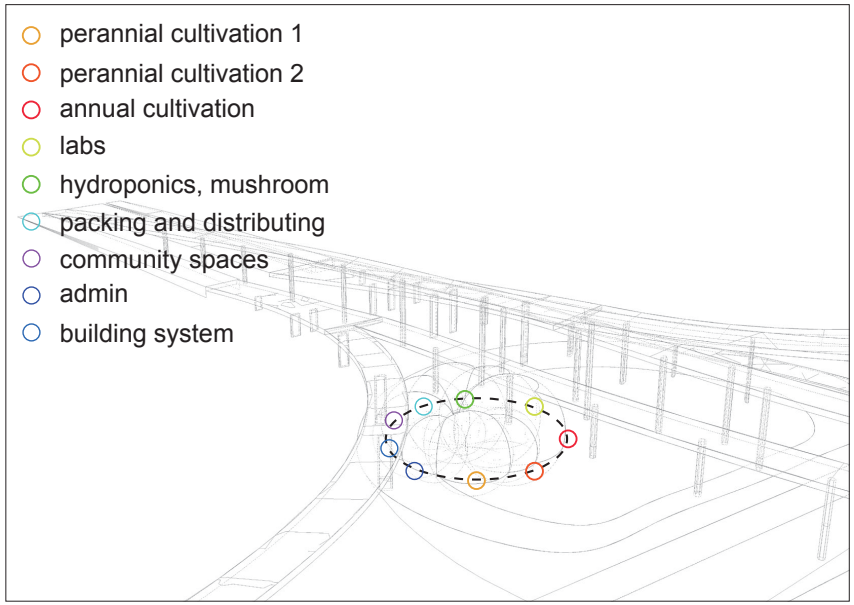
# Part 3 Computational Simulation

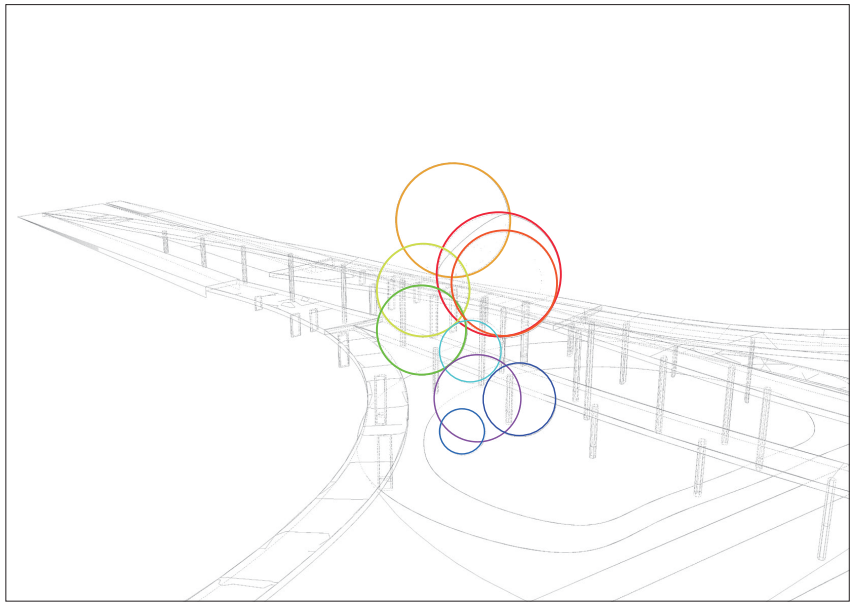
# System for Generating Configuration

| Function | Area demand ( sqm) | light demand | cooling hours(hr | height | main users | Activity |
|---|---|---|---|---|---|---|
| Cultivation Area | | | | | workers | Crop planting, harvesting |
| annual cultivation mode | 1000 | high | annual | 4m | | |
| perennial cultivation mode 1 | 400 | high | <100 | 6m | | |
| perennial cultiavation mode 2 | 1500 | medium to high | 450 | 5m | | |
| hydroponics cultivation mode | | low | | 3m | | |
| mushroom | 700 | low | | 3m | | |
| fish | 200 | low | | 3m | | |
| Crop and Food Resaerch Lab | 200 | medium | | 4m | researchers | researching |
| Crop Processing | 100 | low | | 3m | workers | crops from cultivation area are delived to here and processed |
| Crop Storage | 250 | low | | 3m | workers | crop storing |
| Crop Packing and Distributing | 100 | low | | 3m | workers | packing and distributing |
| Workshop | 600 | medium | | 5-6m | visitors | learning how to plant crops |
| Reception Hall | 400 | low to medium | | 6m | visitors | visitors enter the building |
| Restaurant and Cafe | 650 | low to medium | | 6m | visitors | recreation |
| Administration | 400 | medium | | 4m | staff | working |
| Building System | 800 | low | | 4m | workers | generating energy |

# System for Generating Configuration





perannial cultivation 1 — grape, blackberry, blueberry, tarraggon, strawberry, thyme, fig, bay laurel, rosemary

perannial cultivation 2 — raspberry, currant, sorrel, articode, asparagus, rosemary, comfrey, hyssop

annual cultivation — bean, carrot, cucumber, dill, onion, peas, peppers, tomato, zucchuni, nasturtim

labs — research and science work space

hydroponics, mushroom

processing to packing — crop processing, storage, packing

community spaces

admin — botanic labs, botanic workshop, reception, hall, food shop, open market, public entrance

building system — offices, conference room

energy generation and collection, waste management, ventilation, water distribution, entrance for drivers, ground parking

**Rules for generating the configuration:**

- all functions should be at least 4 meters away from the flyovers;

- cultivation areas (perannial 1&2, annual cultivation) should be located in the place where they can have the best dayllight environment;

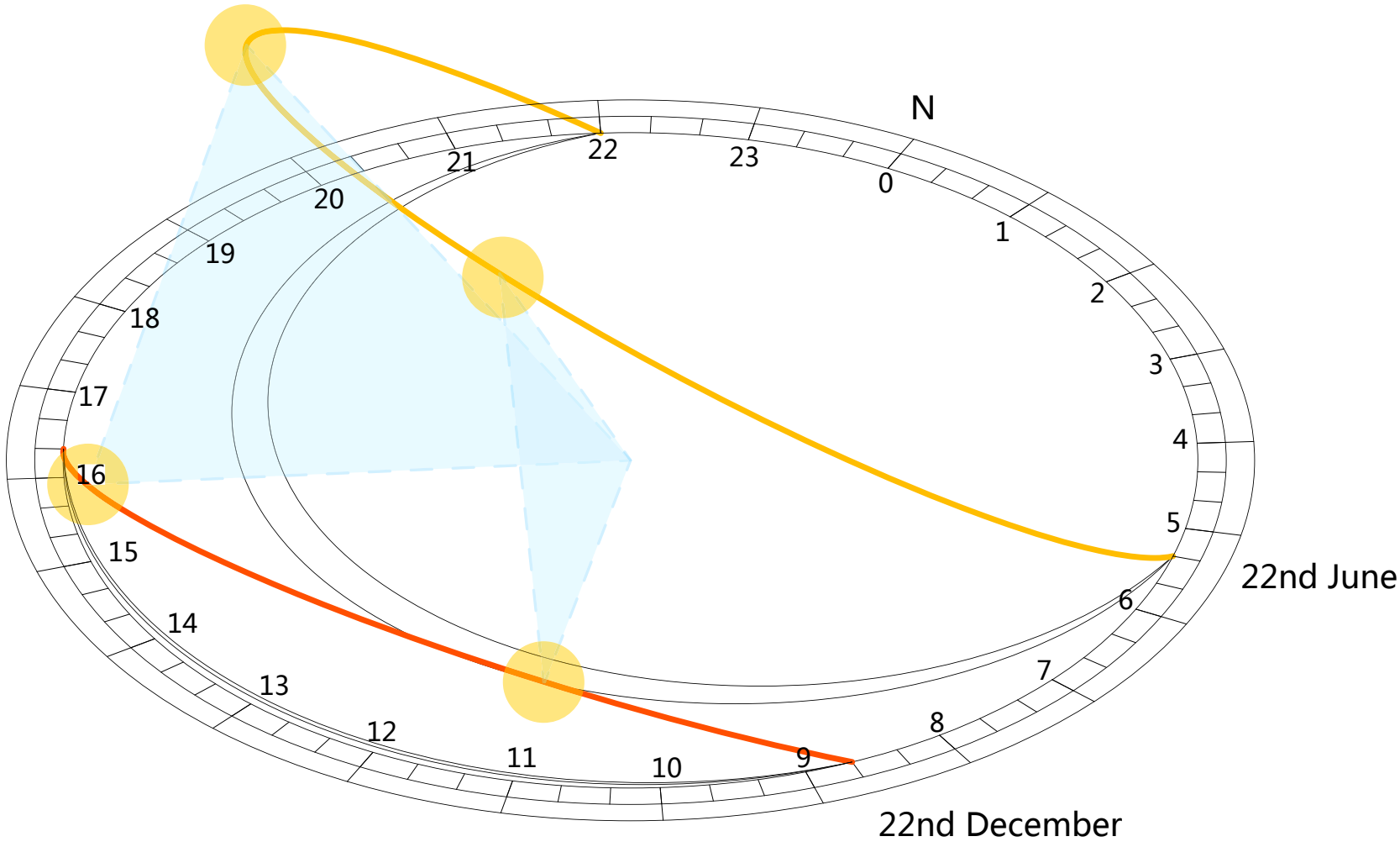
-building system should be on the levels with poor daylight, as well should be near the parking place

- compared with other community areas, worshops need to be located in the place with more daylight (it means that there should be less shading in front of it )

-labs and food processing, storage and packing parts should be near cultivation areas

- functions like food processing, storage, mushroom, which is not much affected by the highways and the light environment, could be set next to the flyovers, and they can be decorated by green facade.

## System for Generating Configuration



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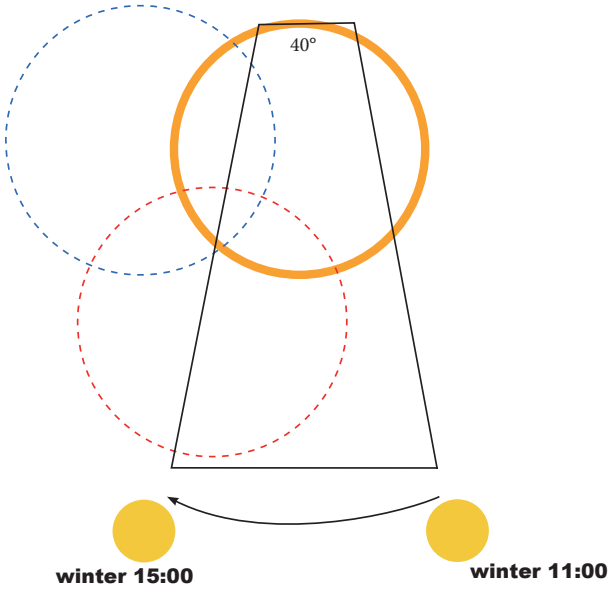
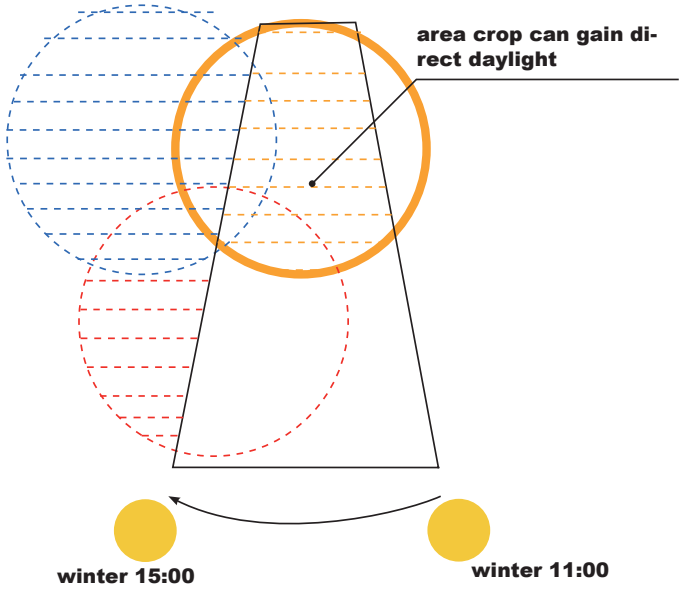
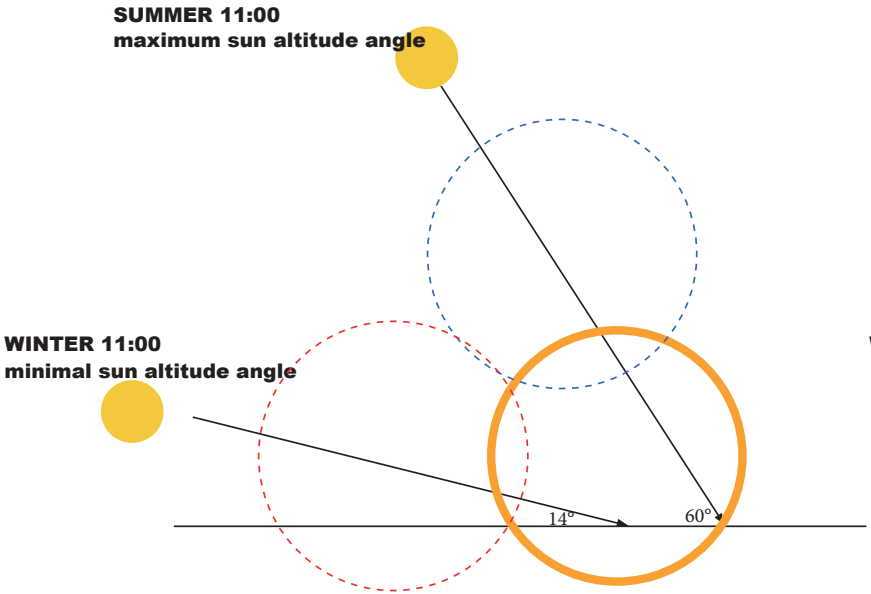
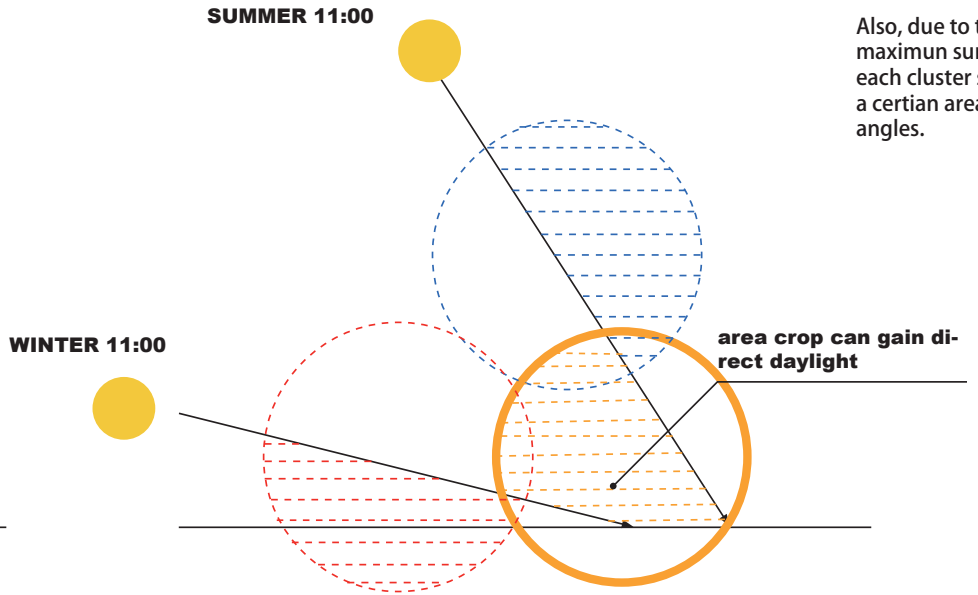



During a sunny day in winter, the system should ensure that the cultivation areas, which have daylight demand, can gain direct sunlight at least from 11:00 to 15:00.

Also, due to the minimal and maximun sun altitude angles, each cluster should move within a certian area defined by these angles.



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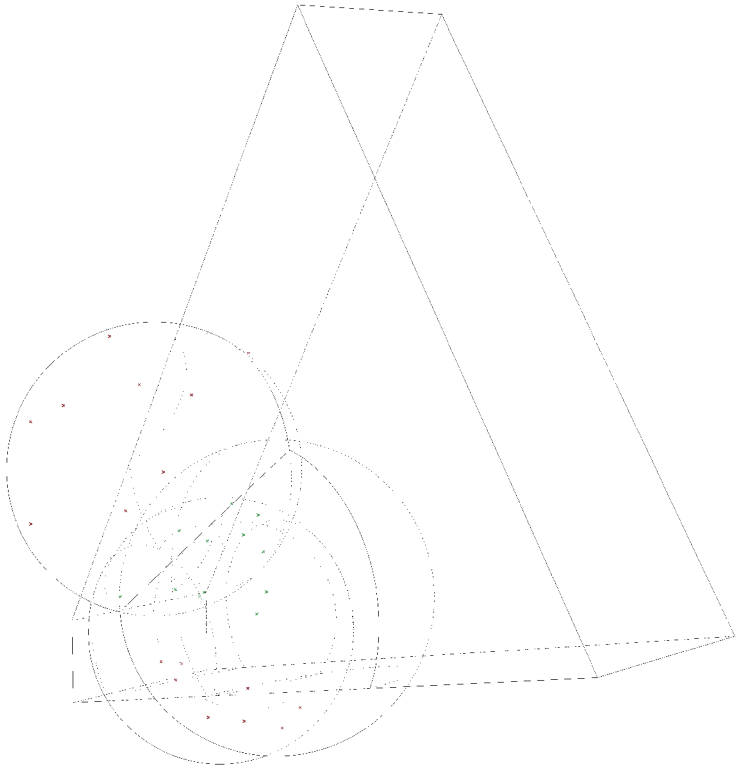
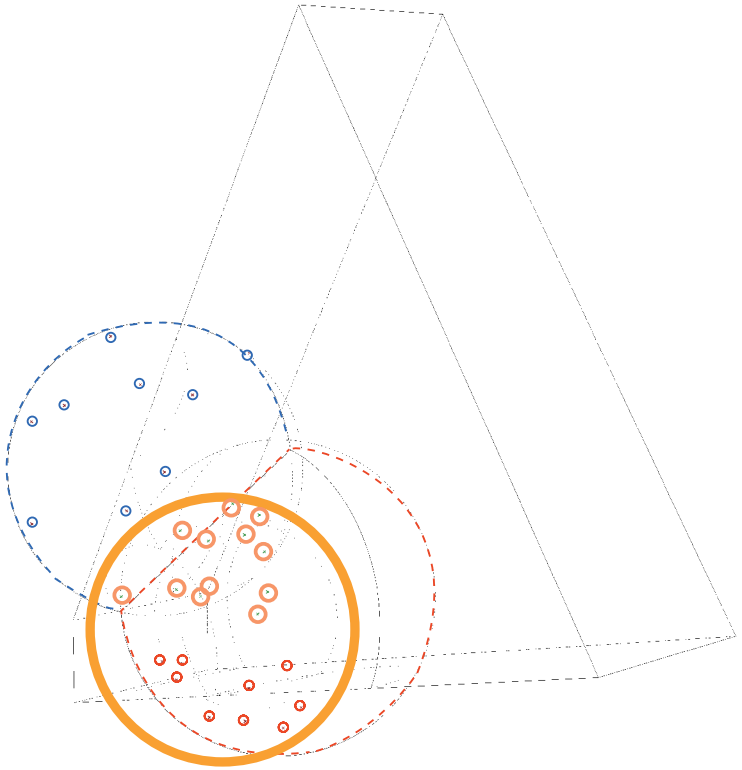
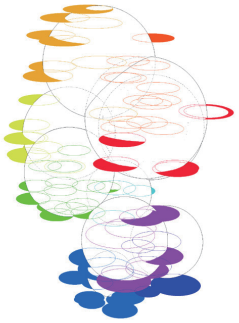


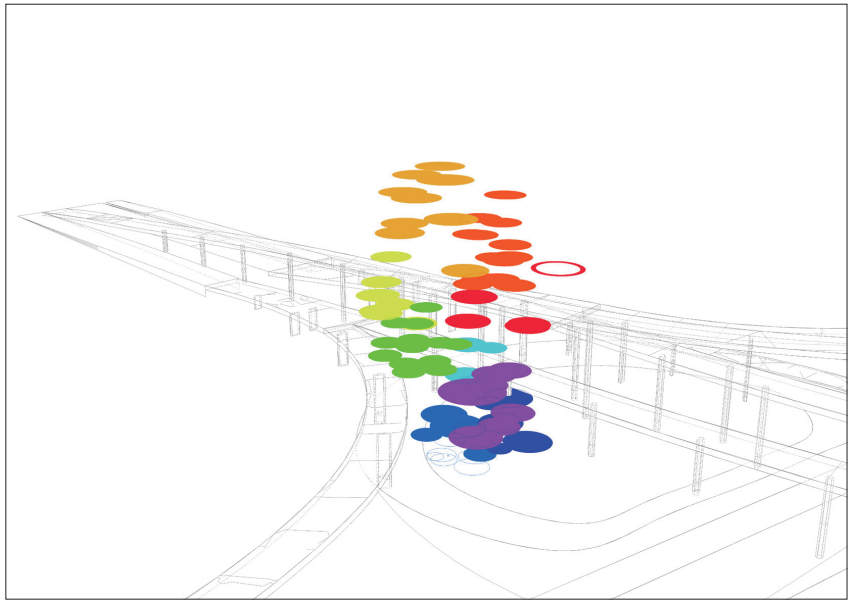


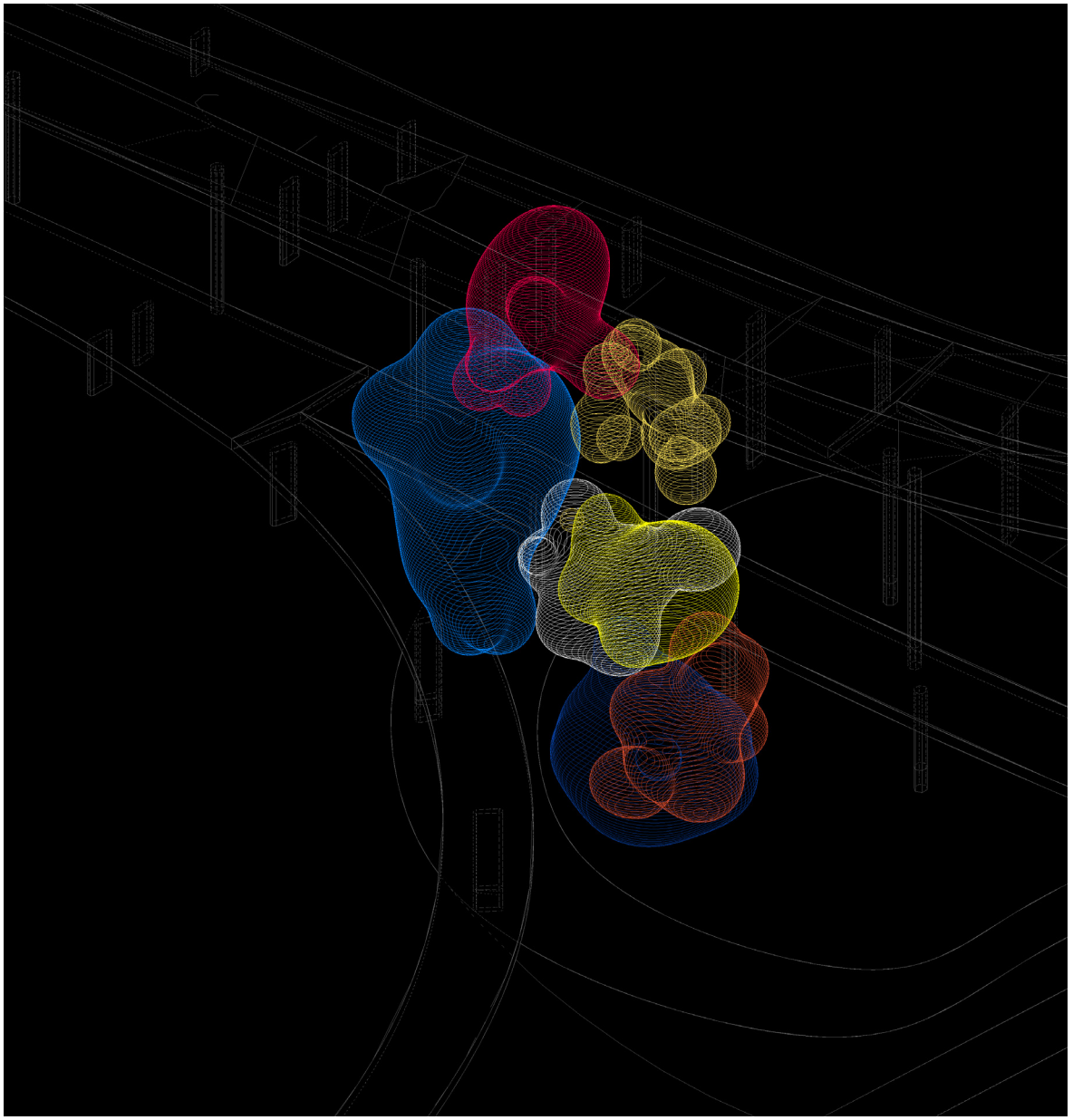
# System for Generating Configuration



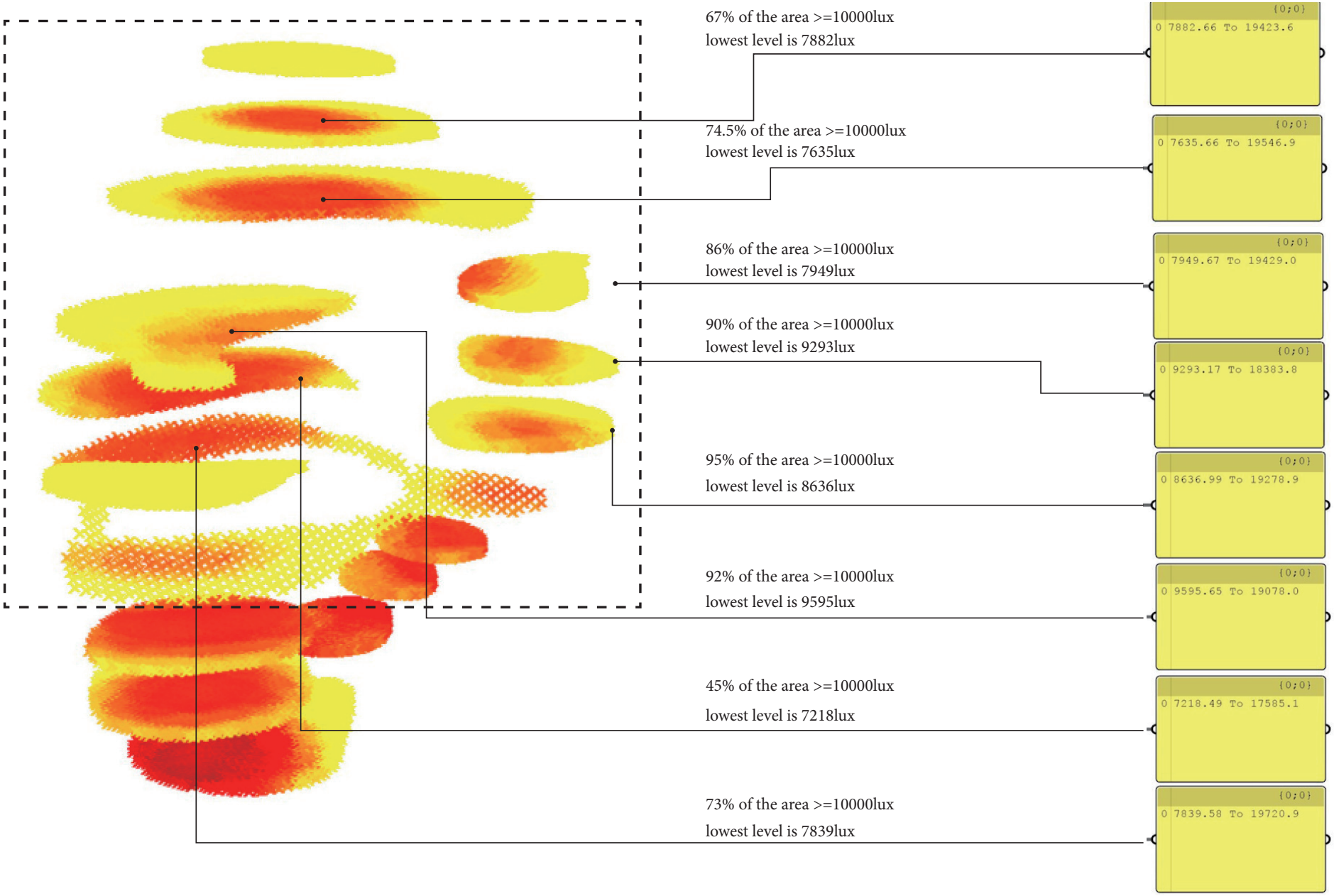
- perannial cultivation 1
- perannial cultivation 2
- annual cultivation
- labs
- hydroponics, mushroom
- packing and distributing
- community spaces
- admin
- building system





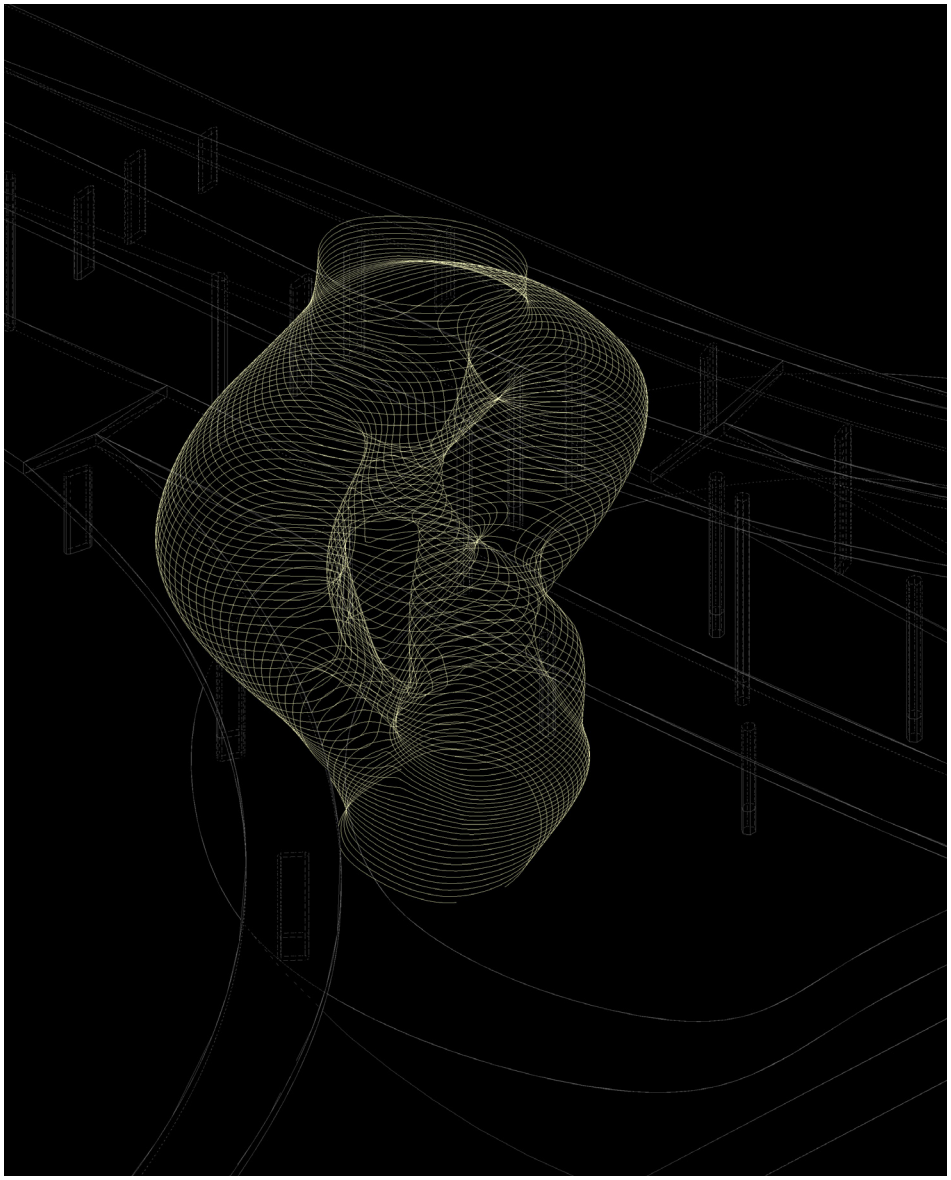


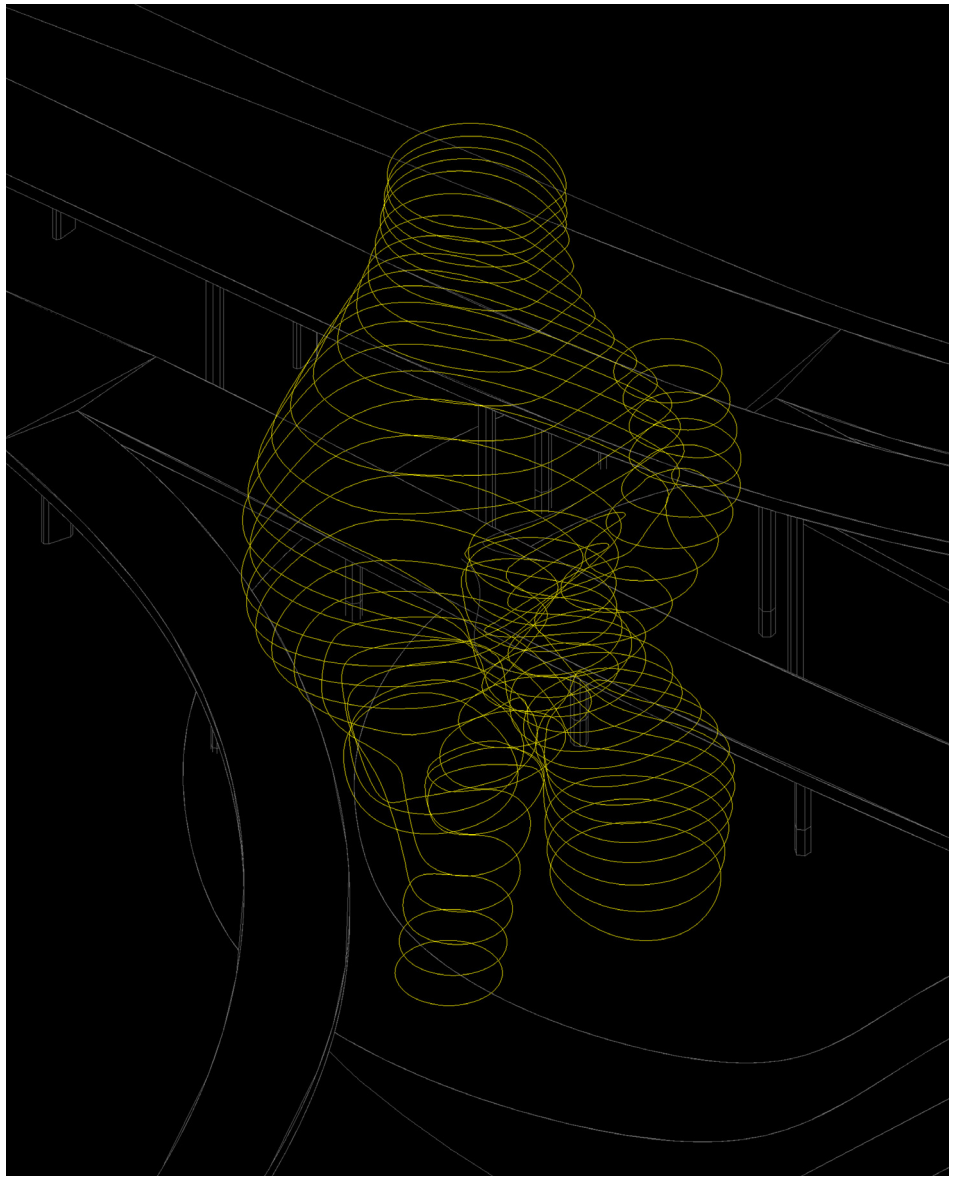
# geco daylight analysis



# Part 4 Architectural Design

## formation of the geometry of building





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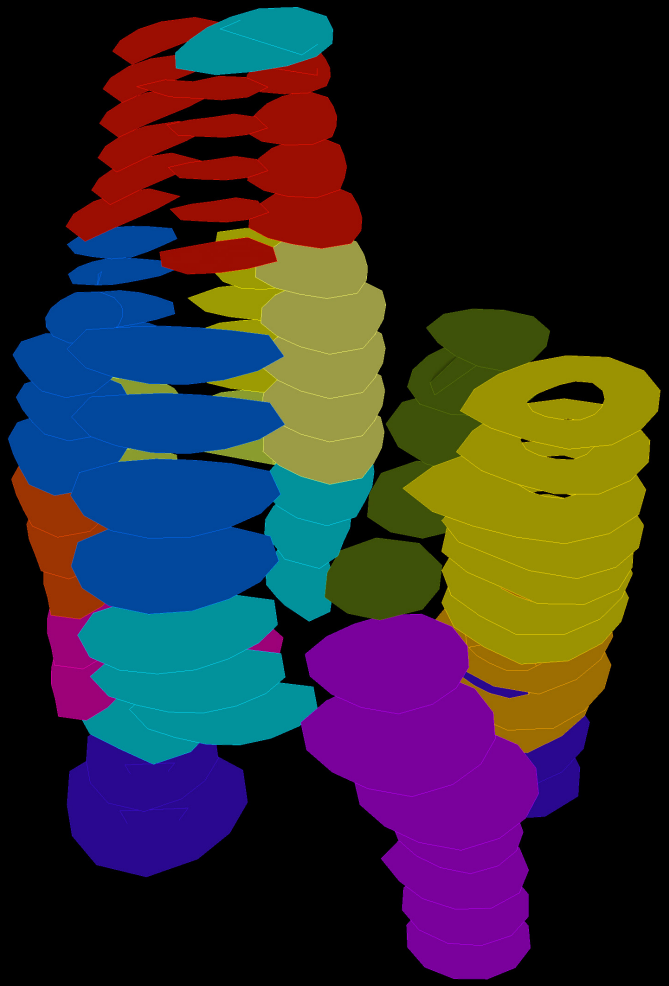
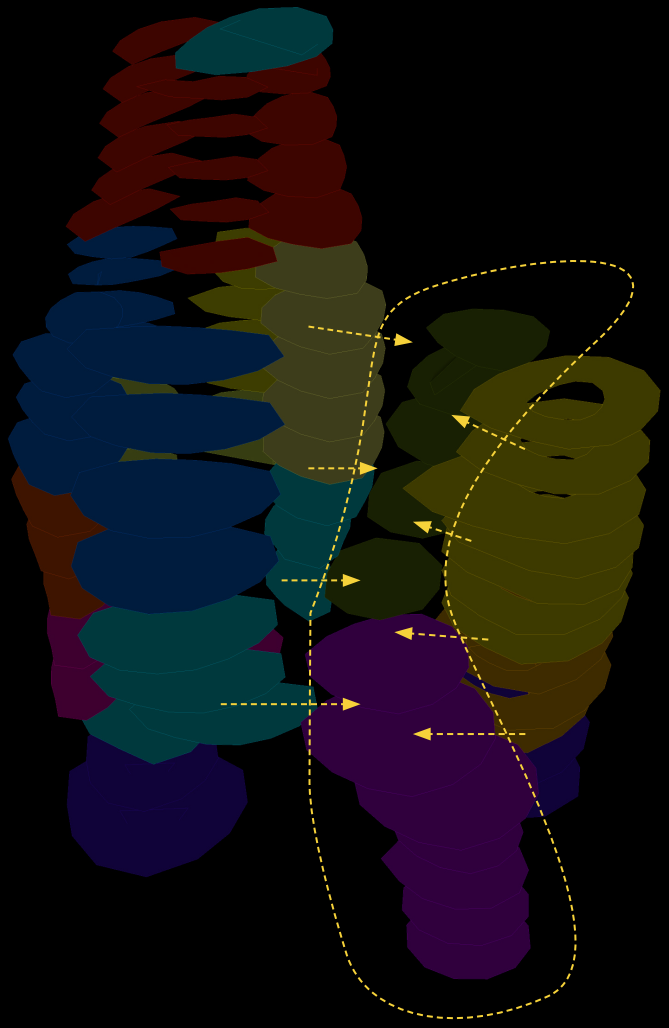


- perennial cultivation1
- perennial cultivation2 with high daylight demand
- perennial cultivation2 with midle to low demand
- outdoor green space (outdoor cultivation/grass land)
- annual cultivation
- hyroponics (including mushroom and fish)
- food processing, storage, packing and distributing
- workshop
- community spaces (reception, cafe, restaurant, bar, shop )
- outdoor market
- building system

formation of the geometry of building



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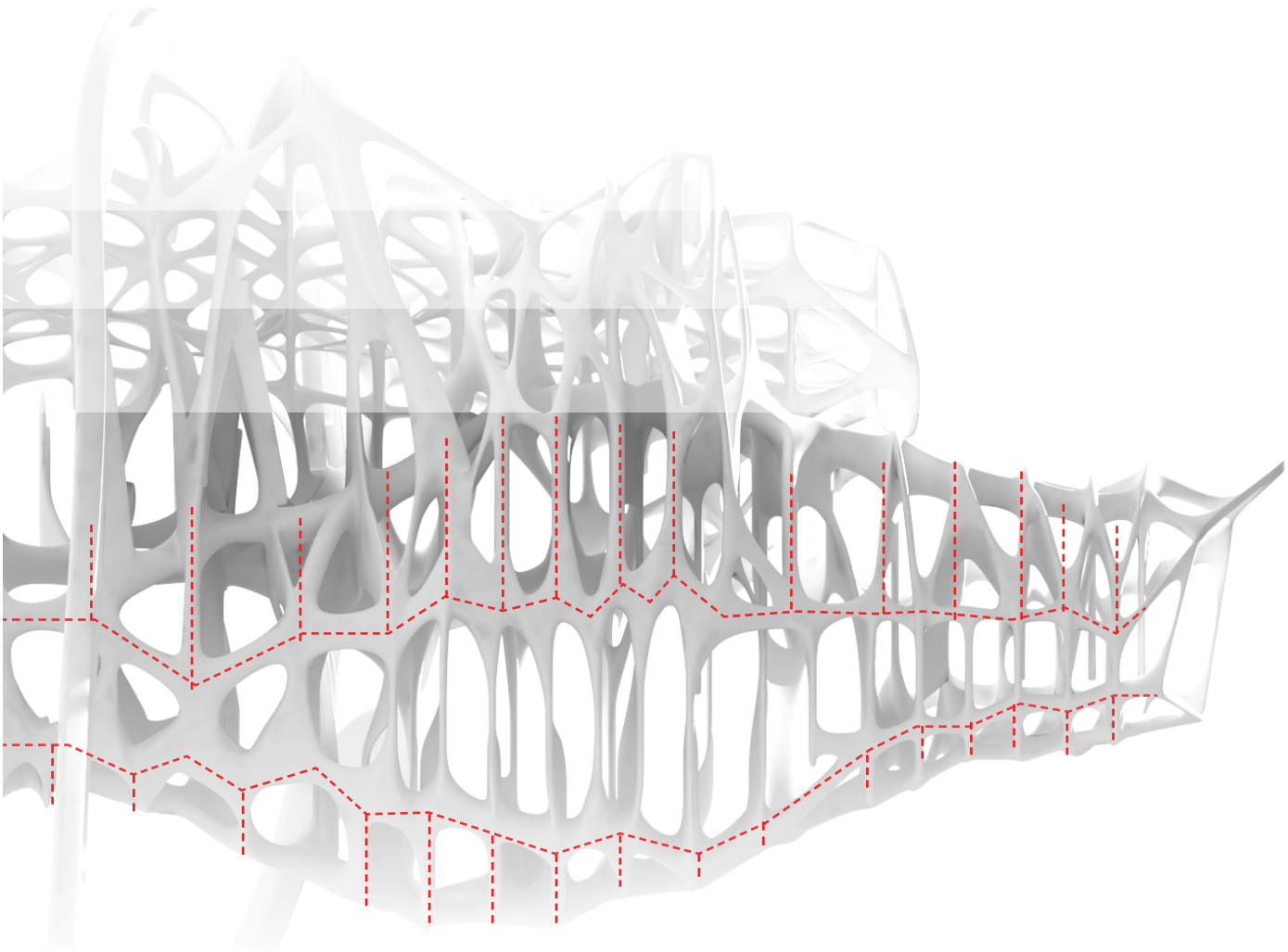
# Creating various identities for guiding visitors

| | City scale network | Education zone/path | Tourism zone/path | Cultivation zone/path |
|---|---|---|---|---|
| Color of Wayfinding | | | | |
| Pavement / Floor |  |  |  |  |

The represetations of various directions to different functions are achieved through applying materials to guide visitors, as well as through placing signs at some strategic points of diffenrent functions.

The identities of each function is reflected through equipments, floors, ceilings, walls, lights, and furniture).



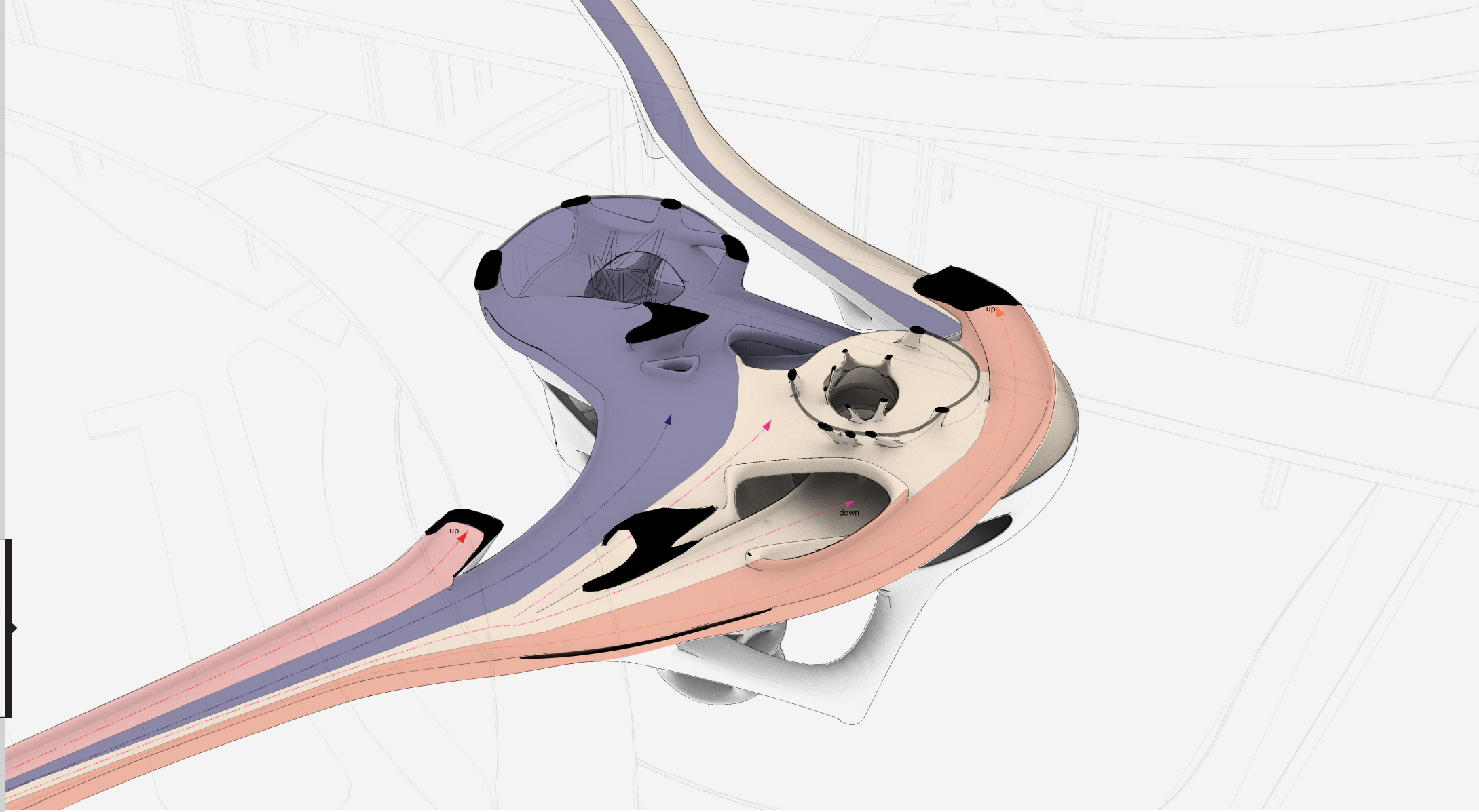
Kleinpolder plan 1: 500


food market zone/path

education zone/path


food market zone/path

education zone/path

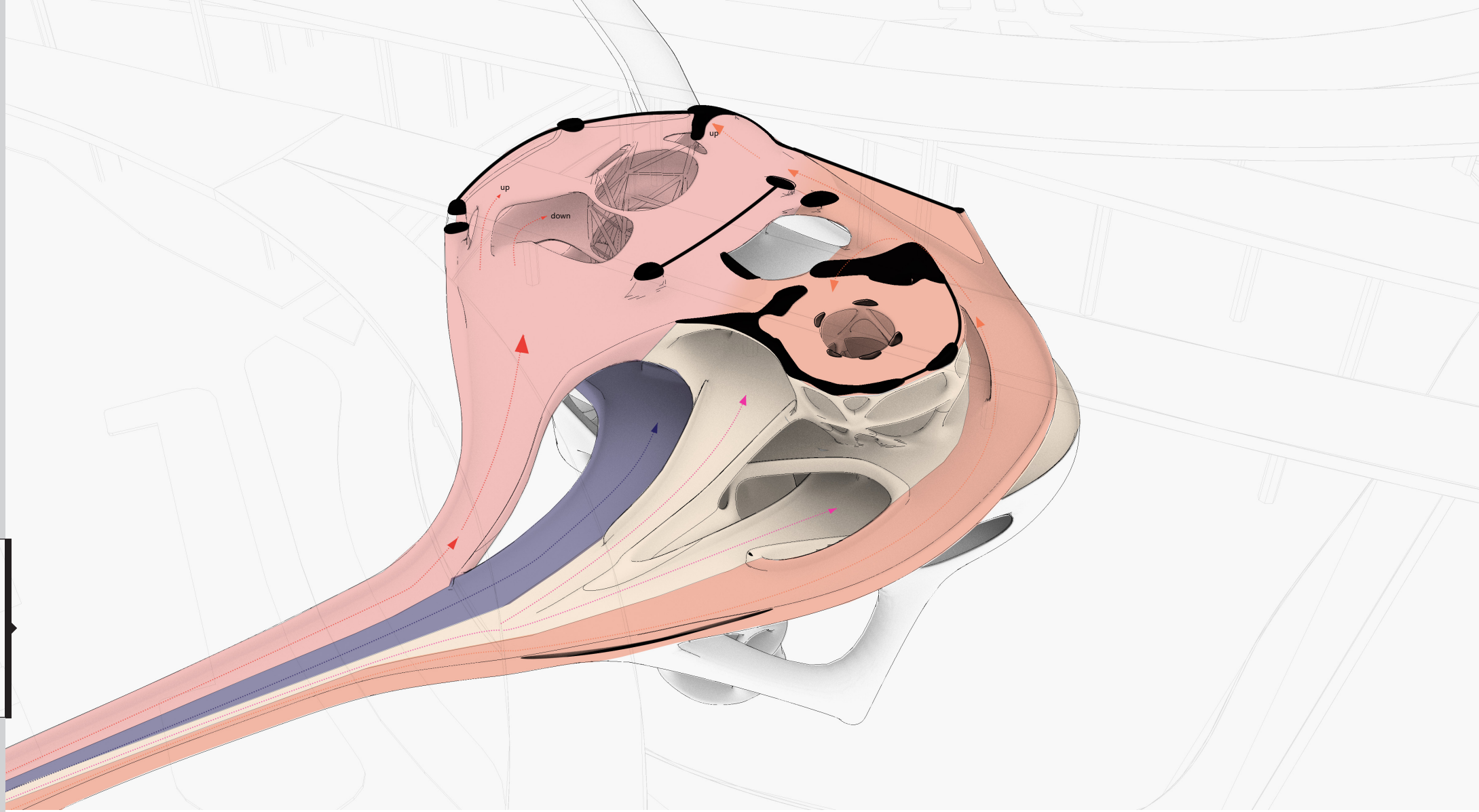



food market zone/path

education zone/path

tourism zone/path

cultivation zone/path

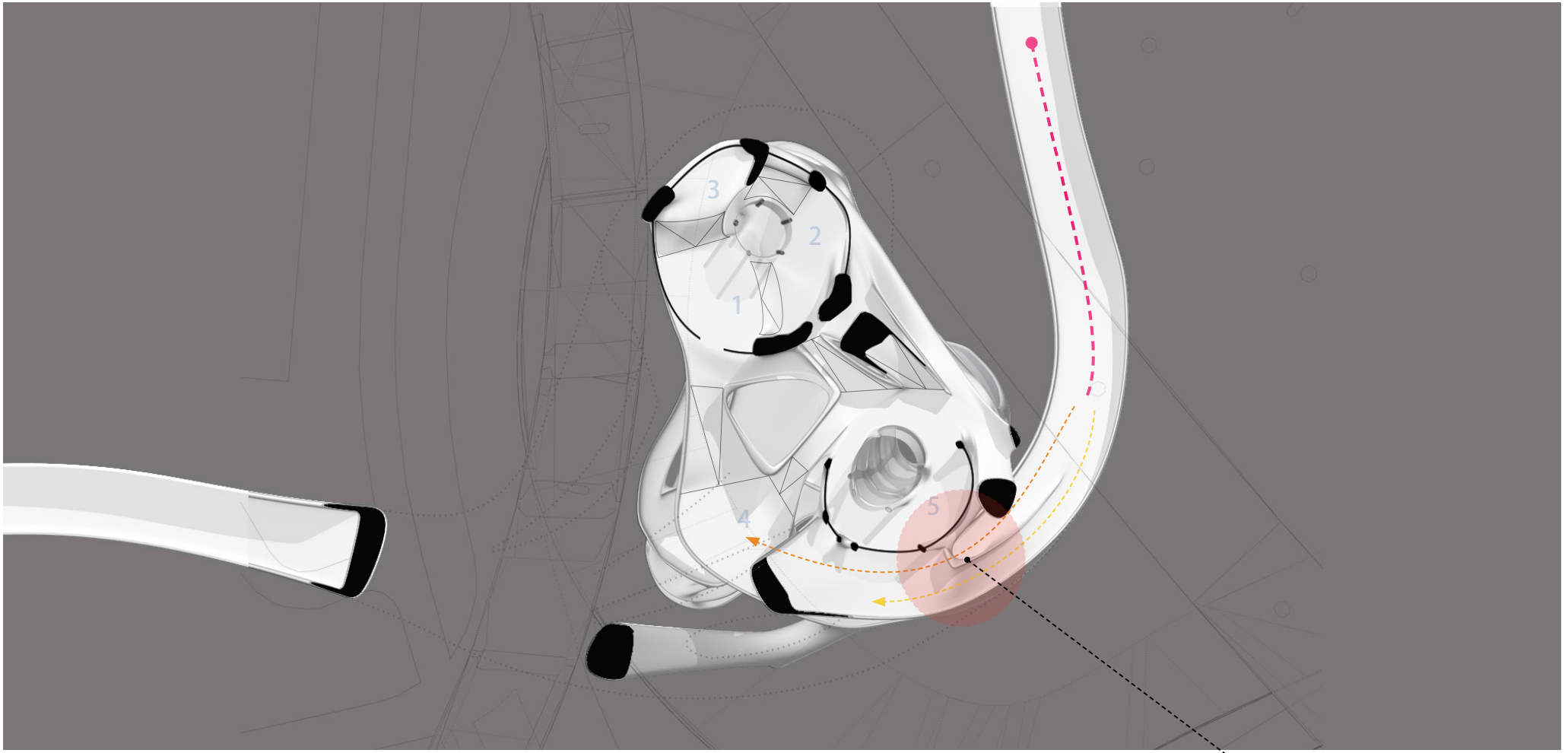



food market zone/path

education zone/path

tourism zone/path

cultivation zone/path




## LEVEL 3 PLAN

1 Food Shop

2 Cafe

3 Food packing and distributing

4 Market

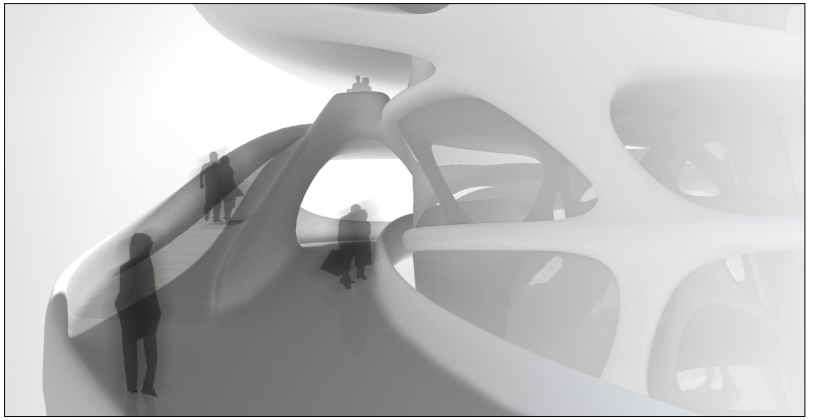
5 Botanic Workshop

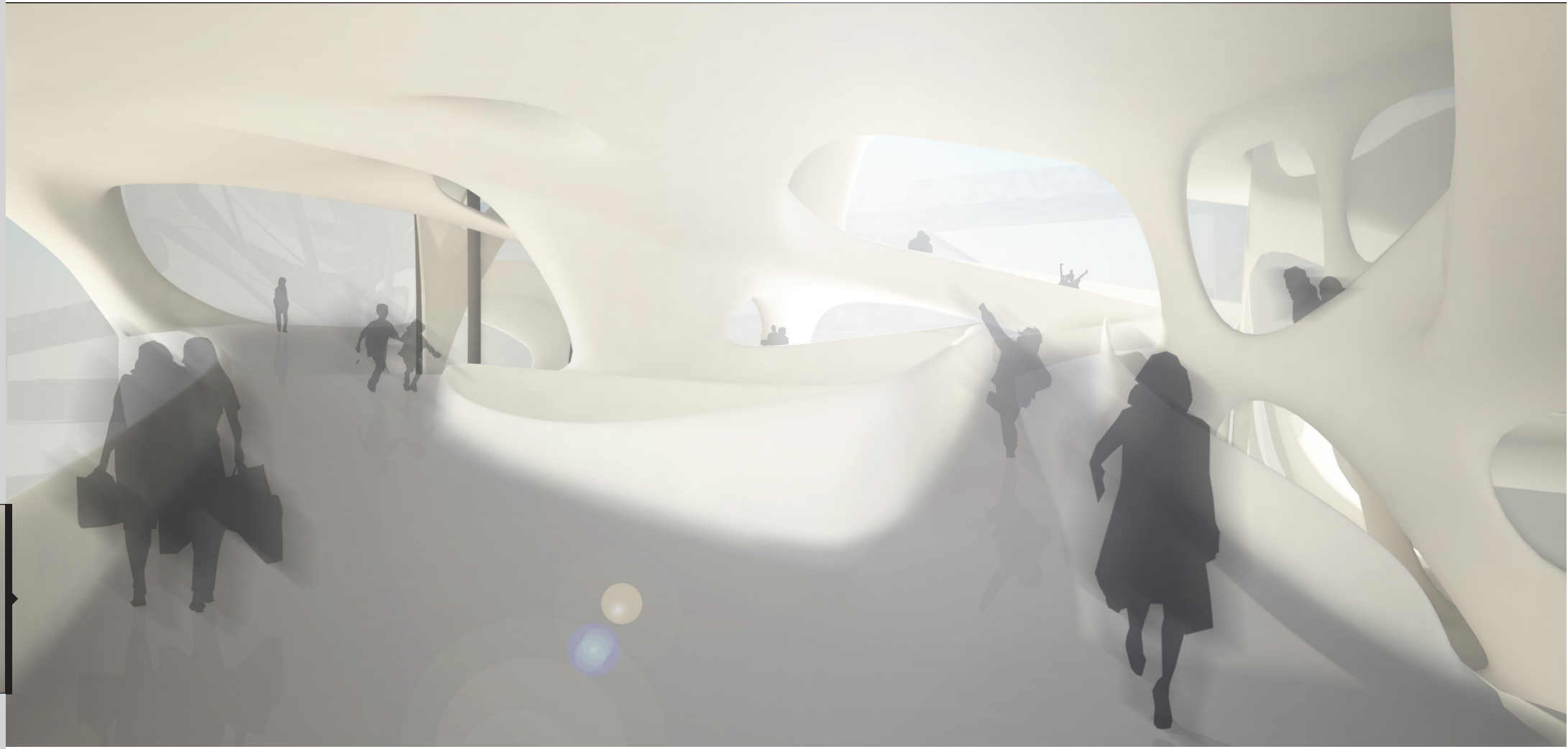
## CIRCULATION ROUTE

pedestrian flow from residential area

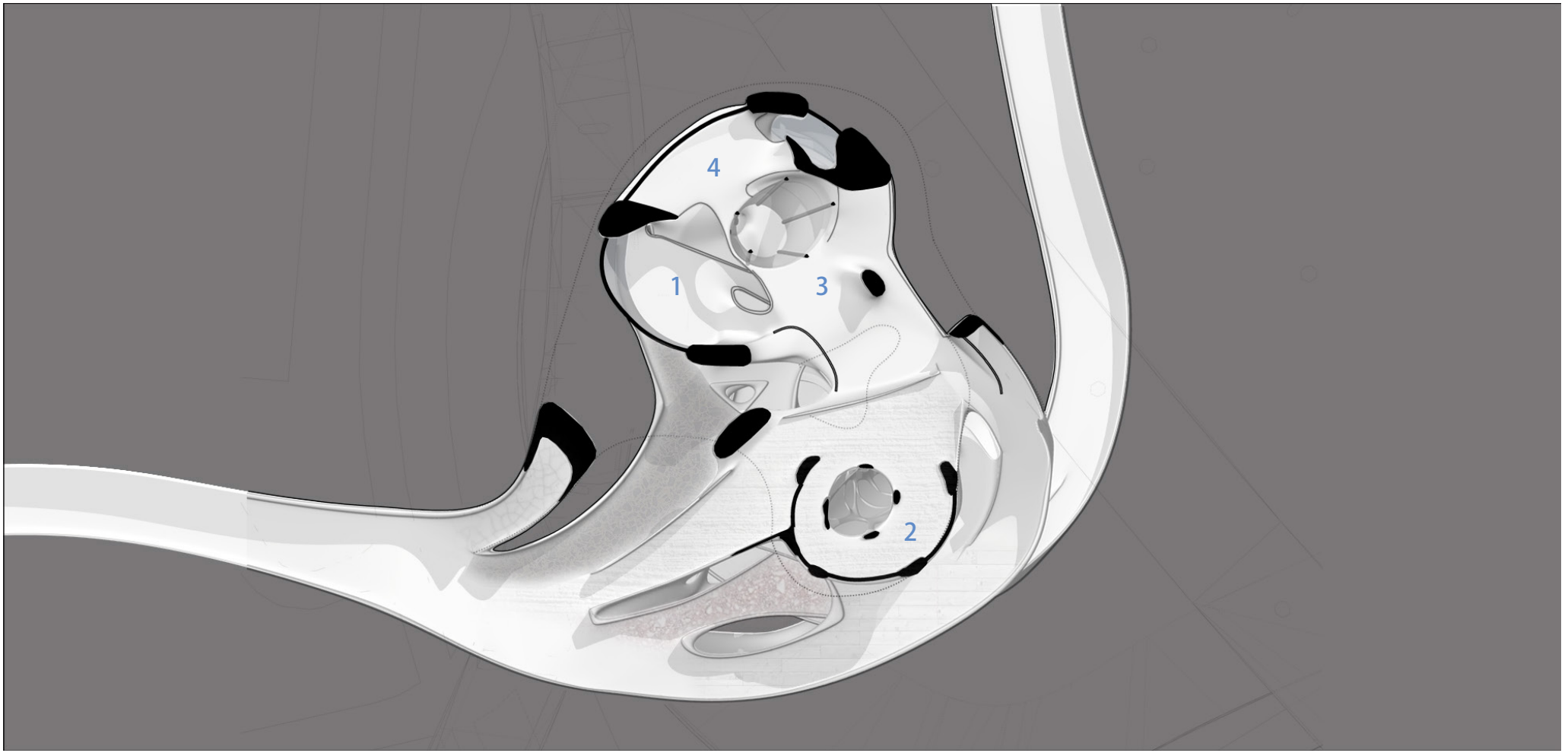
direction to the market

direction botanic workshop





interior view



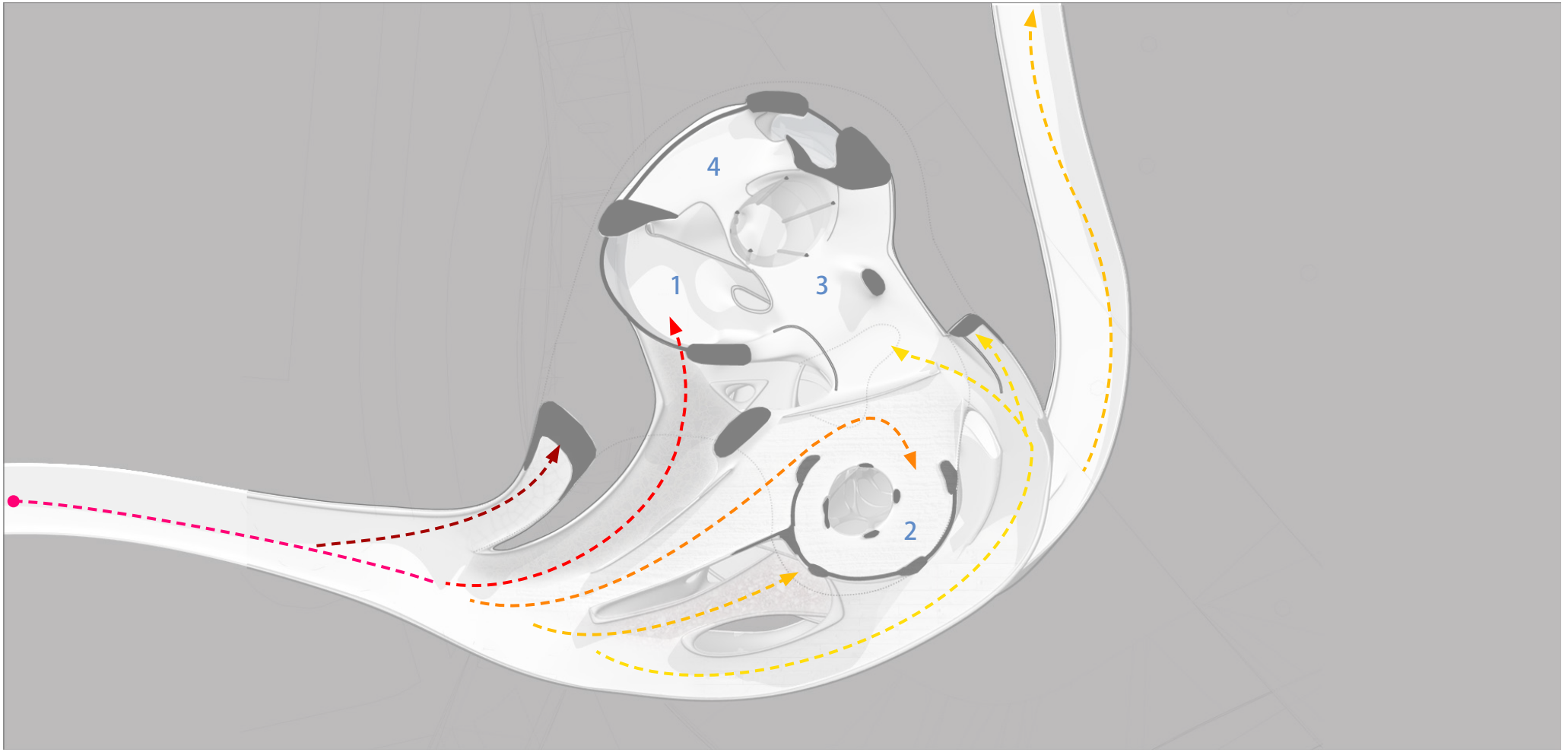

## LEVEL 4 PLAN

1 Reception

2 Botanic Workshop

3 Bar

4 Storage




## LEVEL 4 PLAN

1 Reception

2 Botanic Workshop

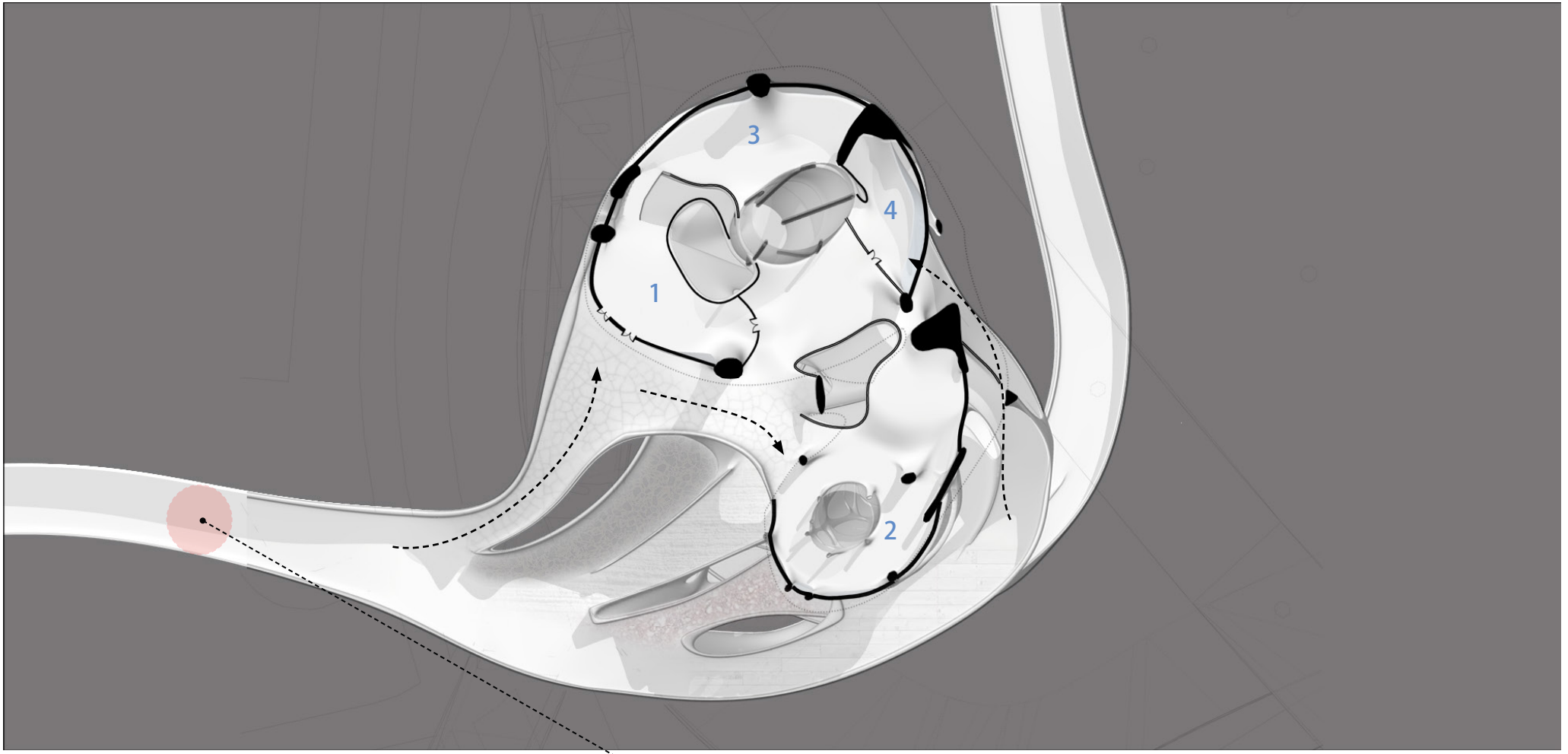
3 Bar

4 Storage

## CIRCULATION ROUTE

- pedestrian flow from residential area
- direction to upper foyer
- direction to reception
- direction to the workshop
- direction to down workshop or the direct connection to the other side residential area
- direction to the bar and upper entrance to visit the hydroponisc area

view of the entrance



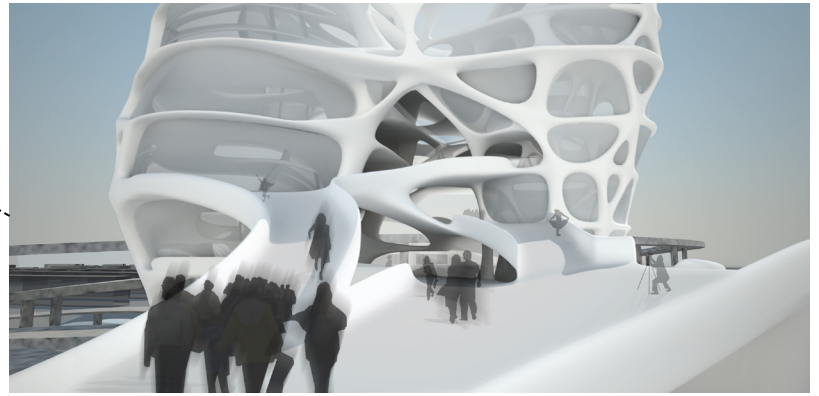

## LEVEL 5 PLAN

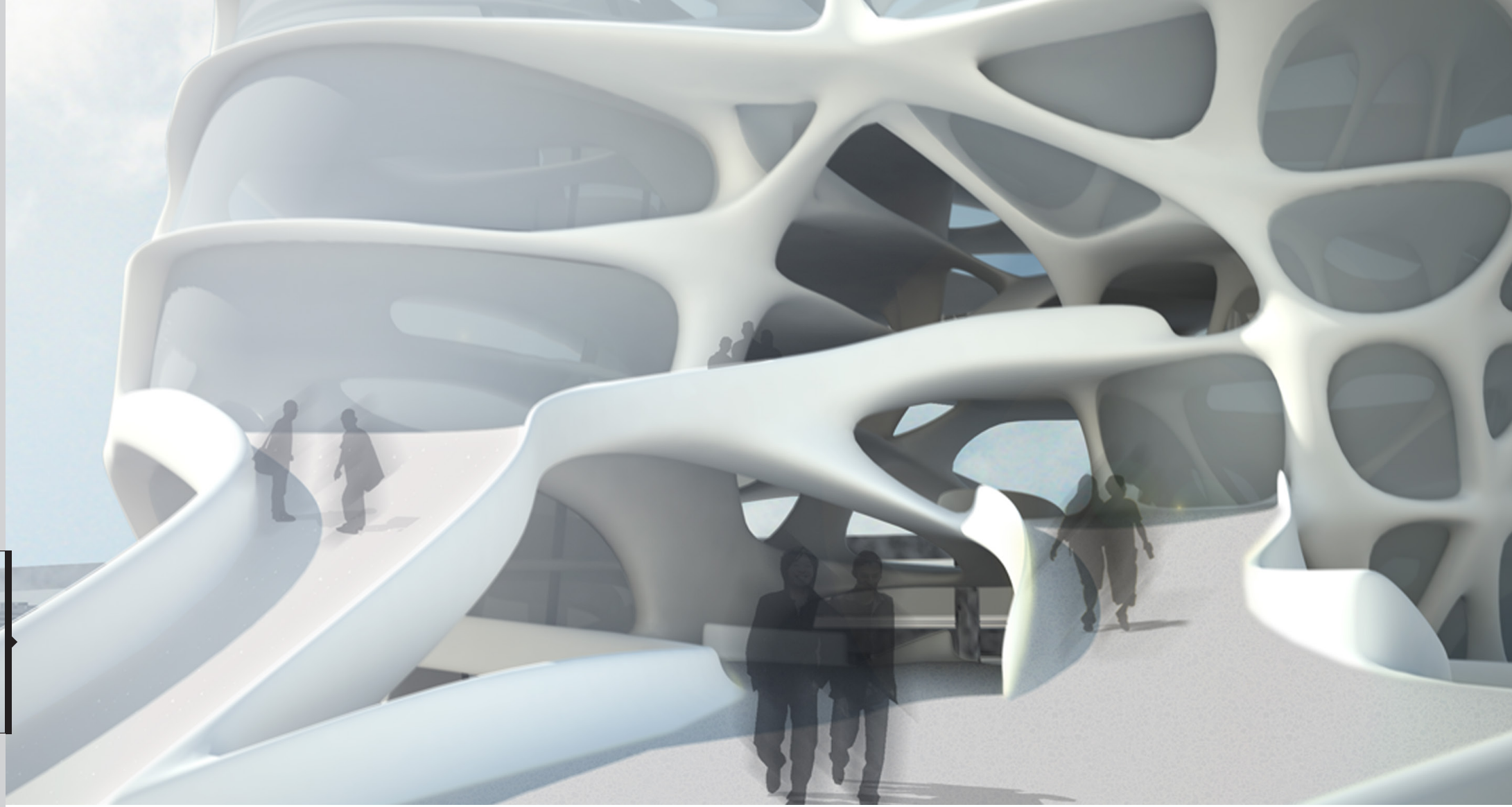
1 Foyer

2 Botanic Workshop

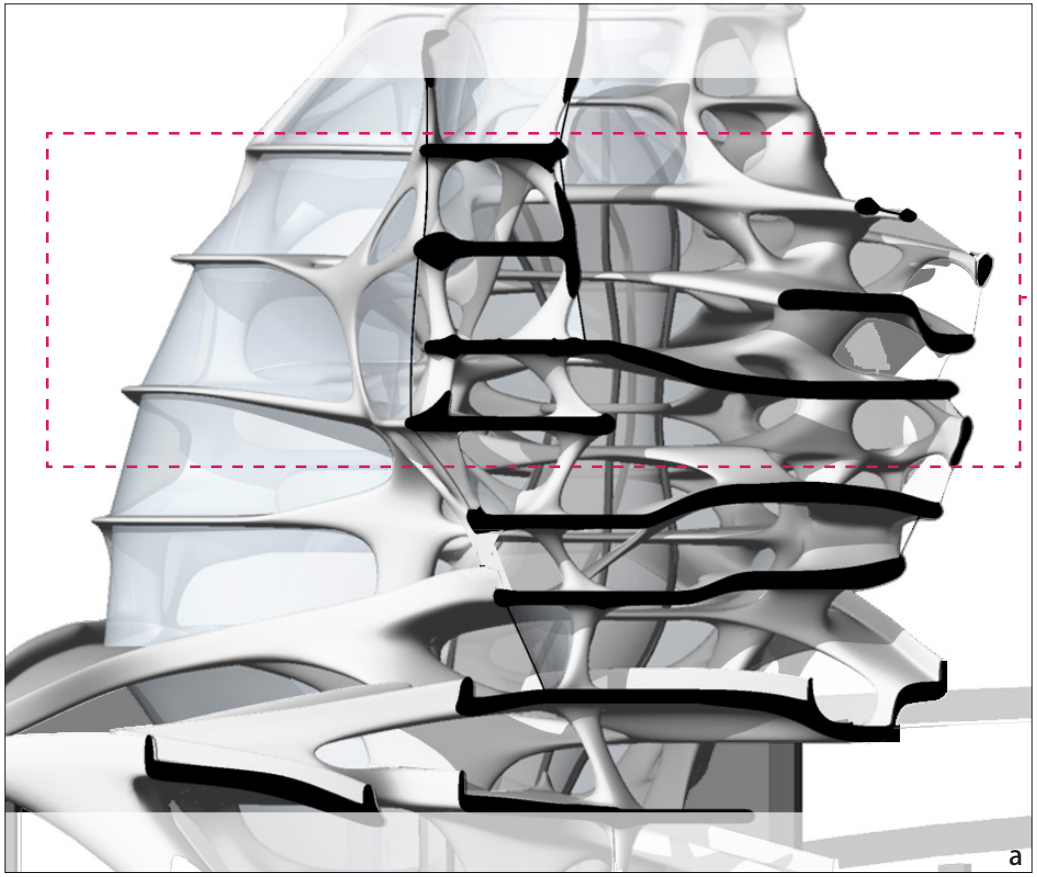
3 Food Processing

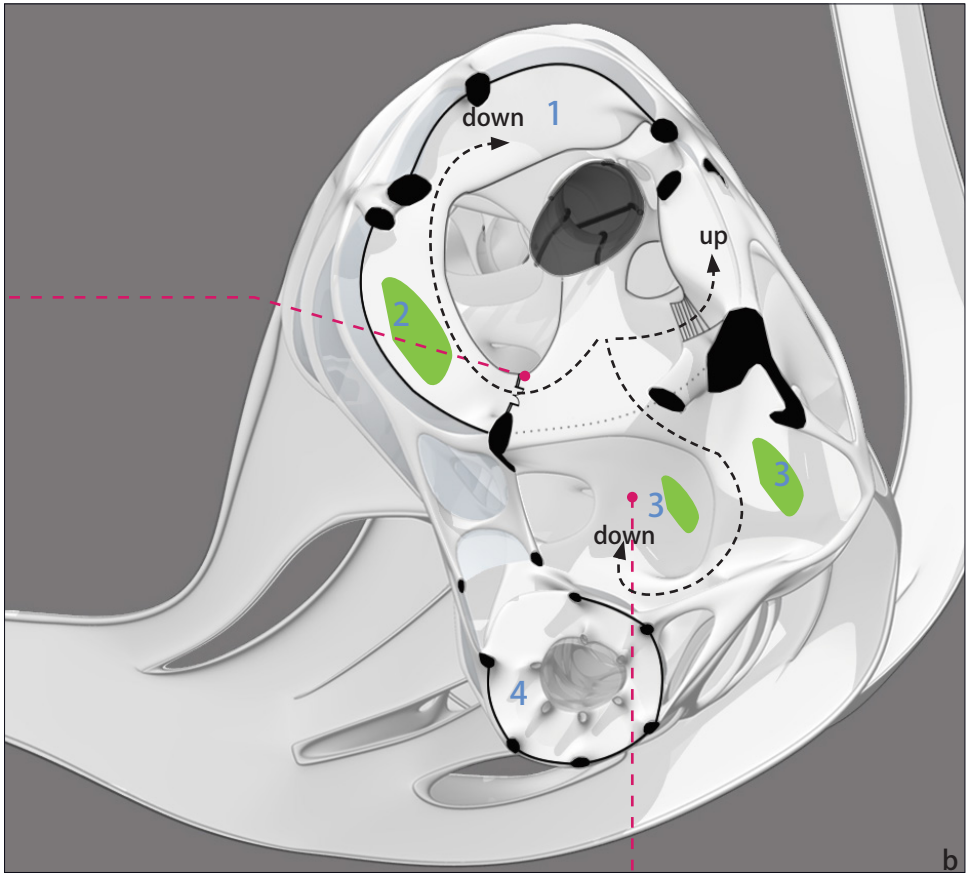
4 Visitor entrance to the hydroponics area

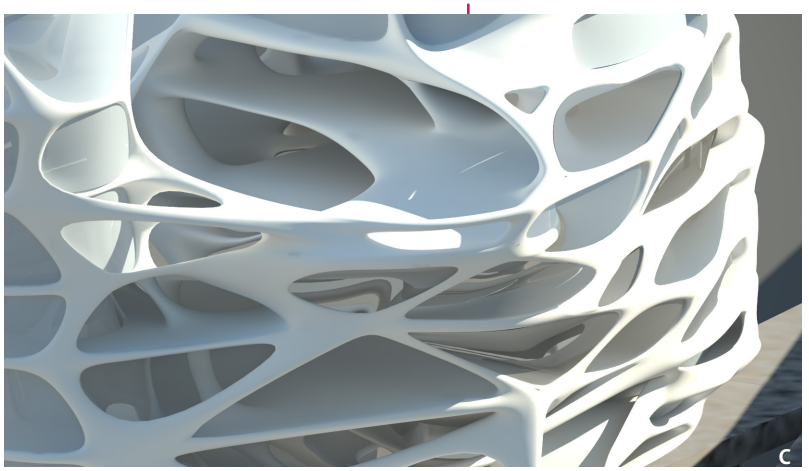




view of the entrance




a. fragment section

b. fragment plan

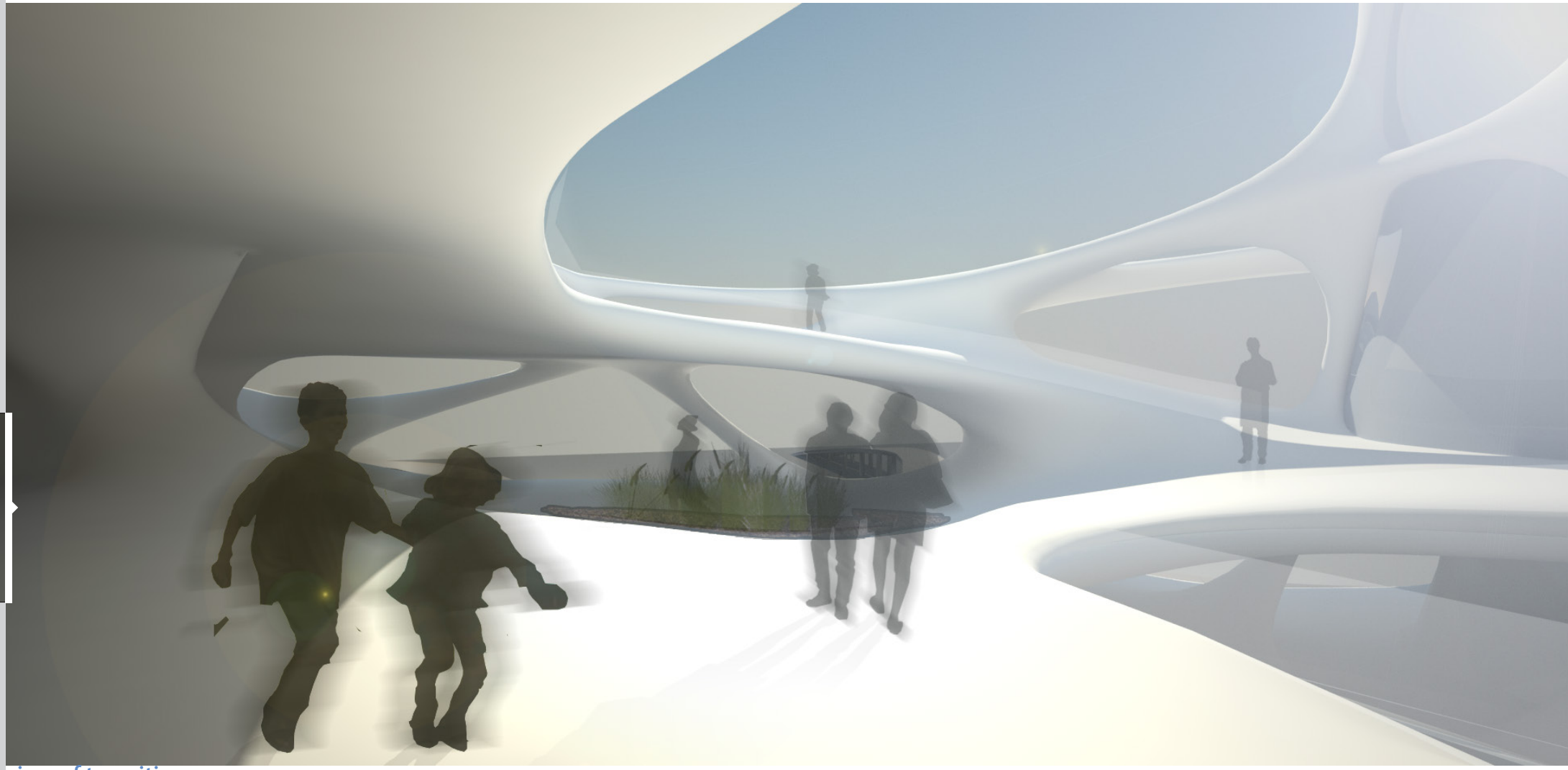
c. aerial view

1 Hydroponics

2 Perenniel

3 Outdoor Cultivation

4 Annual Cultivation



view of transition space

east view

1. annual cultivation

2. perennial cultivation 1(high demand for day-lighting and with shorter roots)

3. perennial cultivation 2(medium to low de-mand for daylighting)

4. perennial cultivation (high or high for day-lighting and with longer roots)

5. hydroponics

6. aquaponics

7.labs

8. processing, storage, packing and distributing

9. office

10. building system, energy generation and collection

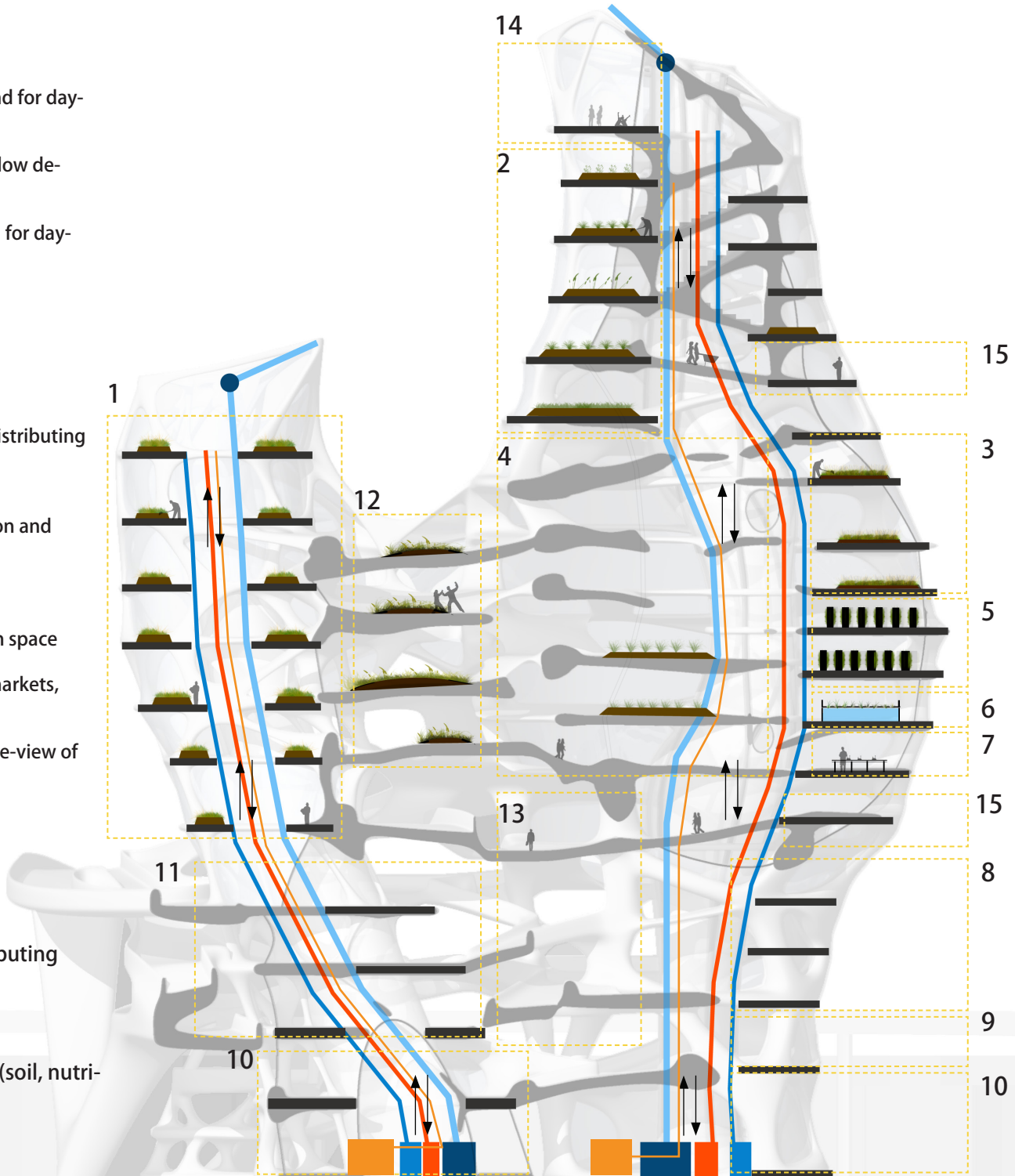
11. botanic workshop

12. public cultivation space and green space

13. public community space(shops, markets, bar, cafe, etc.)

14. public space for having bird’ s eye-view of Rotterdam city

15. crop gathering



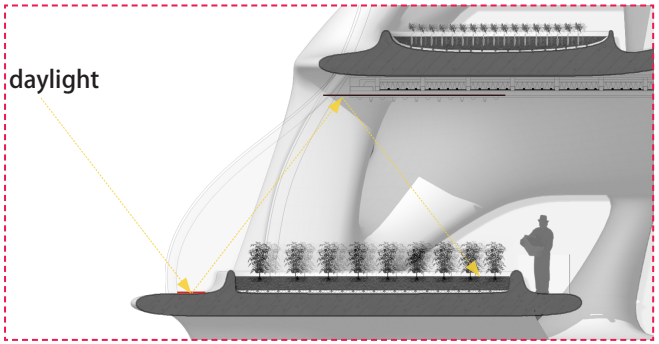

elevator

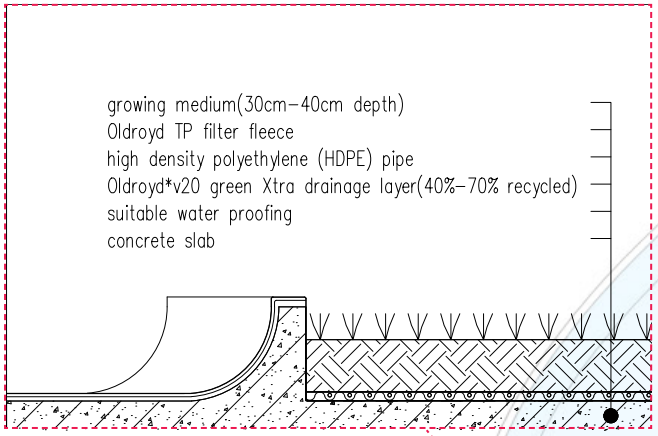
water collecting and distributing

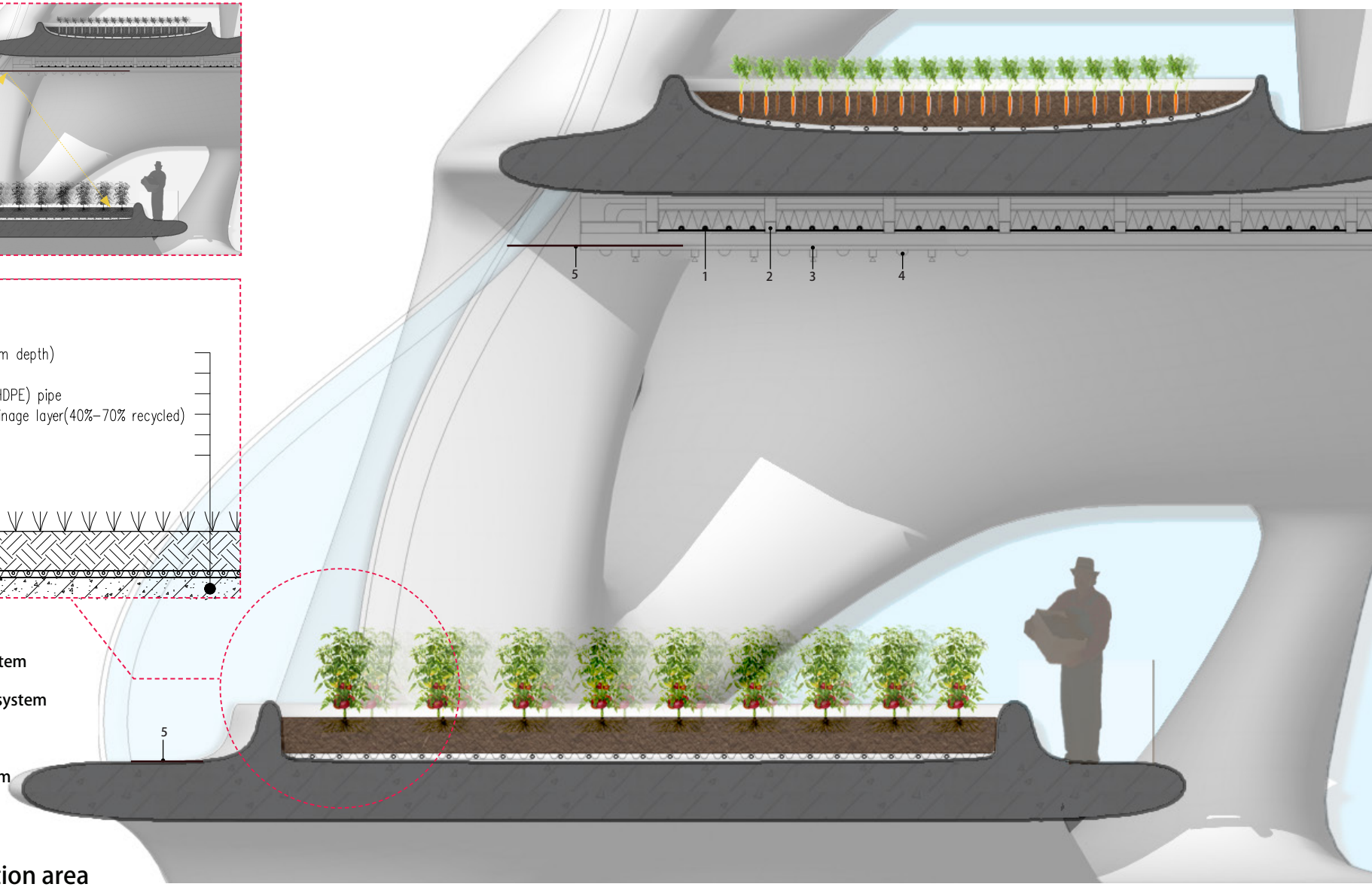
heating

cooling

pipes for vertical transport(soil, nutri-ents, waste)



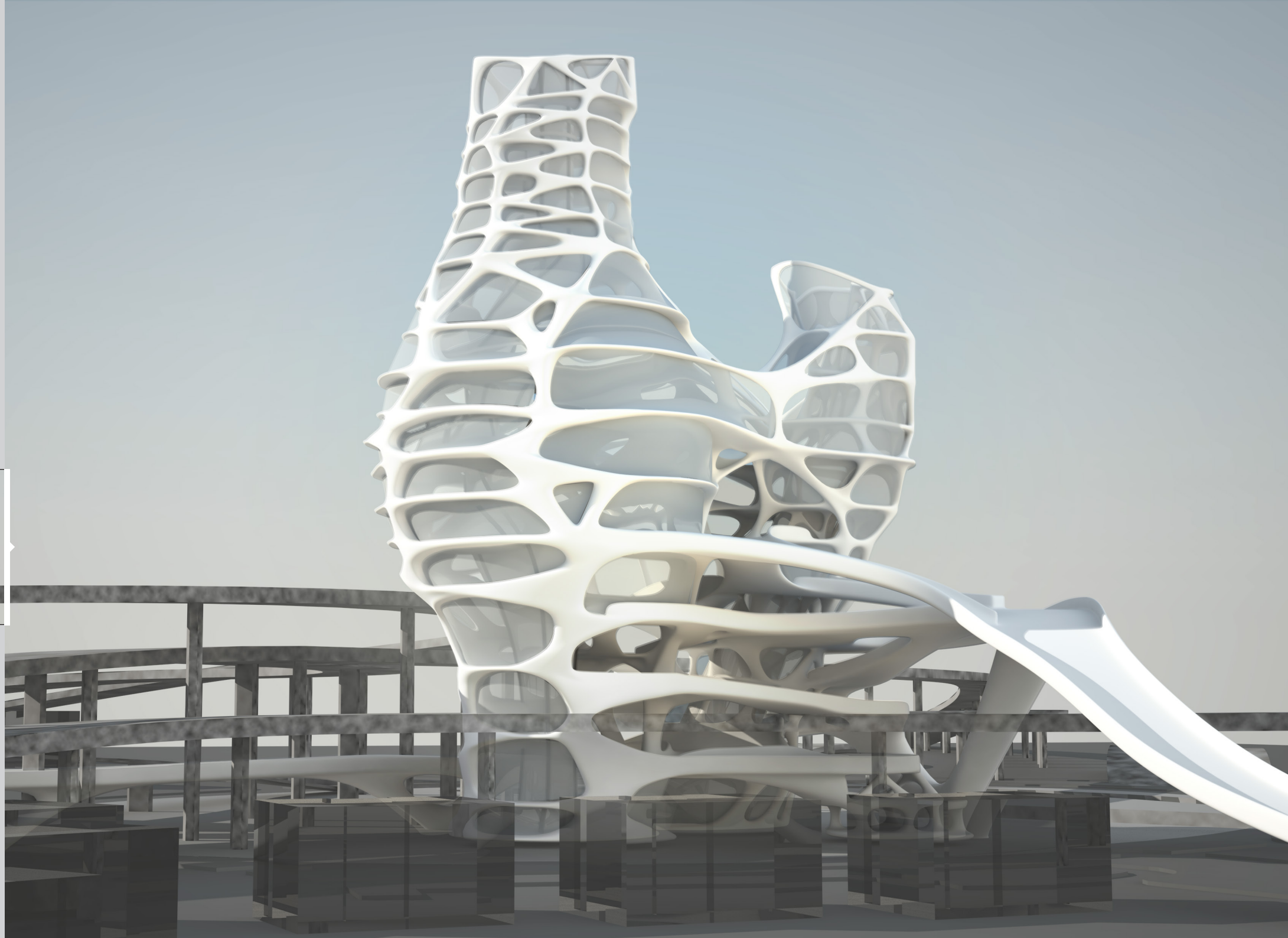



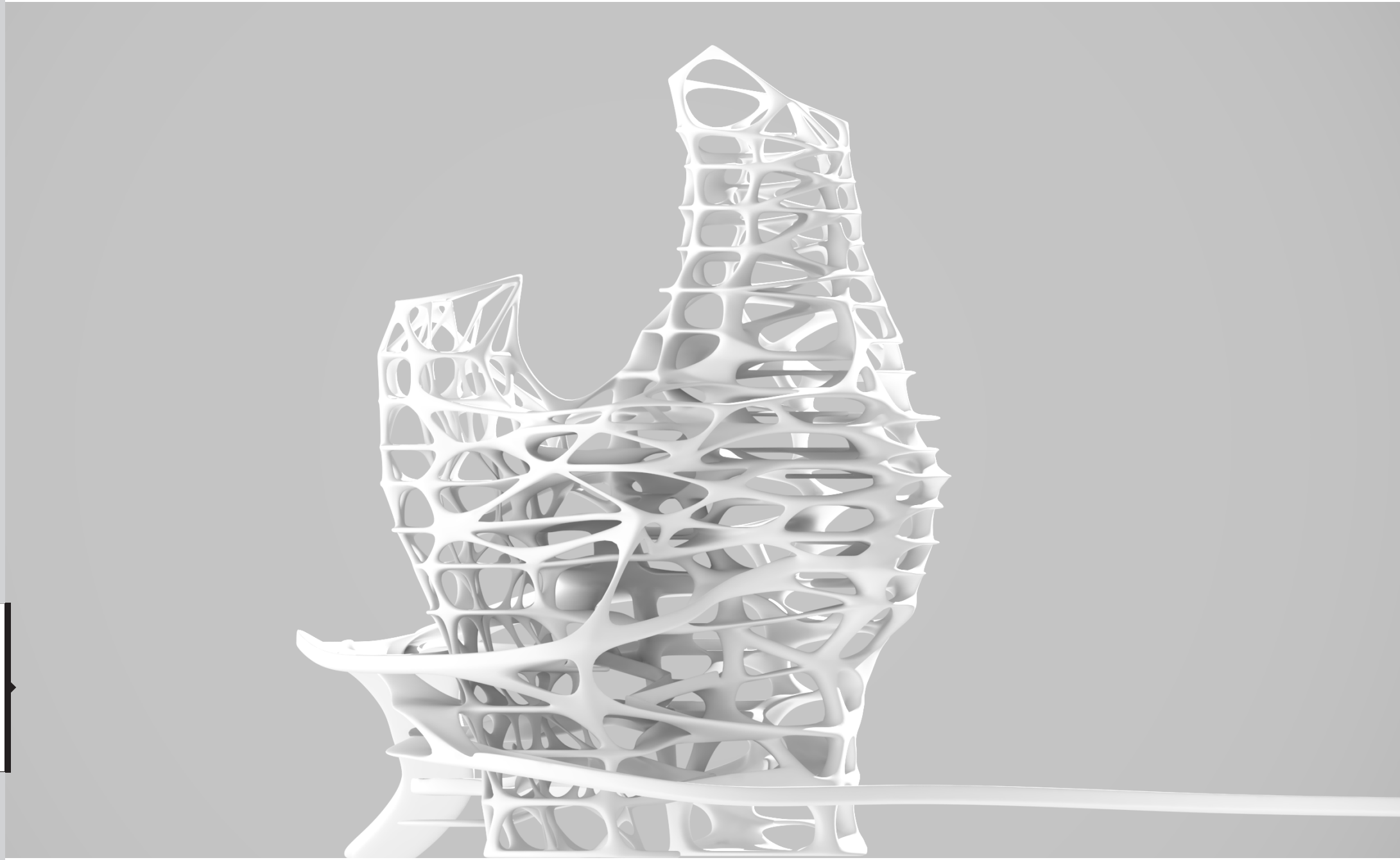

1. ceilling cooling and heating system
2. ceilling mechanical ventilation system
3. sprinkler system
4. LED(light-emitting diode) system
5. reflective surface

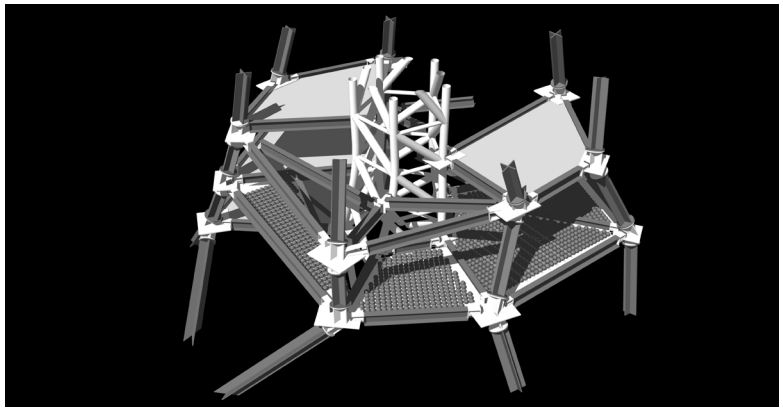
## detail section / cultivation area

west view

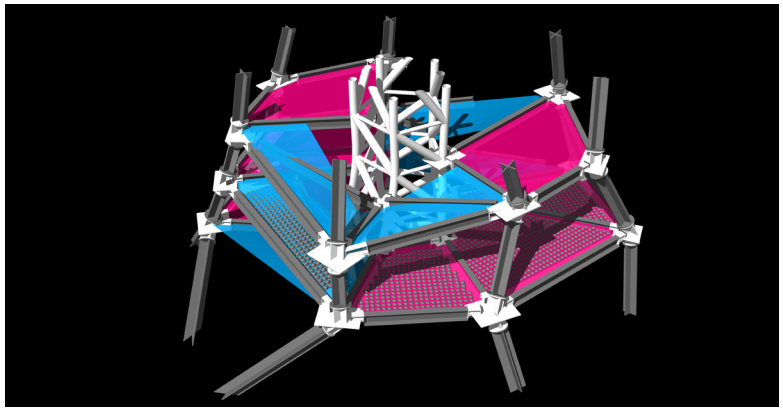


# Part 5 Structure and Fabrication

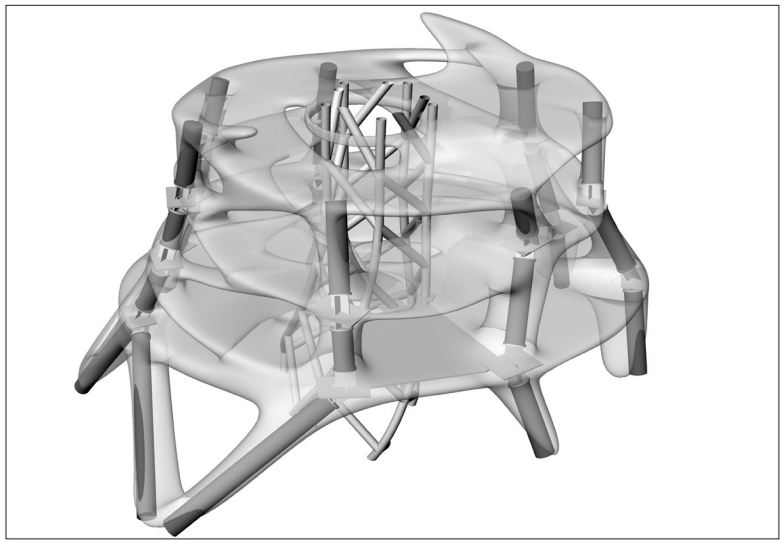




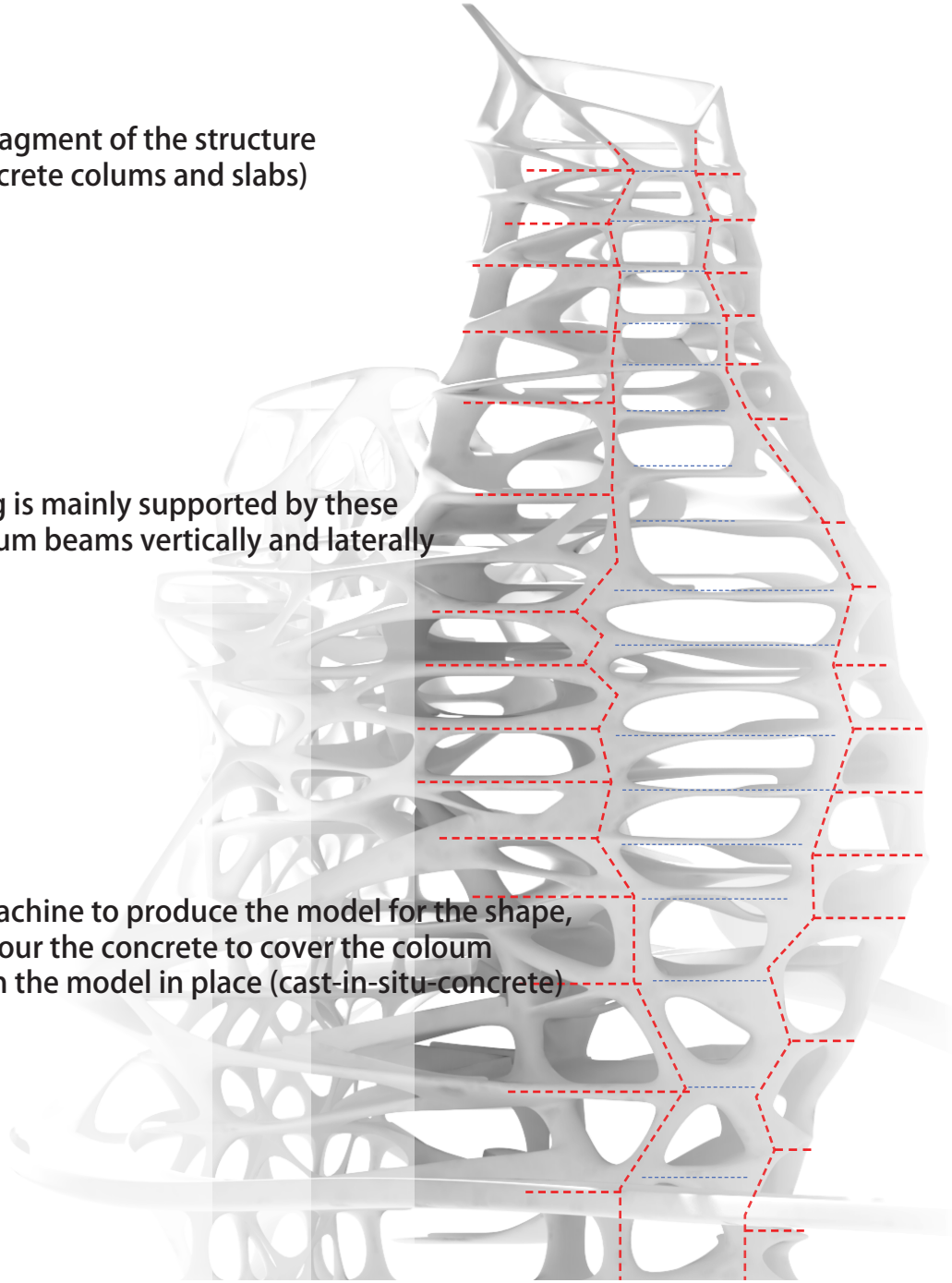
this is the fragment of the structure
(hybrid concrete colums and slabs)

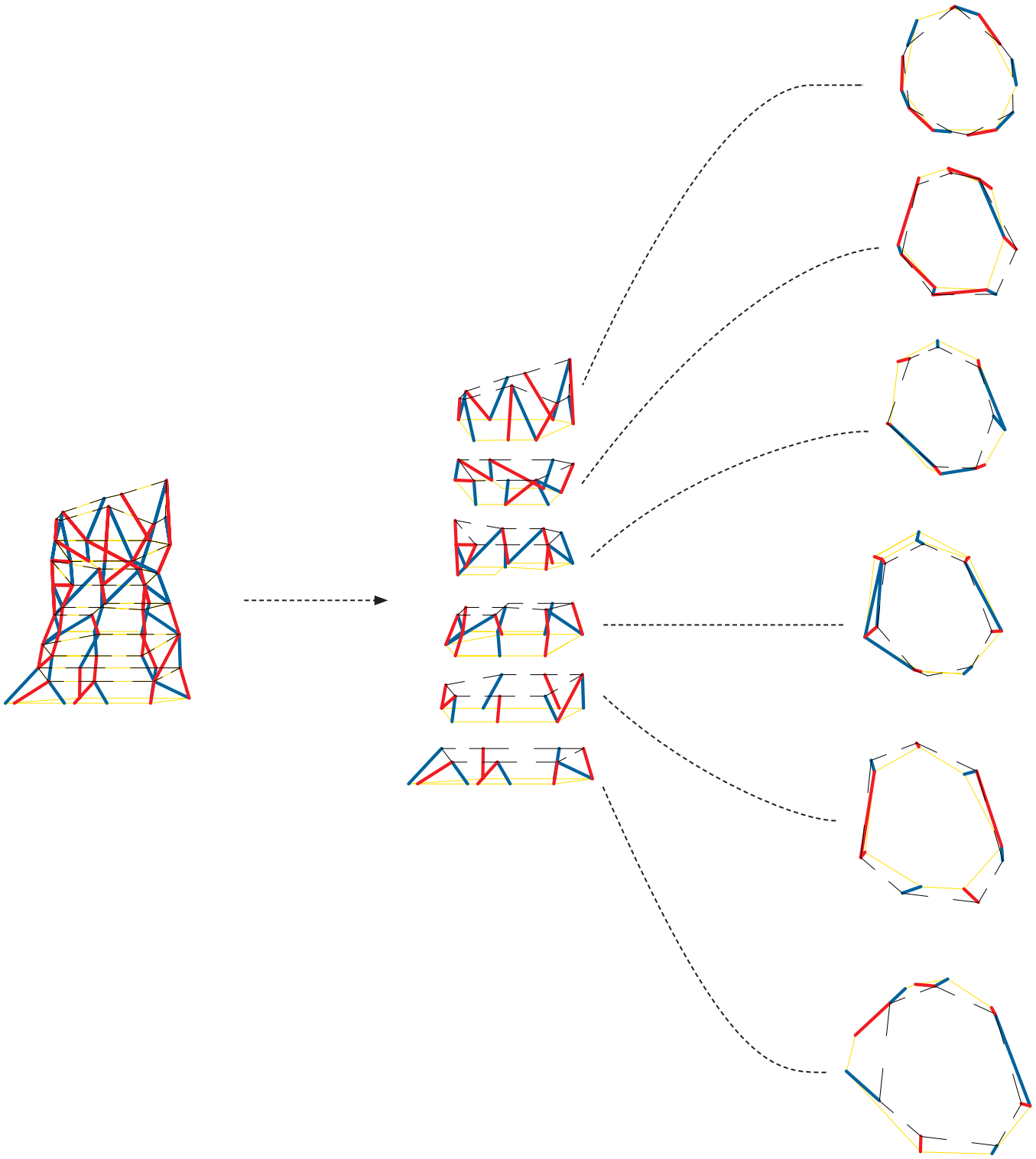


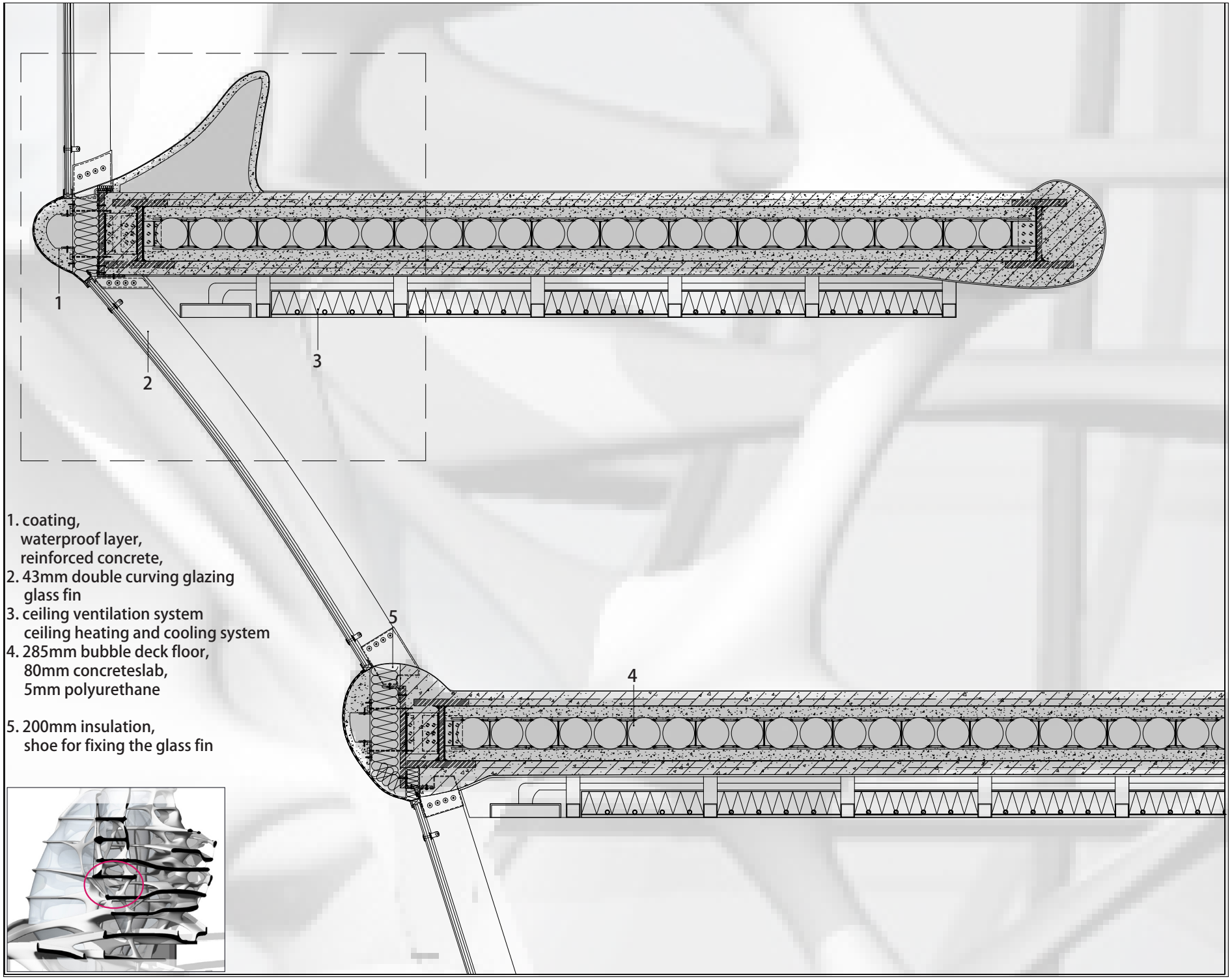
the building is mainly supported by these
straight colum beams vertically and laterally



use CNC machine to produce the model for the shape,
and then pour the concrete to cover the coloum
beams with the model in place (cast-in-situ-concrete)

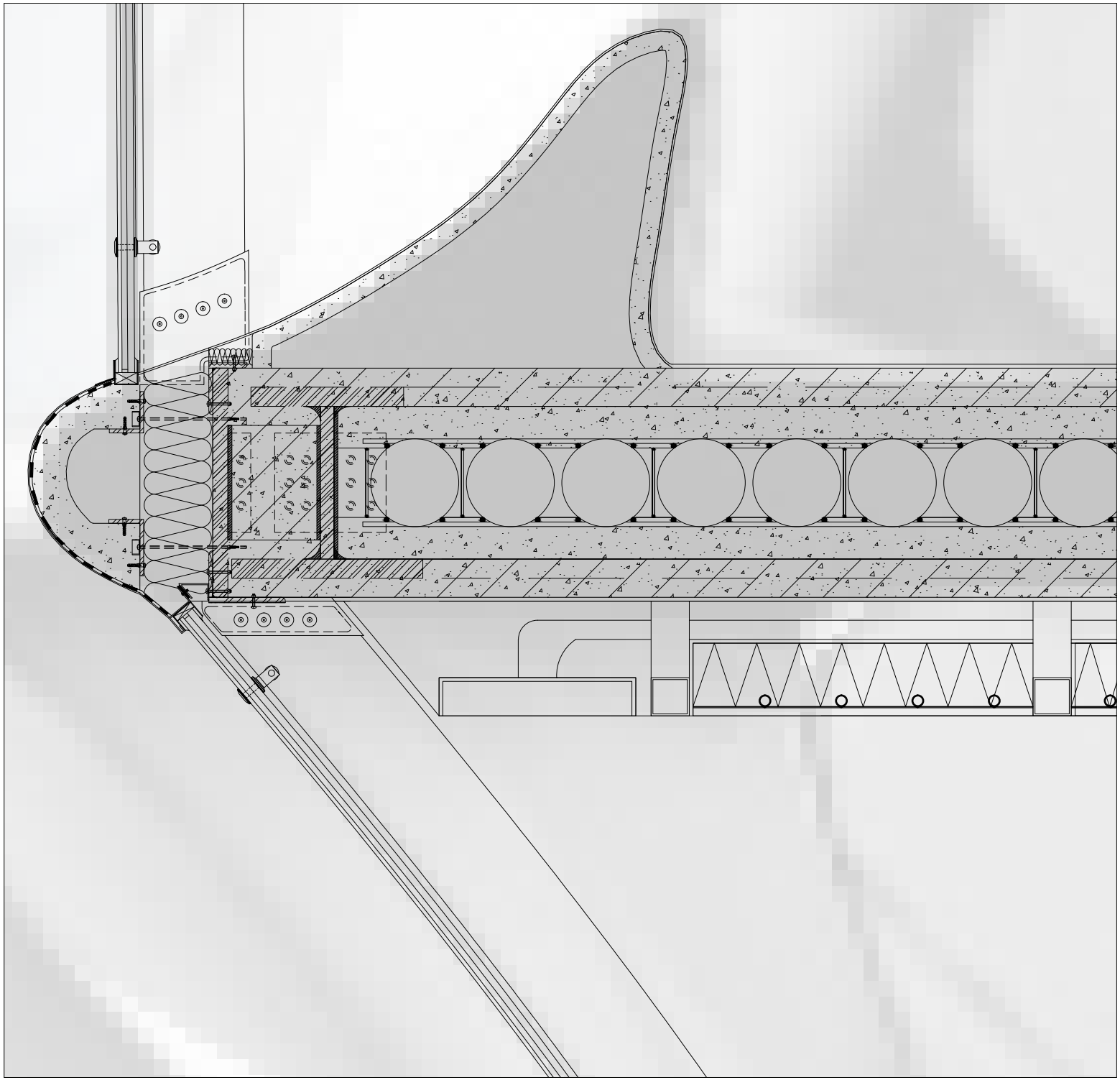







1. coating,
   waterproof layer,
   reinforced concrete,
2. 43mm double curving glazing
   glass fin
3. ceiling ventilation system
   ceiling heating and cooling system
4. 285mm bubble deck floor,
   80mm concreteslab,
   5mm polyurethane

5. 200mm insulation,
   shoe for fixing the glass fin



1:10 Detail Section