

# Vertical Garden-City

Designing a green living environment  
in the centre of Amsterdam



# CO<sub>2</sub> Emissions targets Dutch Government

49% reduction of CO<sub>2</sub> emissions by 2030  
compared to 1990

Source: Andrew, R. (2018) Global CO<sub>2</sub> emissions

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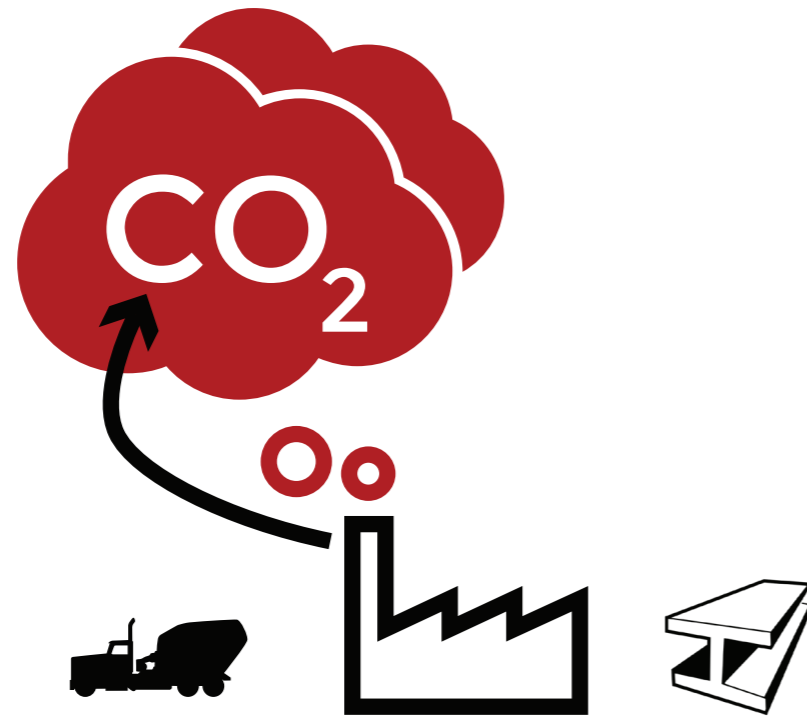
in 2019 the CO<sub>2</sub> emissions have reduced by 15% compared to 1990

Source: Andrew, R. (2018) Global CO<sub>2</sub> emissions

Source: CBS, ECN, TNO, RIVM, Rijksdienst voor Ondernemend Nederland. (2019) Klimaat- en Energieverkenning

# Environment Goals

## Concrete and Steel industry

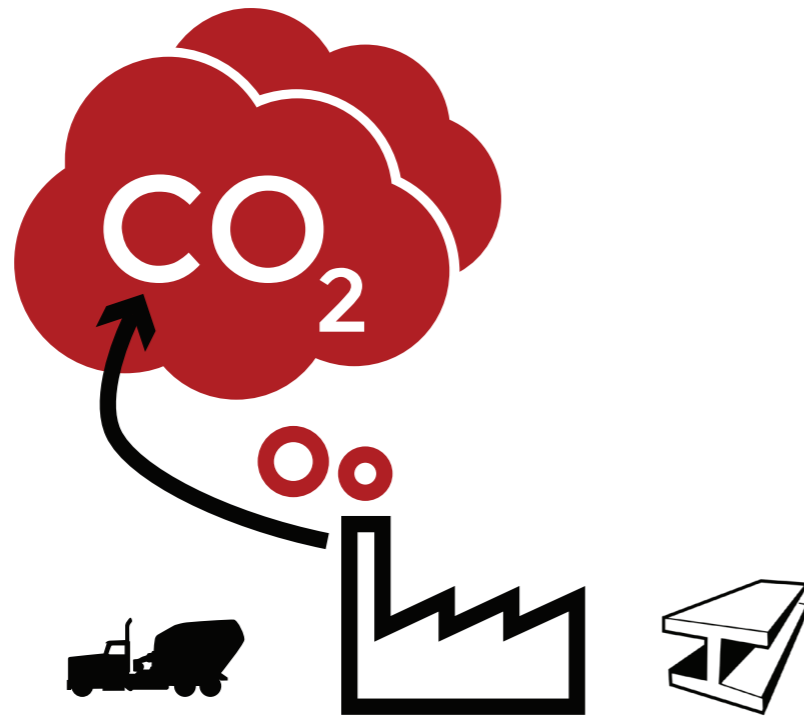


Concrete / Steel industry  
15-17% of worldwide CO<sub>2</sub> emissions

Source: Andrew, R. (2018) Global CO2 emissions  
Source: 'In 2040 kunnen alle huizen in hout gebouwd zijn' Marco Vermeulen, Cobouw.nl

# Environment Goals

## Concrete and Steel industry



Concrete / Steel industry  
15-17% of worldwide CO<sub>2</sub> emissions



98% of housing in the Netherlands is Built with concrete and steel

Source: Andrew, R. (2018) Global CO2 emissions  
Source: 'In 2040 kunnen alle huizen in hout gebouwd zijn' Marco Vermeulen, Cobouw.nl



## Environment Goals

CO<sub>2</sub> negative footprint

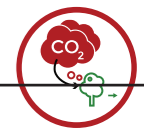
# CO<sub>2</sub> Negative

Sequester more CO<sub>2</sub> than emitted in production

Mainly use Bio Based materials

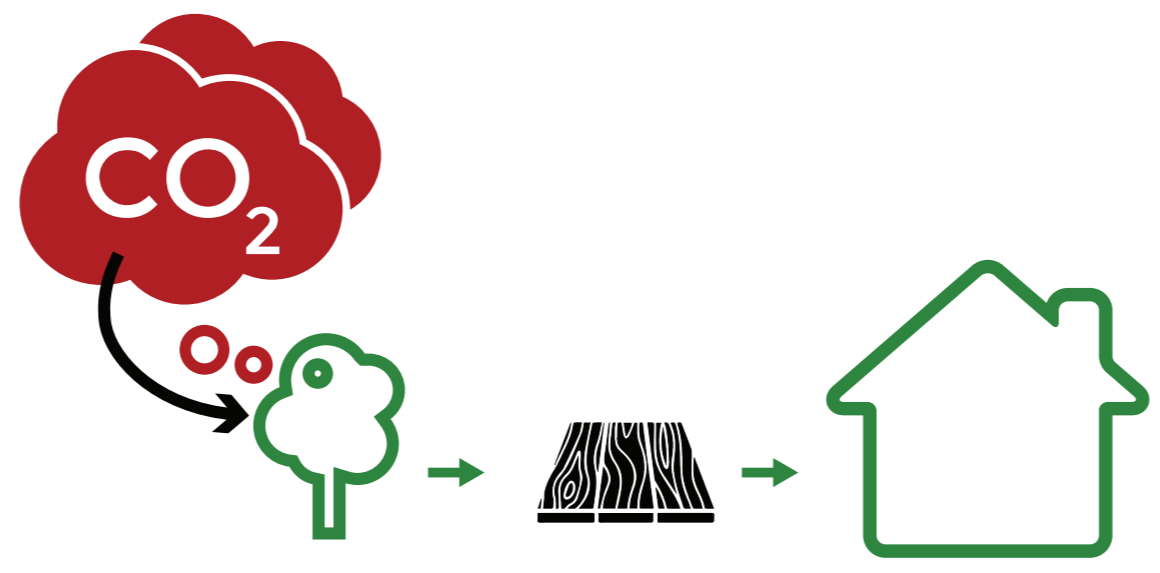
Source: Andrew, R. (2018) Global CO2 emissions

Source: 'In 2040 kunnen alle huizen in hout gebouwd zijn' Marco Vermeulen, Cobouw.nl



# Environment Goals

CO<sub>2</sub> negative footprint

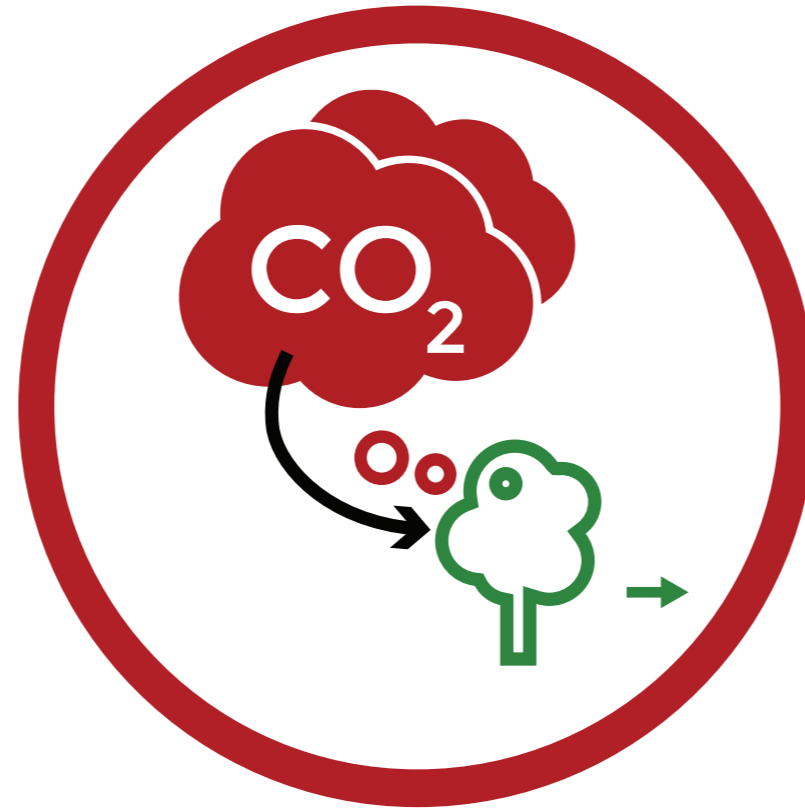


Mass Timber has a negative CO2 footprint of -2.7 kg CO2e/kg

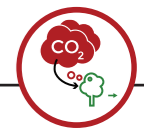
Source: ICE database

# Environment Goals

Design Goal

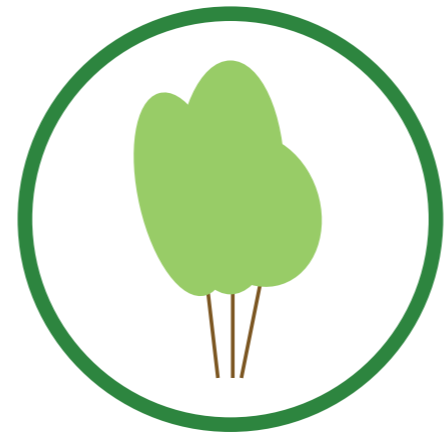


Sequester as much CO<sub>2</sub> as reasonably possible

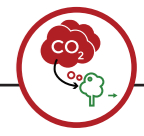


# Environment

Nature inclusive building



**Nature**

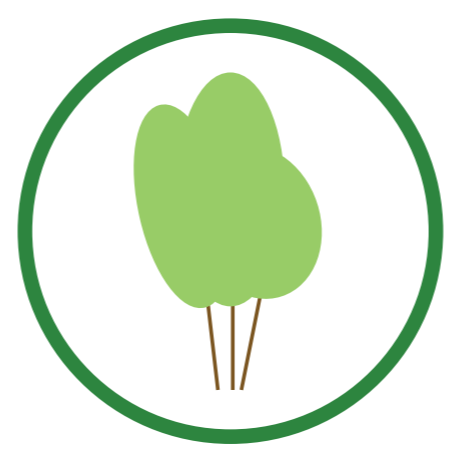


# Environment

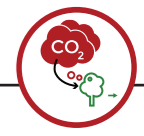
Nature inclusive building



Heat Stress



**Nature**

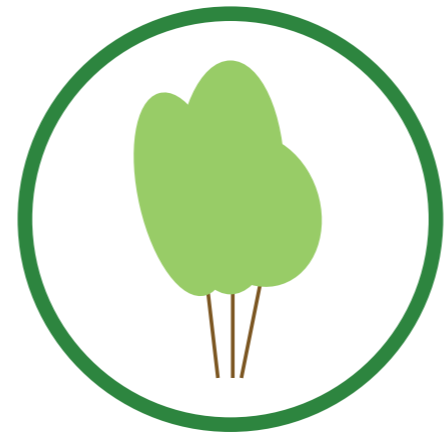


# Environment

Nature inclusive building



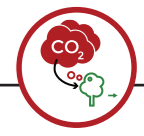
Heat Stress



**Nature**



Nitrogen Crisis



# Environment

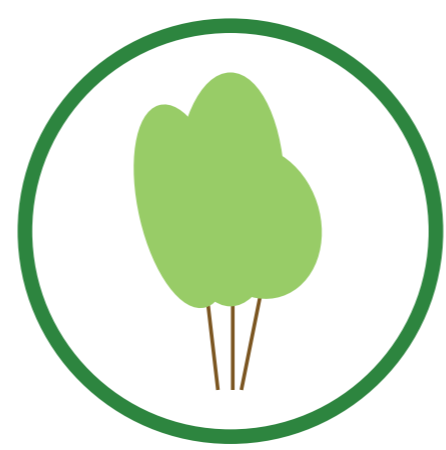
Nature inclusive building



Heat Stress



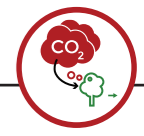
Nitrogen Crisis



**Nature**



Insect Decline



# Environment

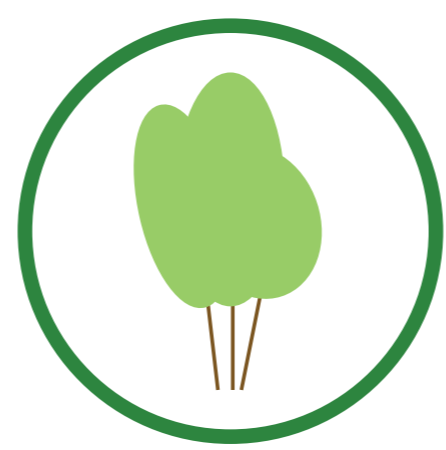
Nature inclusive building



Heat Stress



Nitrogen Crisis



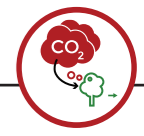
**Nature**



Insect Decline



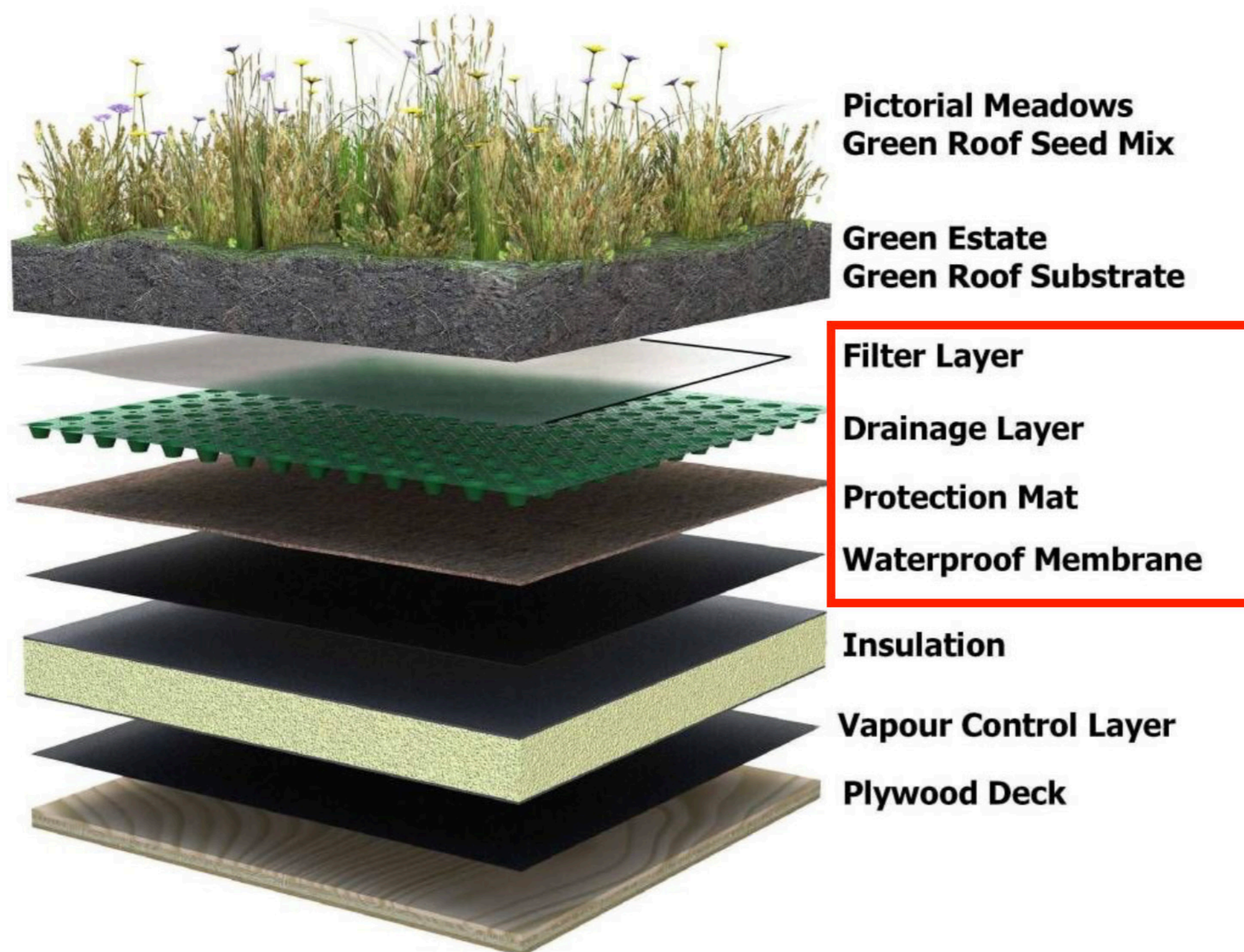
Urban Bird Decline



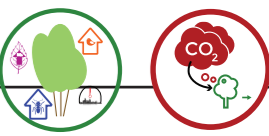
# Nature Inclusive

# Research

## Existing Green Roofs



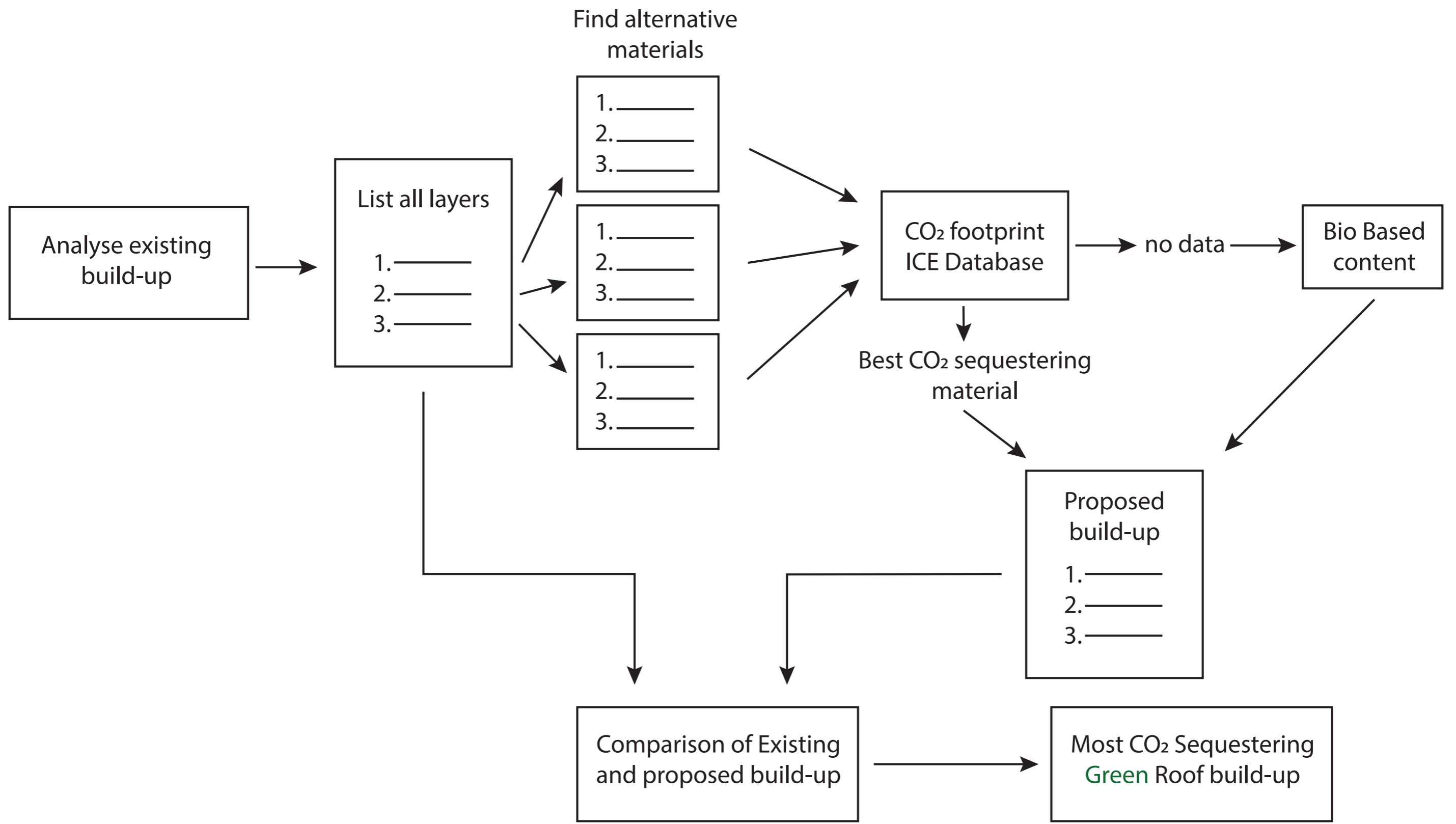
Plastic Layers in existing Green Roof Structures



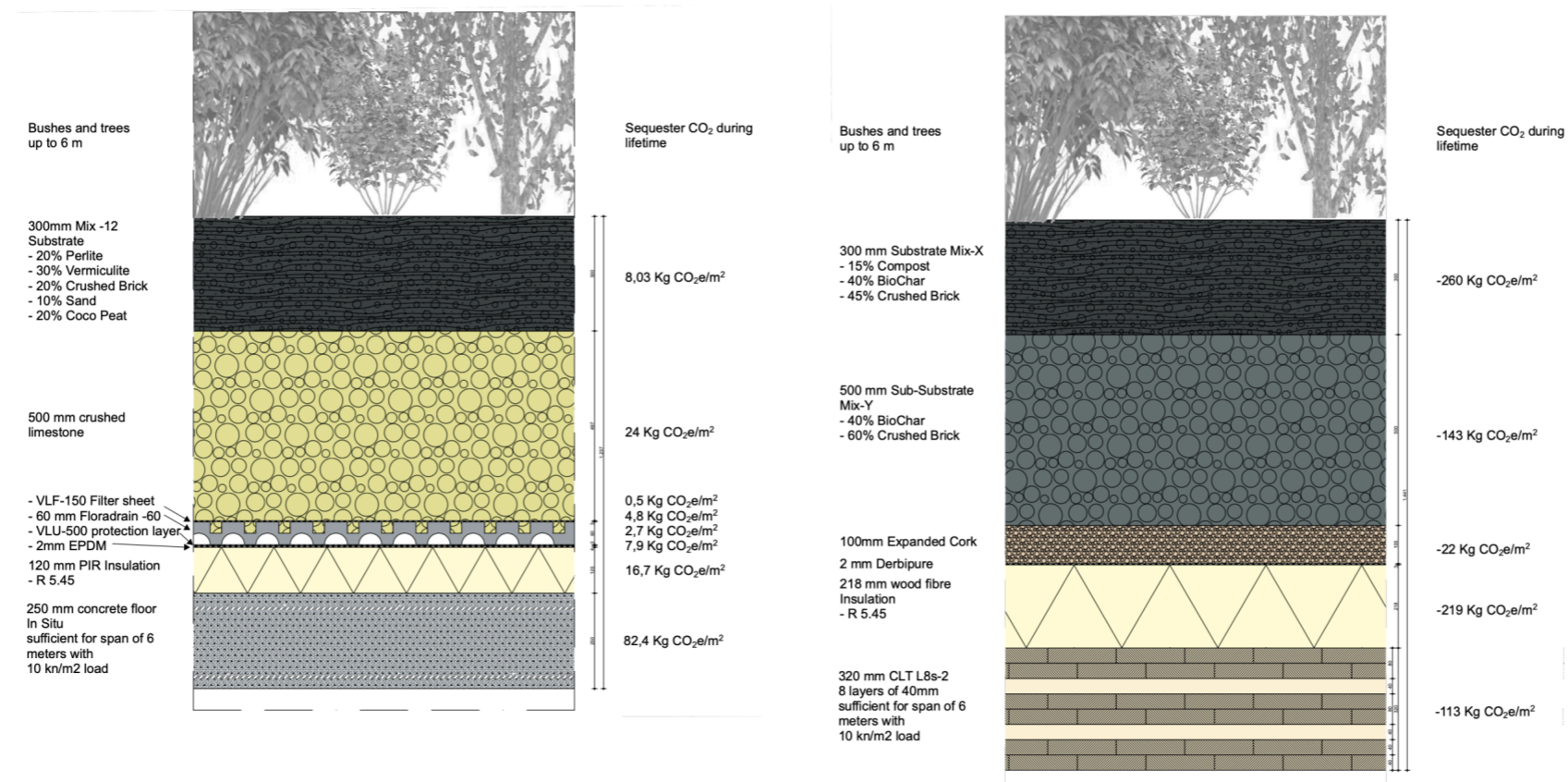
# How to Facilitate maximum roof greenery with bio-based and where possible CO<sub>2</sub> sequestering materials?



# Research Method



# Research Results



|                             | Standard Build-up | Proposed build-up | Difference |
|-----------------------------|-------------------|-------------------|------------|
| <b>Including structure:</b> |                   |                   |            |
| Weight in kg/m <sup>2</sup> | 1688              | 684               | -1004      |
| Thickness in mm             | 1235              | 1440              | 205        |
| Embodied carbon footprint   | 1688              | -756              | -2444      |
| <b>Excluding structure:</b> |                   |                   |            |
| Weight in kg/m <sup>2</sup> | 882               | 551               | -331       |
| Thickness in mm             | 863               | 900               | 37         |
| Embodied carbon footprint   | 40                | -426              | -466       |

# Fascination

## Green living environment



high amount of public and private green

## Urbanised City



Introduce more greenery on balcony



# Marineterrein Amsterdam

Site of the project

Central Location

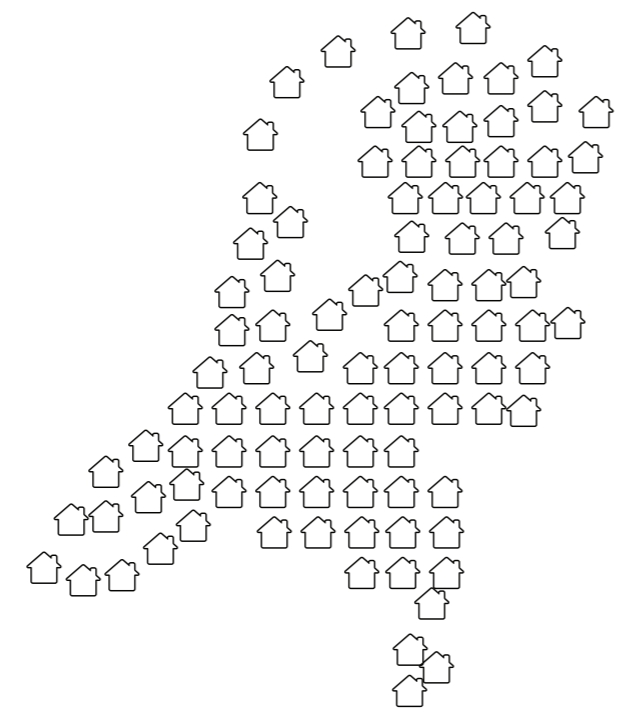
High Density required  
Greenery available  
space to create some-  
thing new





# 1 Million Homes

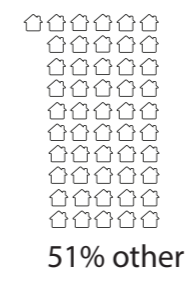
## Housing needs till 2035 in The Netherlands



 10.000 houses



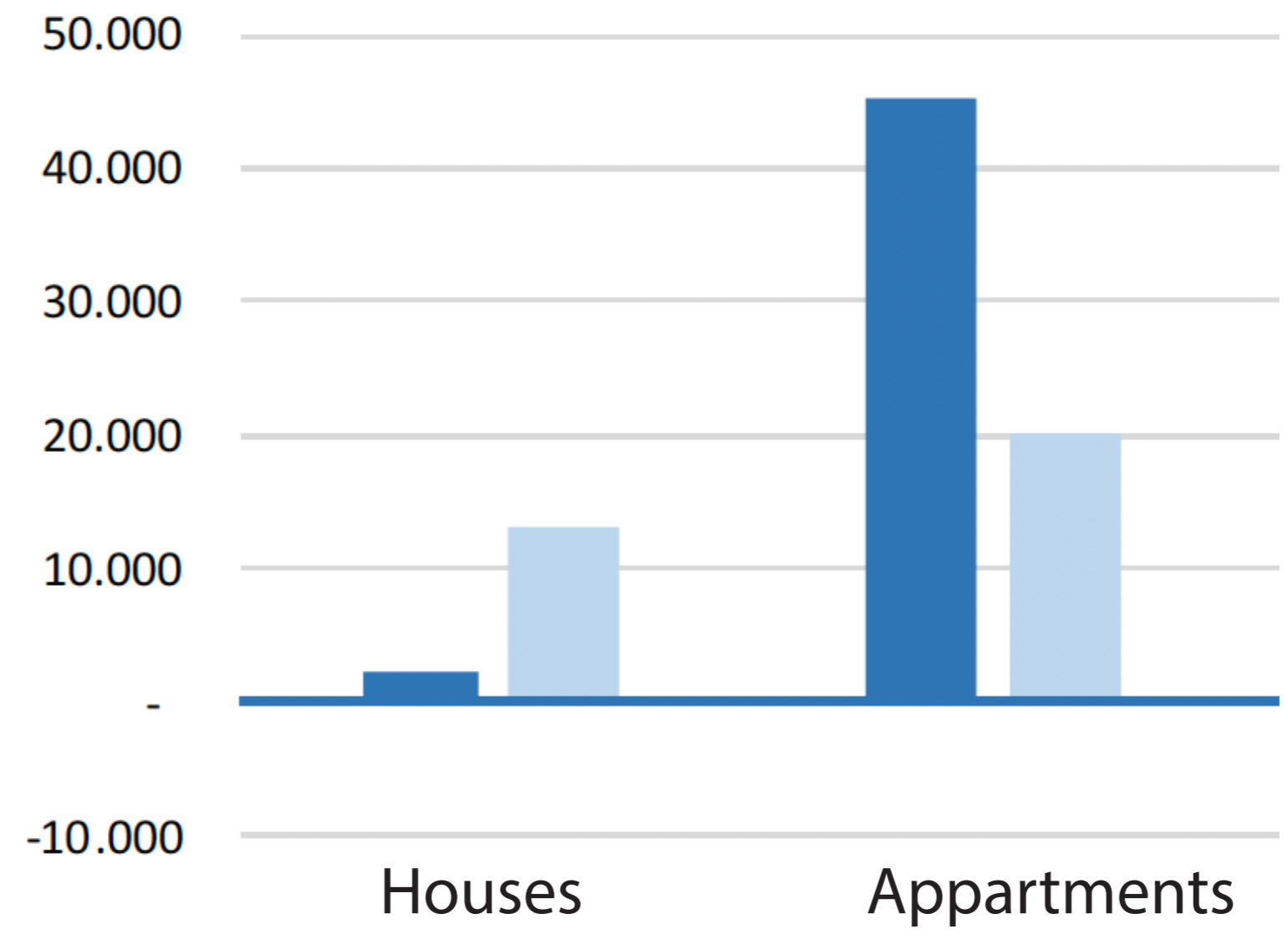
49% Randstad  
22% Amsterdam  
9% The Hague  
9% Rotterdam  
9% Utrecht





# Housing needs Amsterdam

Housing needs vs. plan capacity



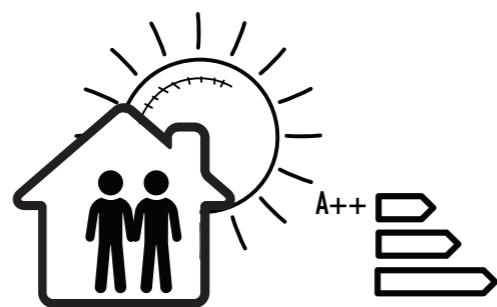
- plan capacity Amsterdam
- additional housing needs Amsterdam

Source: Vooruitzichten bevolking, huishoudens en woningmarkt Prognose en Scenario's 2019-2030, ABF Research



# Moving away of Amsterdam

## Reasons to move



35% want  
Better / More Beautiful home



25% want  
Balcony or Garden



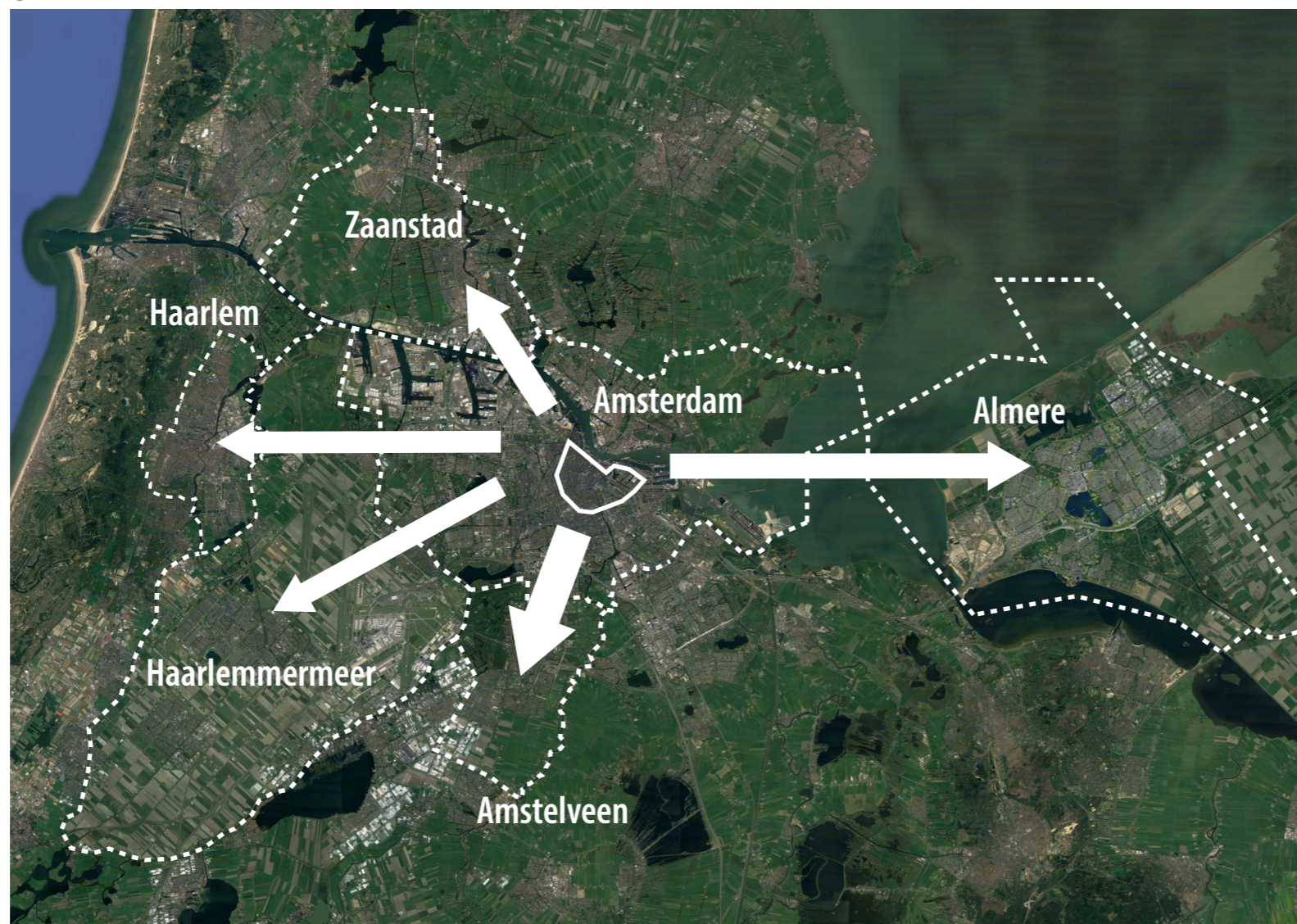
16% want  
Healthier Environment

# Moving away from Amsterdam

people moving to other towns

## Context

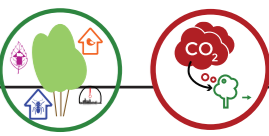
people move away from amsterdam to greener areas



## Context

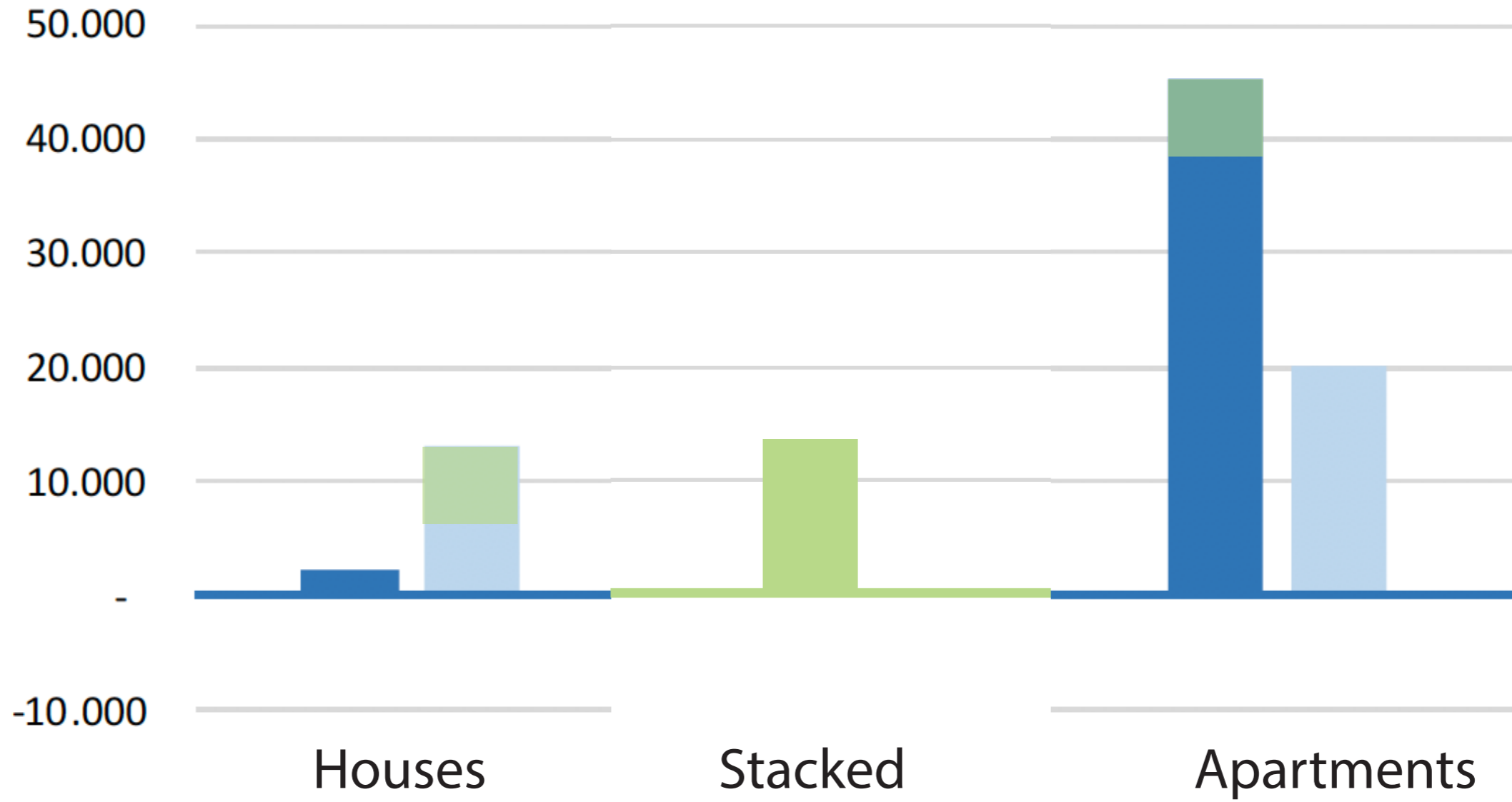
Top 5 moving destinations from amsterdam within the Metropoolregio Amsterdam:

1. 3342 to Amstelveen
2. 2473 to Haarlem
3. 2387 to Zaanstad
4. 2343 to Almere
5. 1979 to Haarlemmermeer



# Housing needs in Amsterdam

## Stacked Houses



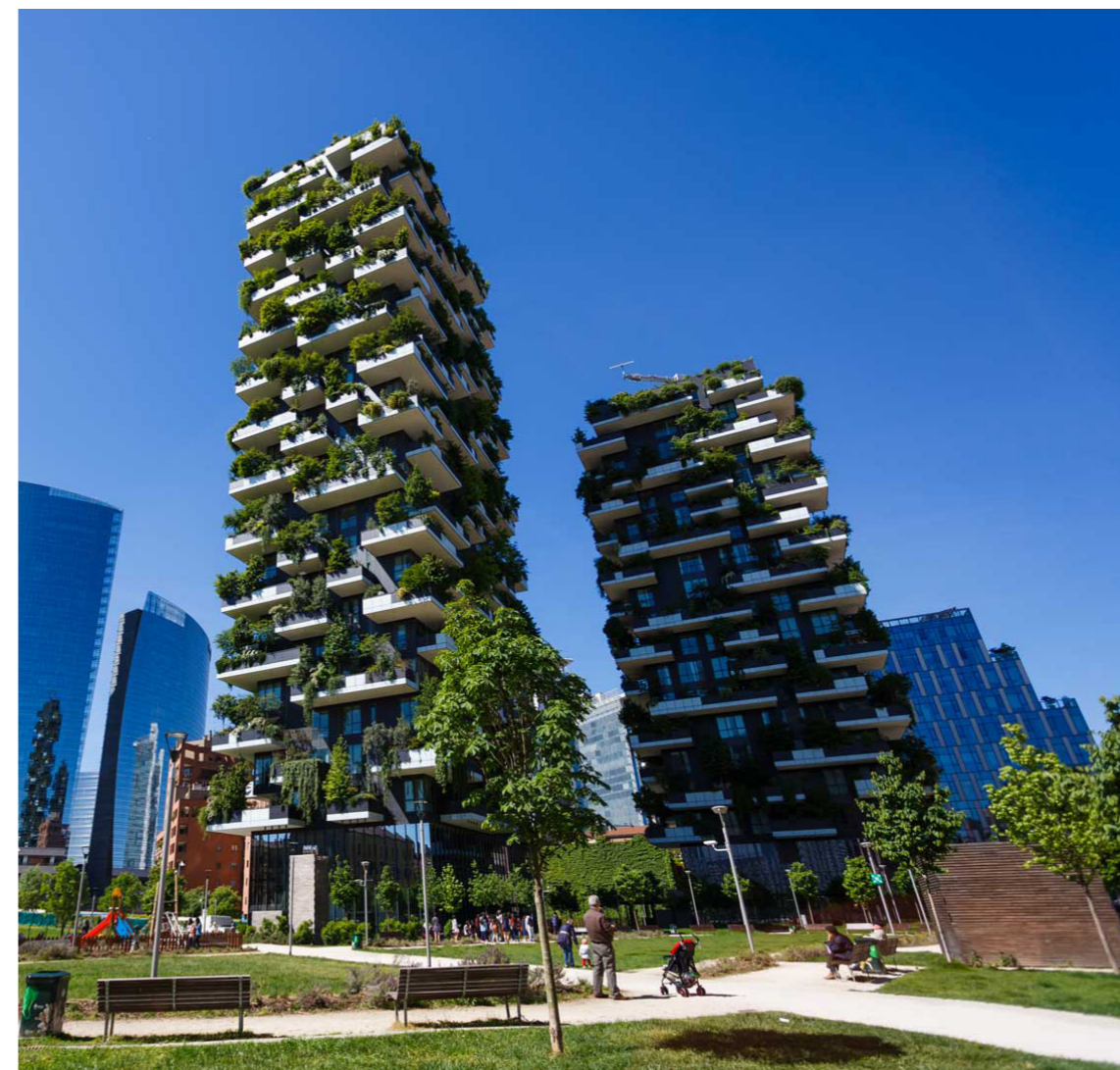
- plan capacity Amsterdam
- additional housing needs Amsterdam

# Existing forms of living with greenery

vertical and horizontal green



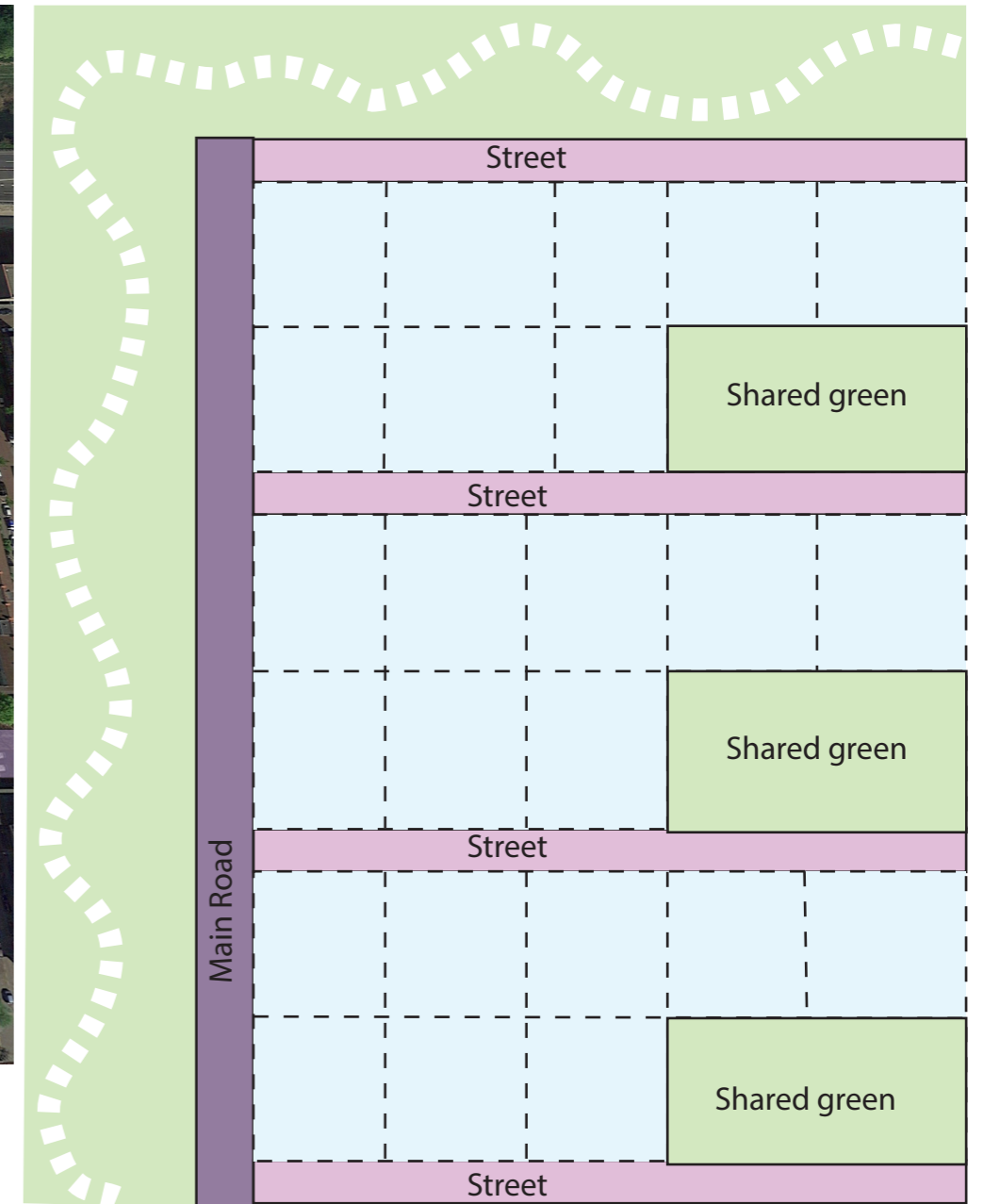
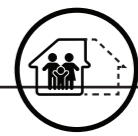
**Westelijke Tuinsteden  
Amsterdam**



**Vertical Forest Milan**

# Western Garden Cities Amsterdam

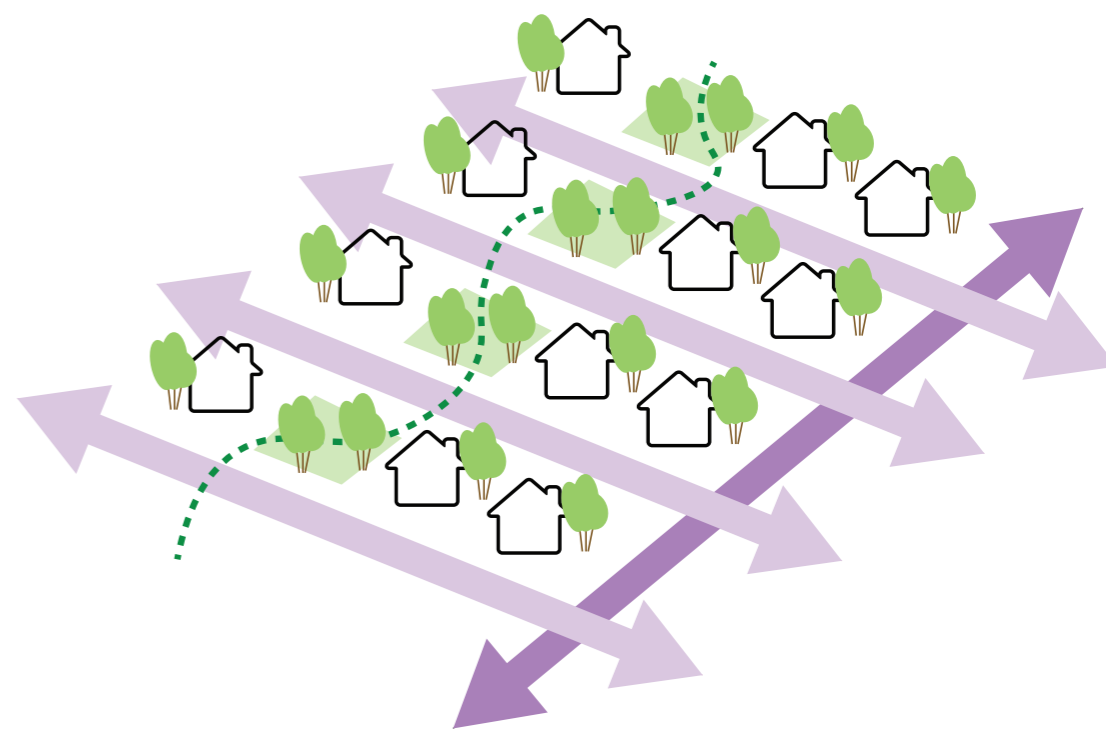
## Geuzenveld Amsterdam





# Western Garden Cities Amsterdam

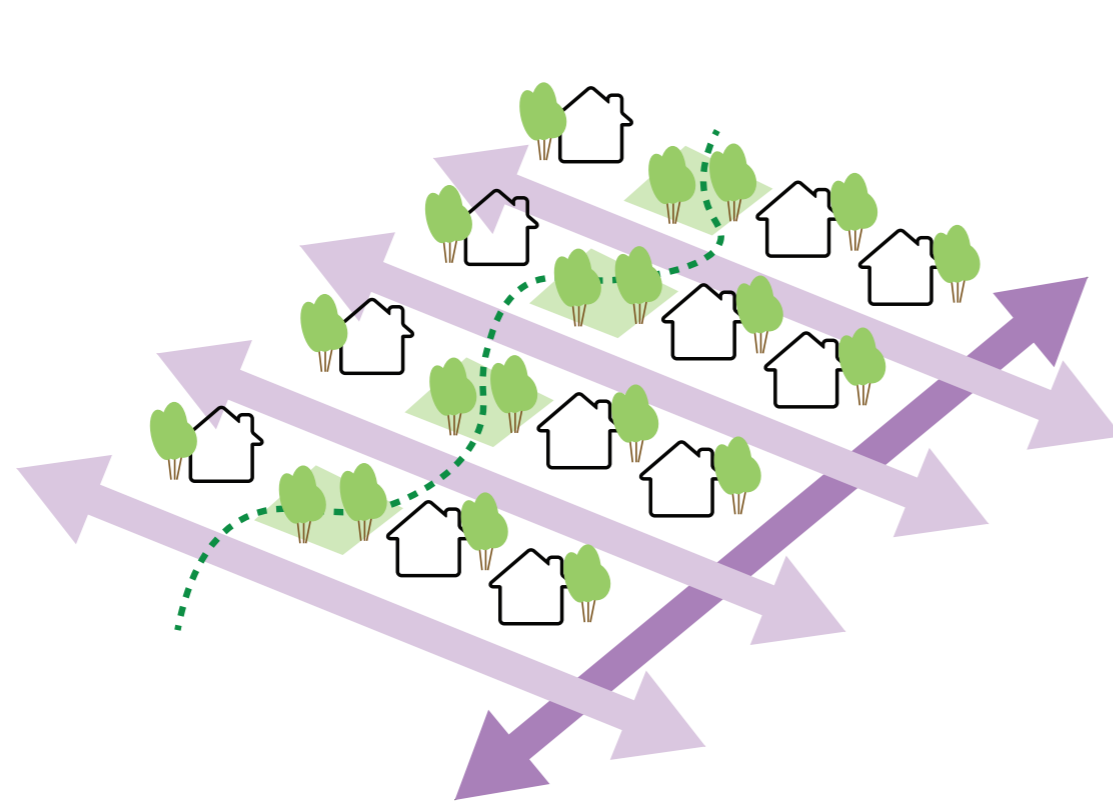
## Geuzenveld Amsterdam



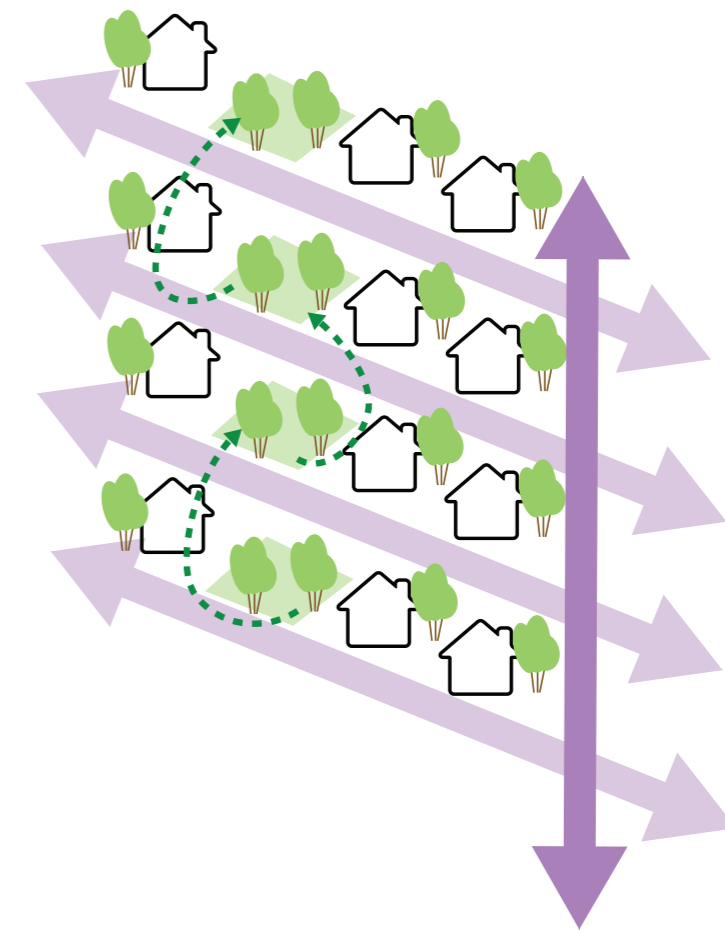


# Concept

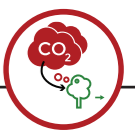
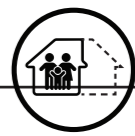
Increase Density



Horizontal Garden City



Vertical Garden City



# Marineterrein Amsterdam

site Location



## Council plans

- Build 1500 homes
- Max height of 4 floors
- 40% social housing rent
- 40% mid priced property/ leasehold



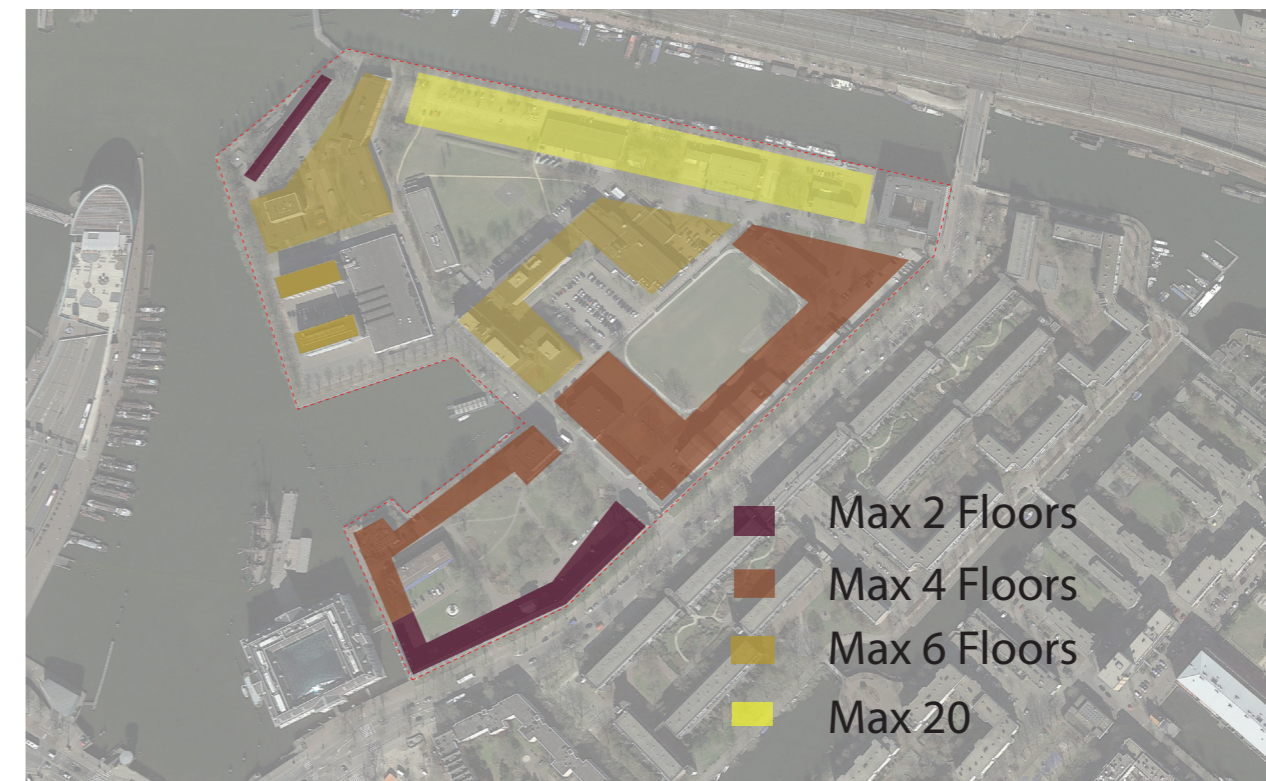
## Council plans

- Build 1500 homes
- Max height of 4 floors
- 40% social housing rent
- 40% mid priced property/ leasehold

optional example of council plans



## Max Building



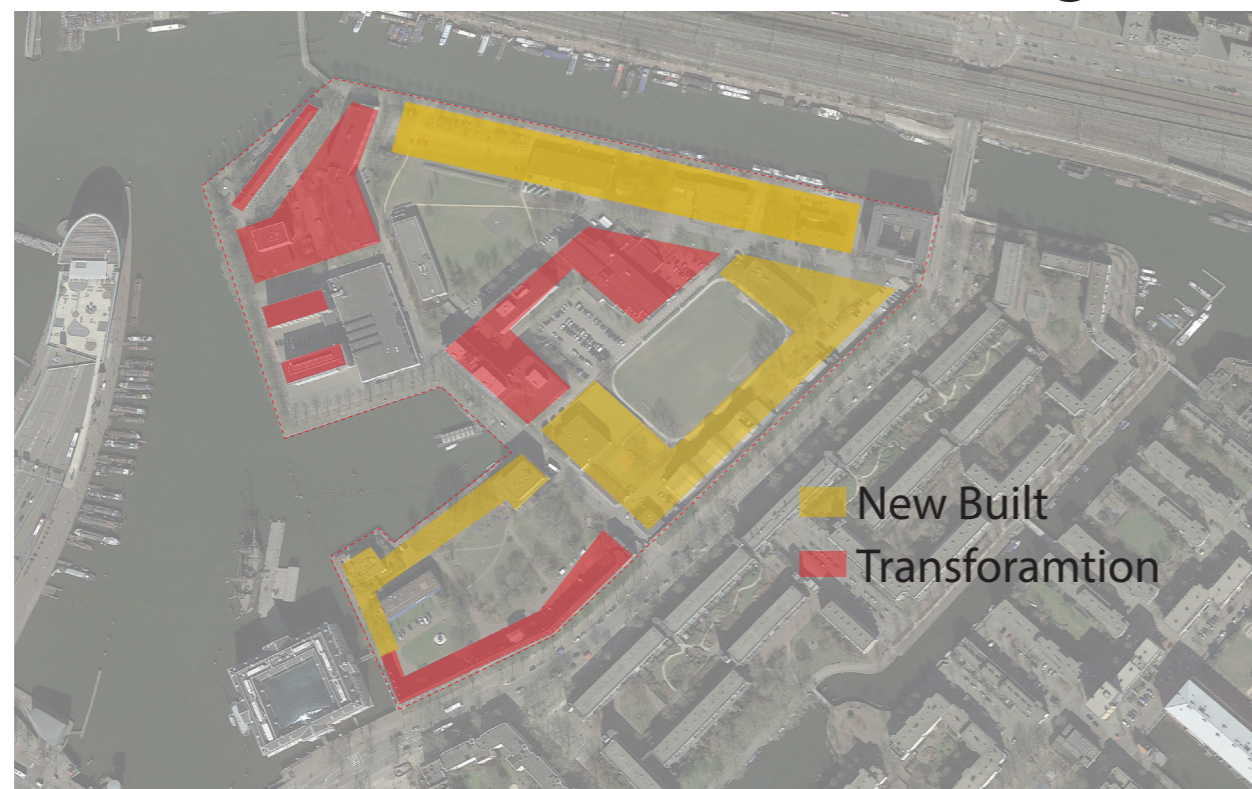
## Price categories



## Green plans

- Increase amount of greenery
- reduce CO<sub>2</sub> emissions through transformation
- Build 1500 homes
- 40% social housing rent
- 40% mid priced property/ leasehold
- 20% high priced property/ leasehold

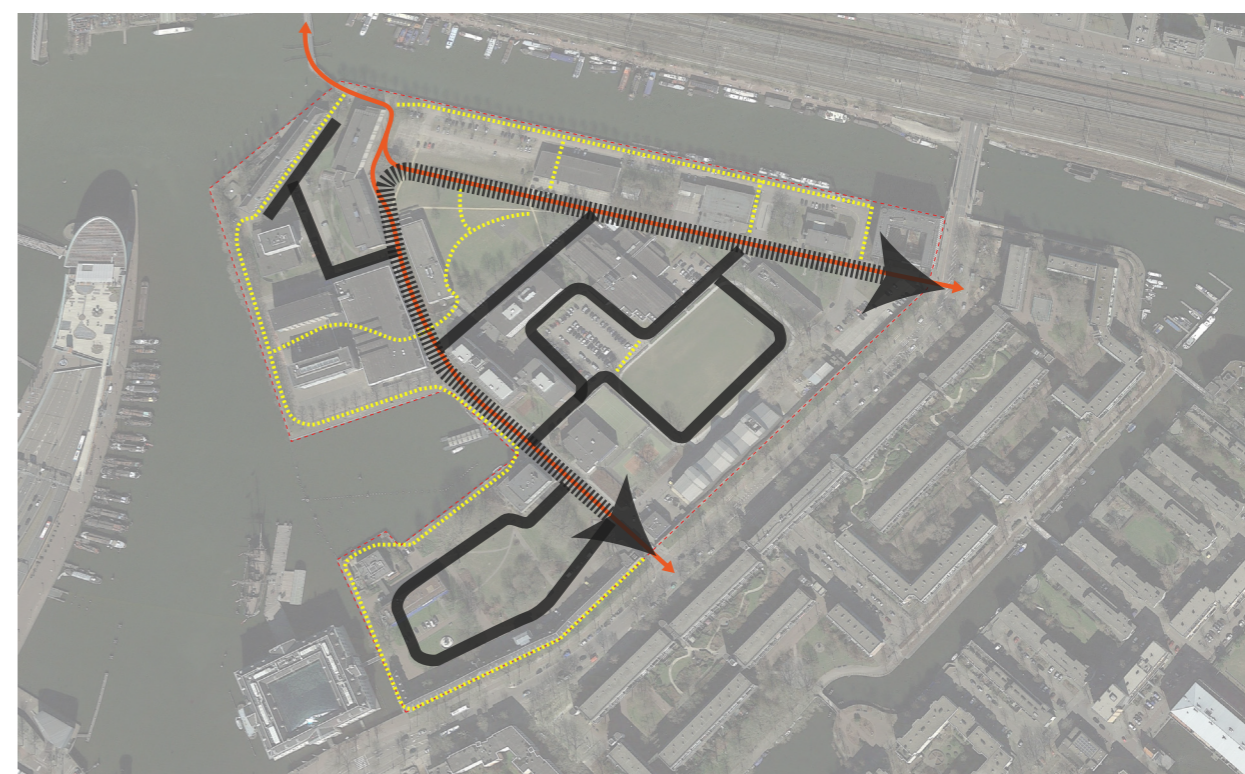
New / transformation of existing



## Green Structure

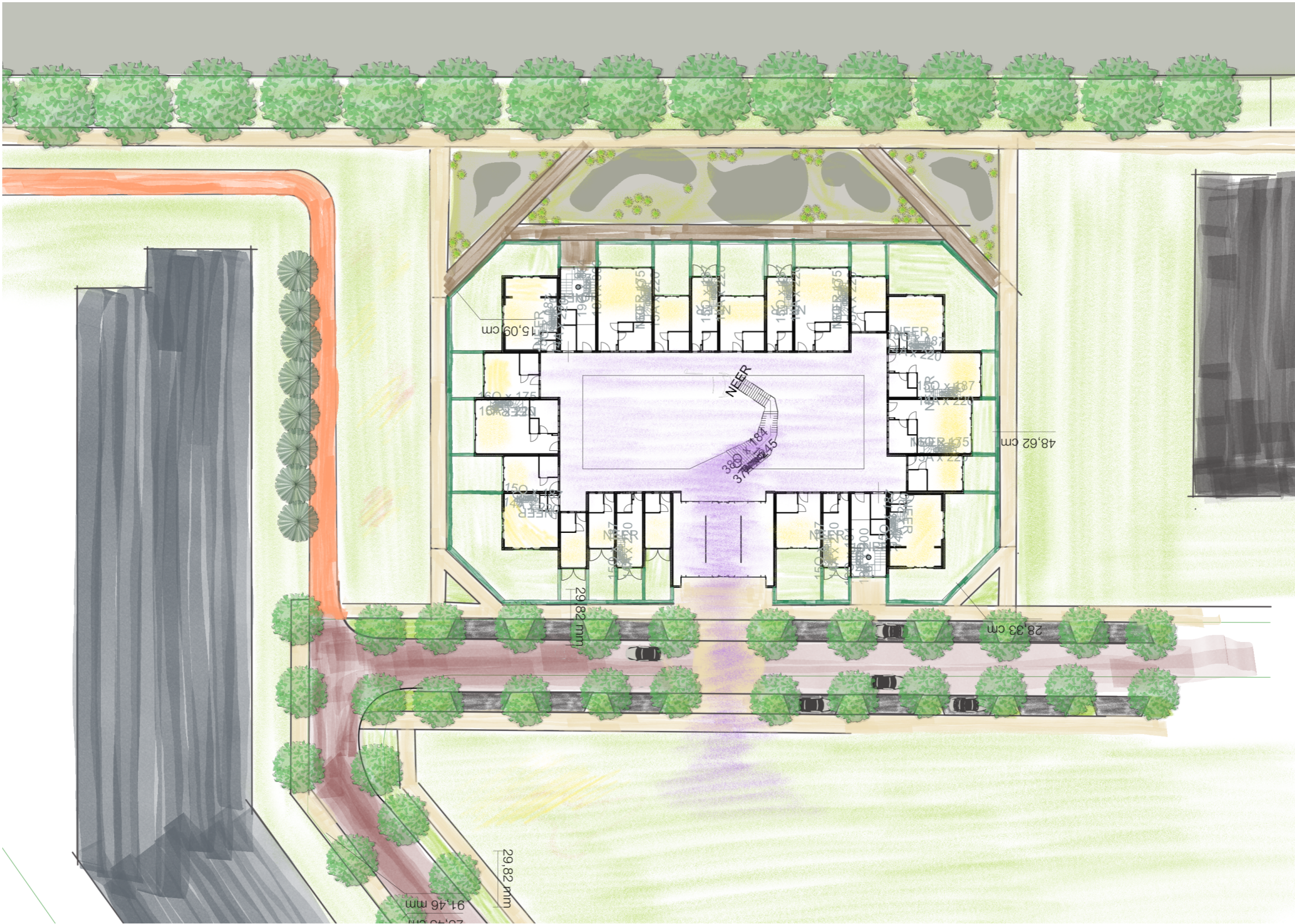
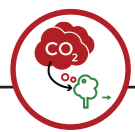
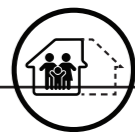


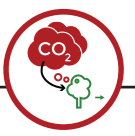
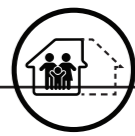
## Traffic



# Site Plan

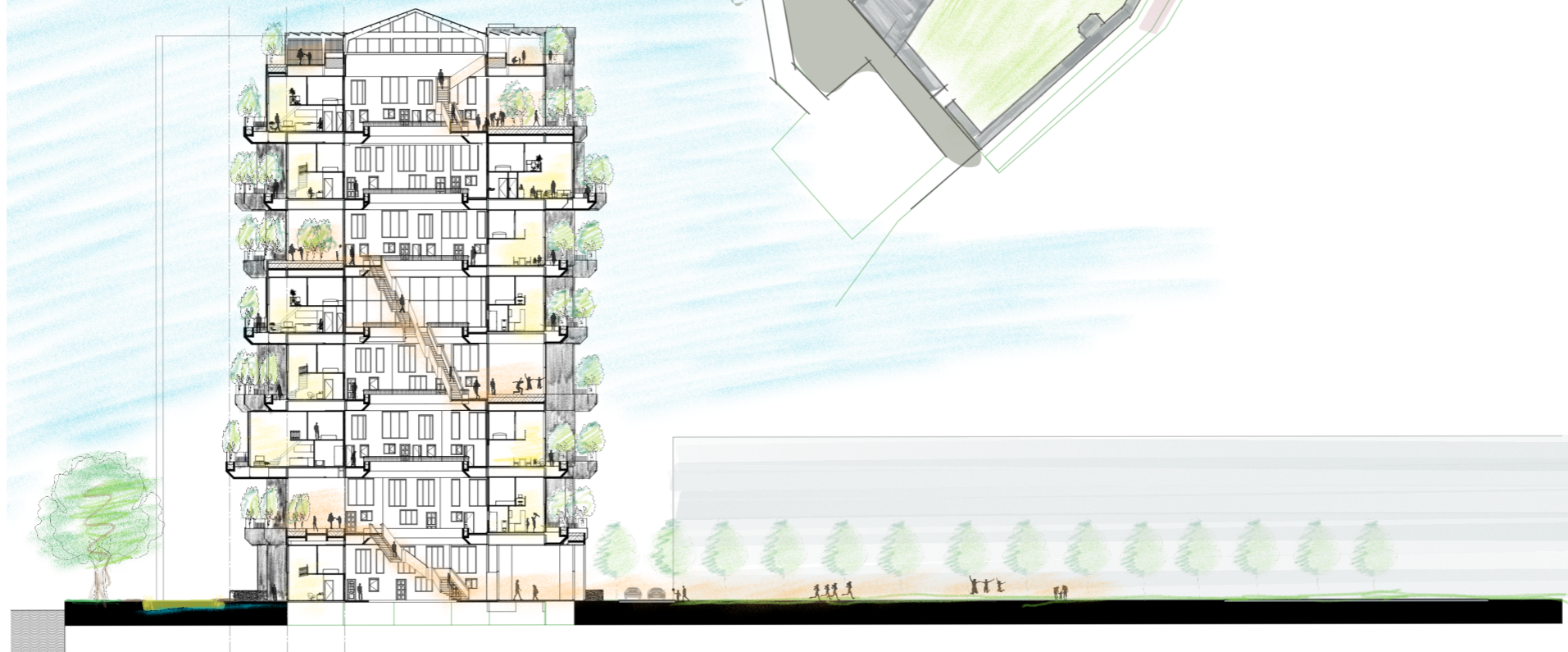
1:500

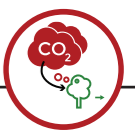
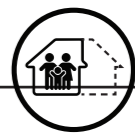




# Urban Plan

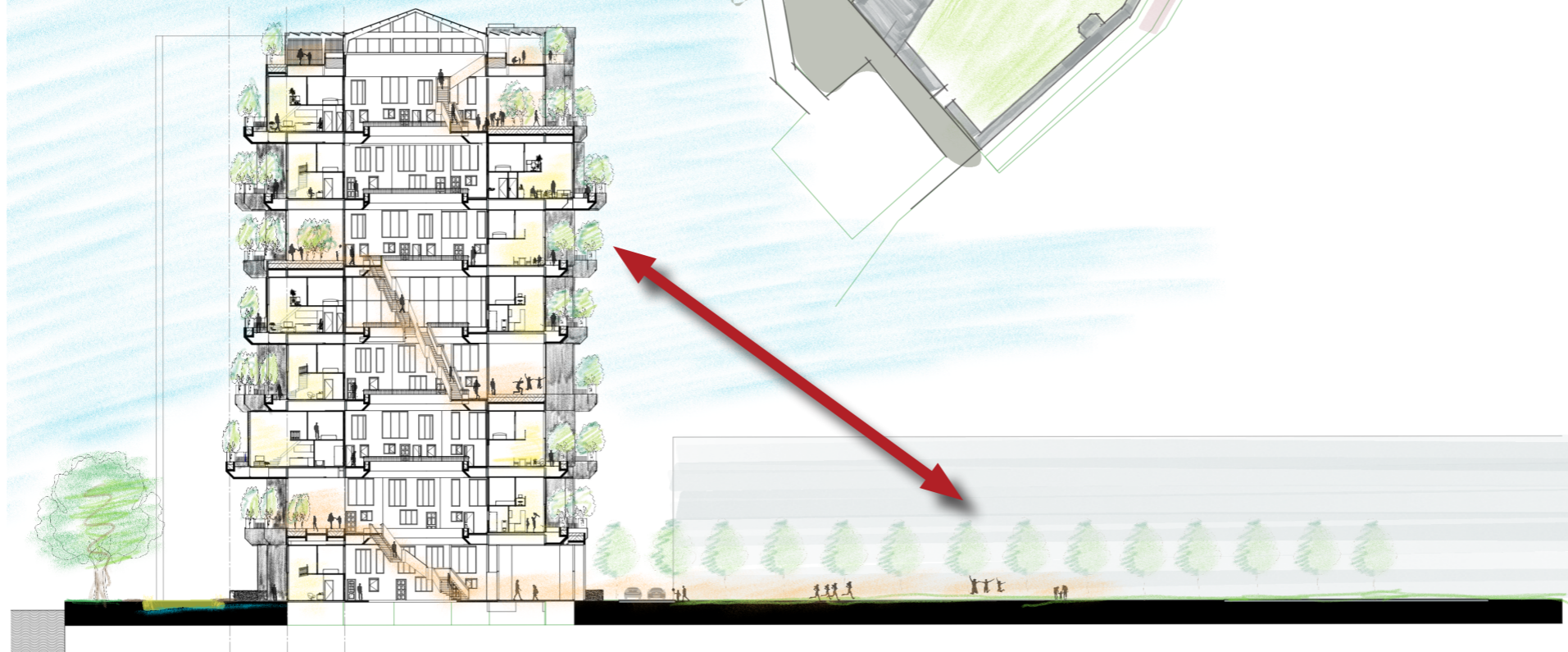
1:2000 A0





# Urban Plan

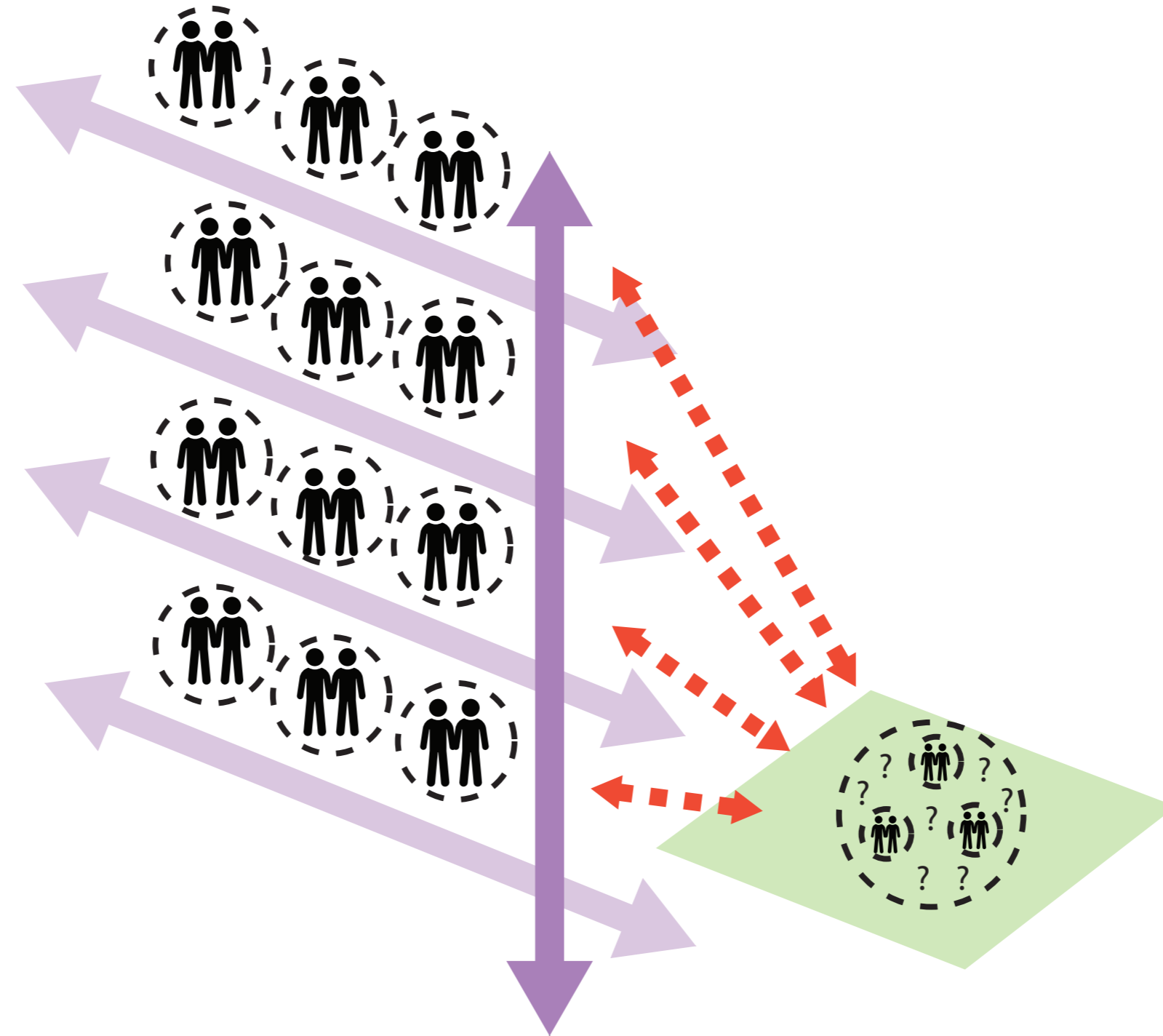
1:2000 A0





# Distance to green / Social interaction

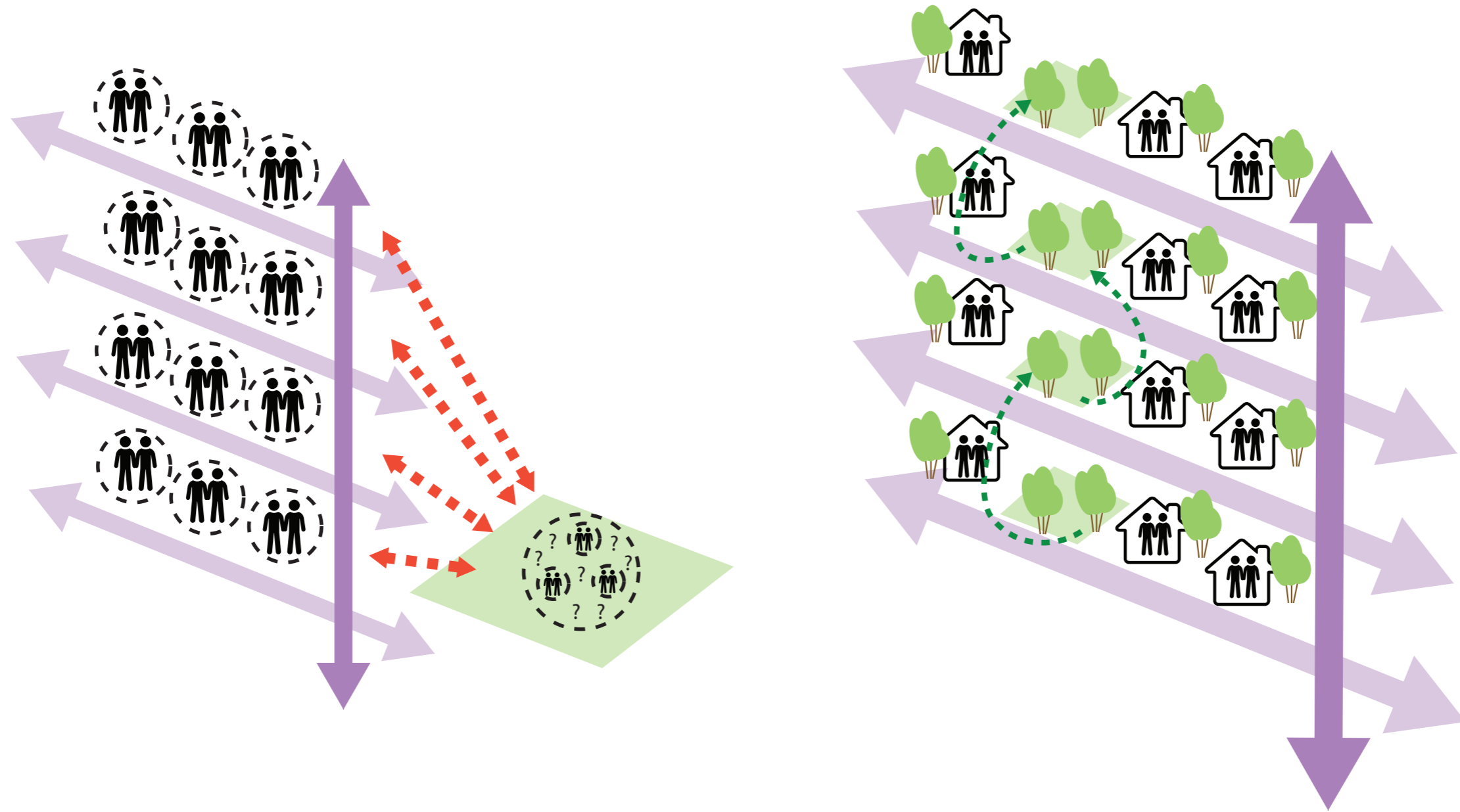
existing Highrise social distance





# Social interaction

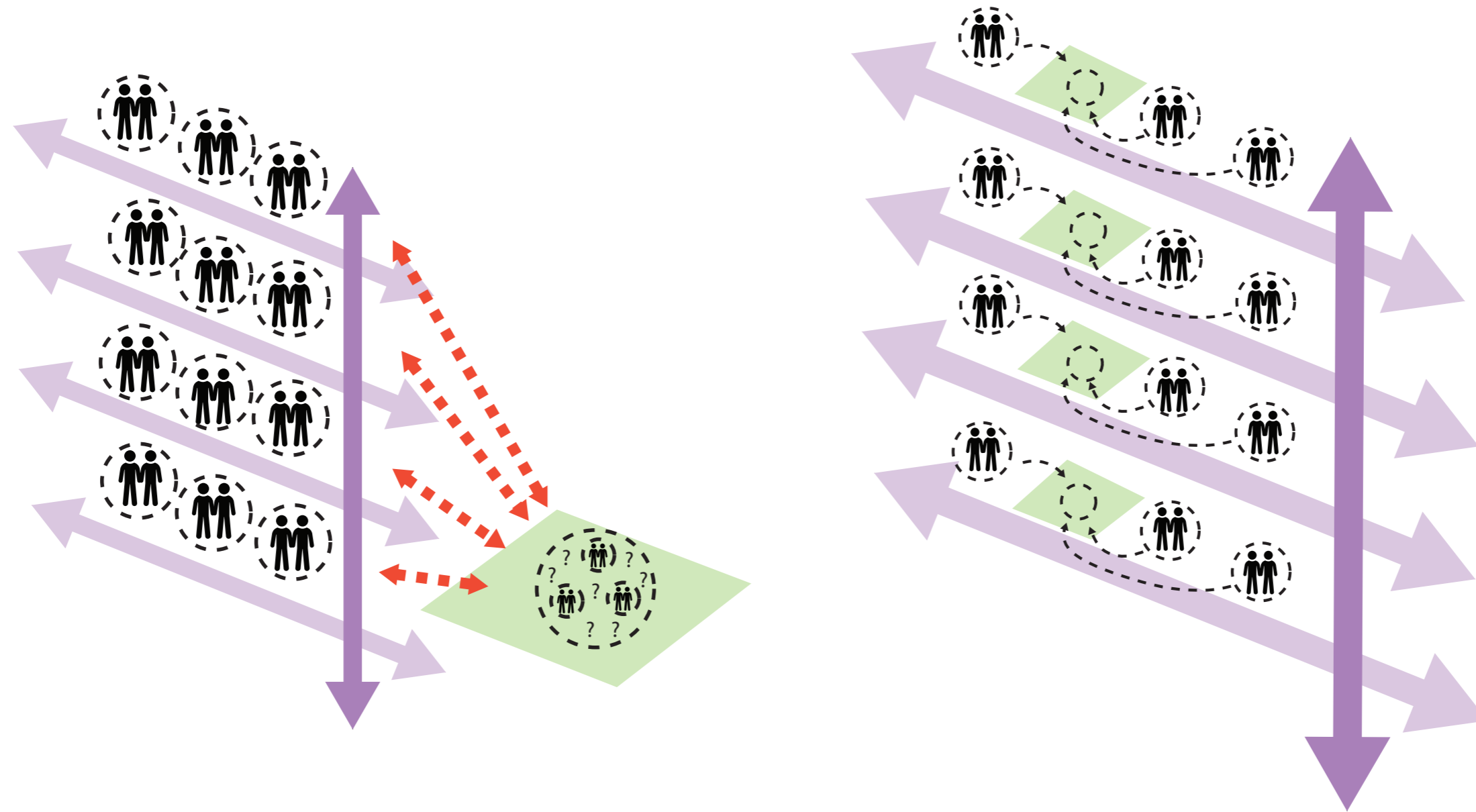
responsibility distance to garden

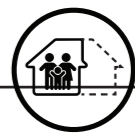




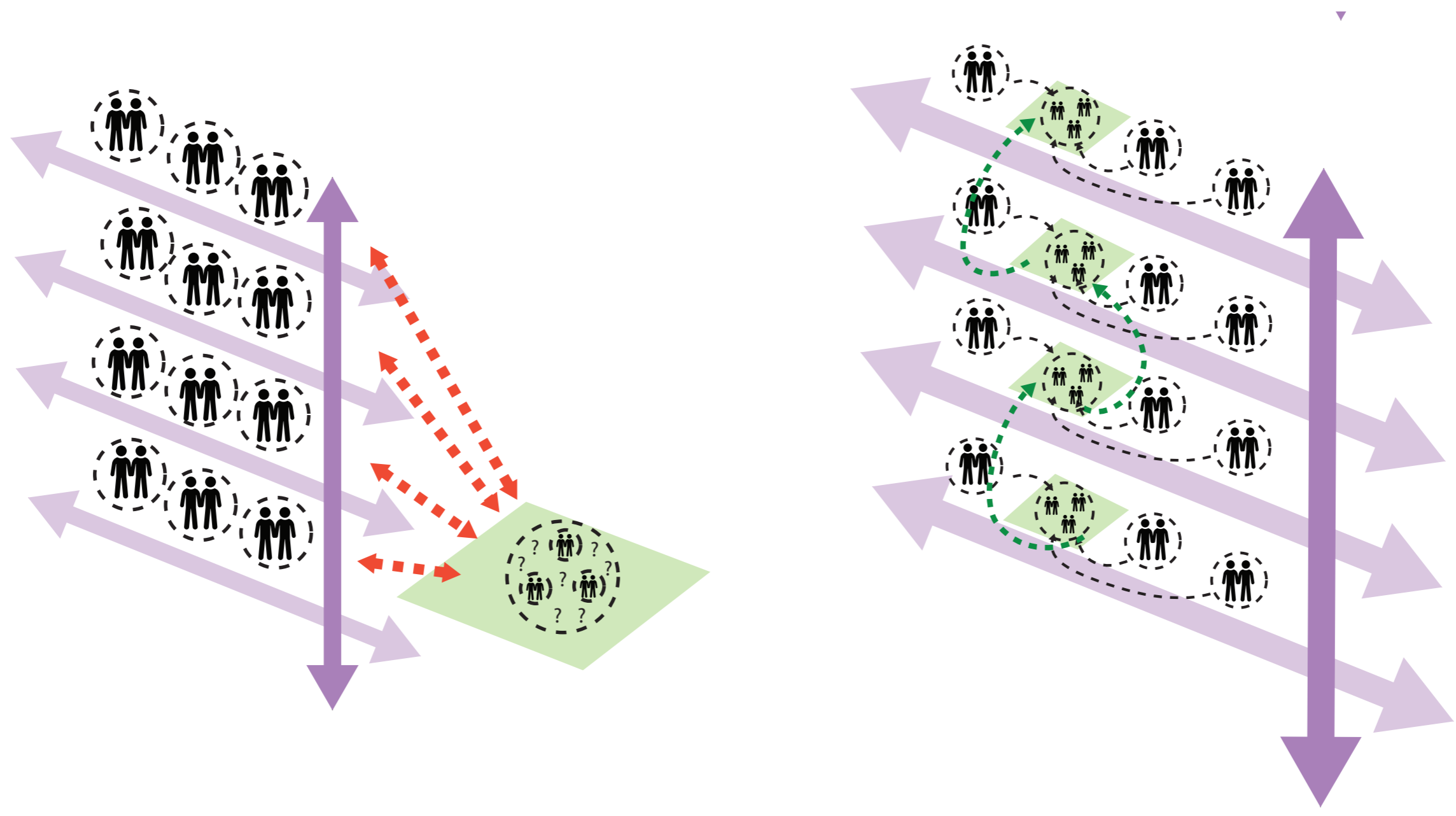
# Social interaction

Garden as a social hub

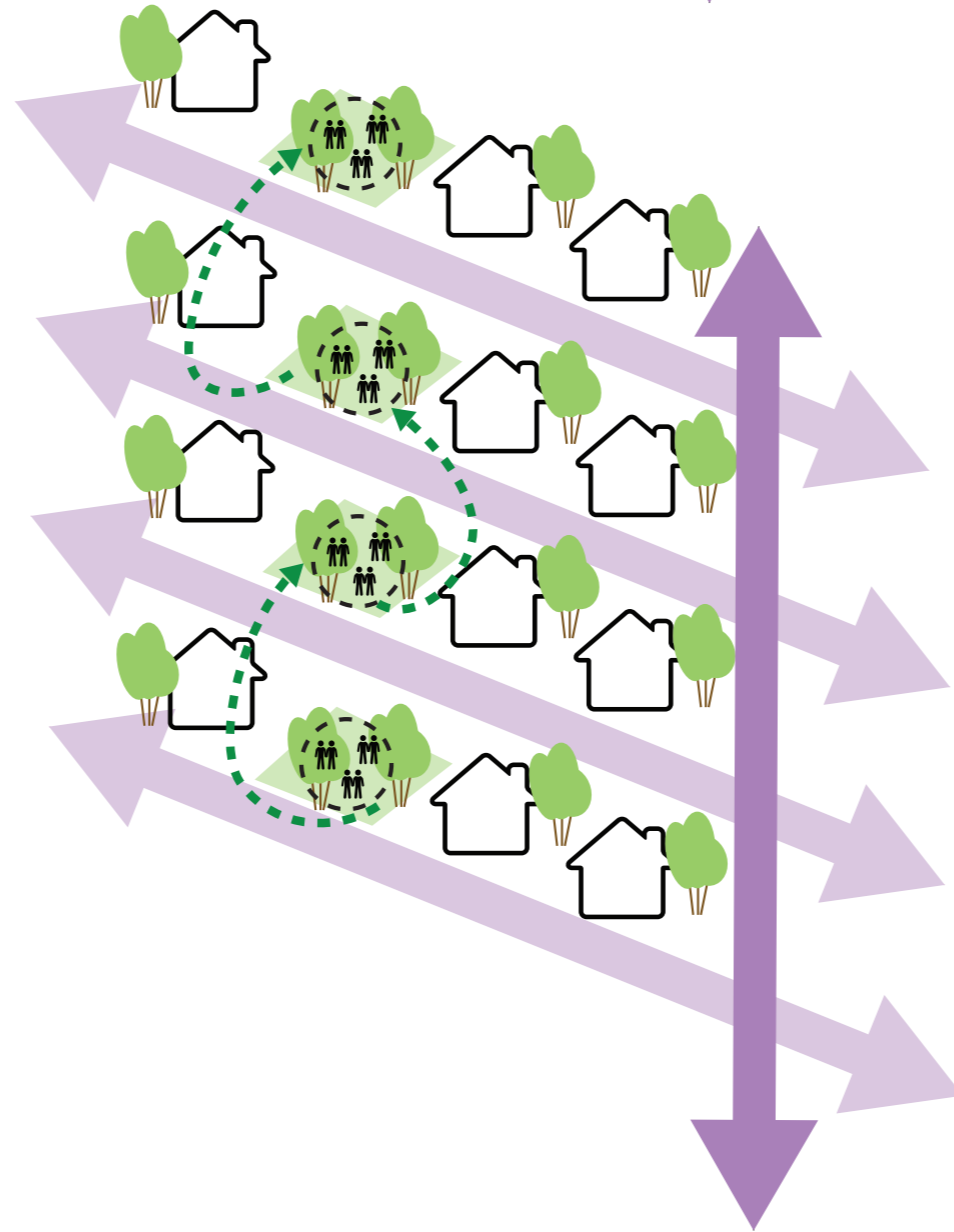




Title  
Subtitle



# Vertical Garden City Concept

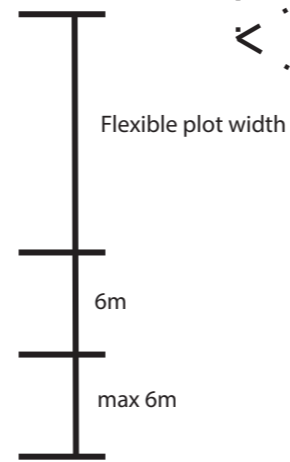
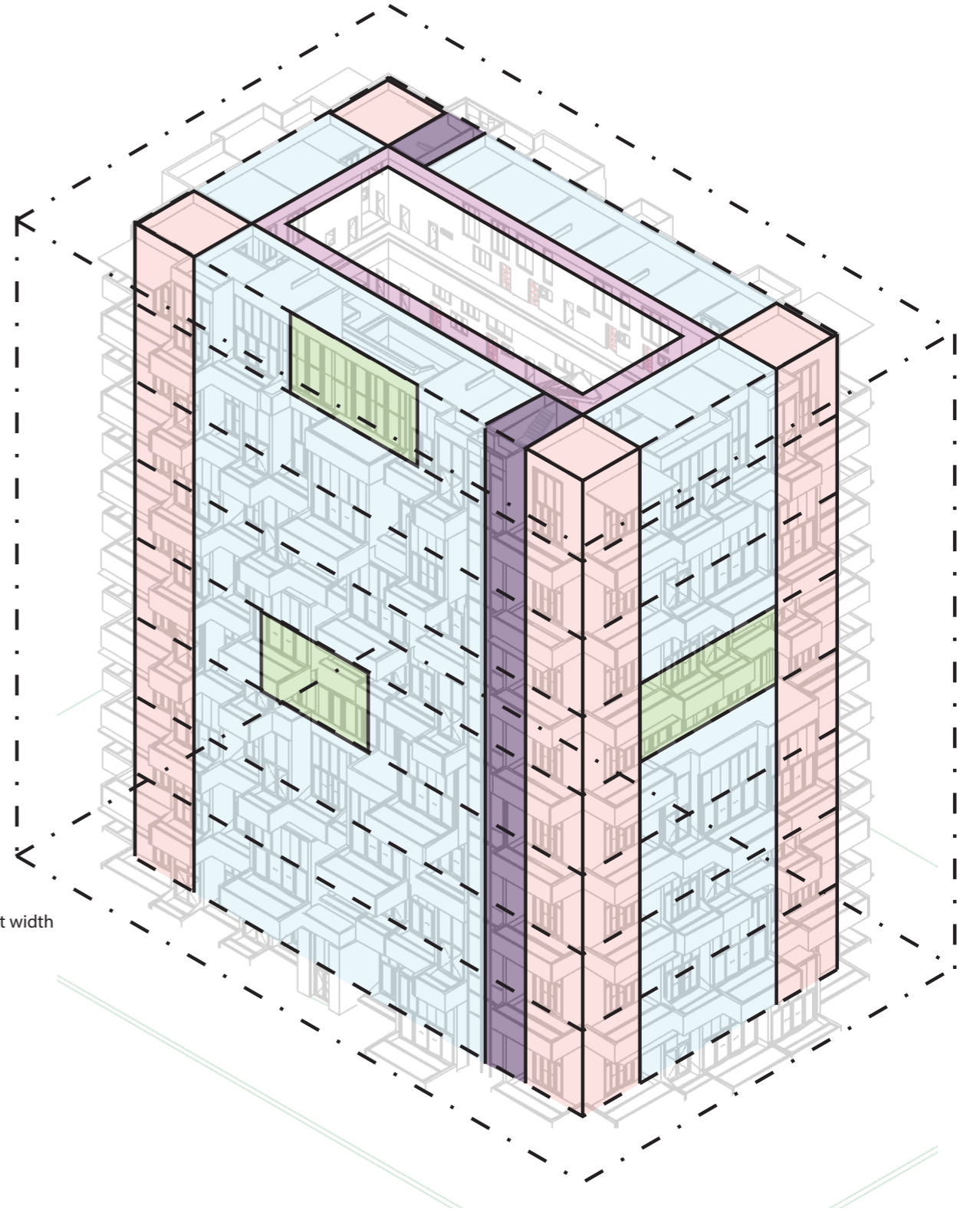
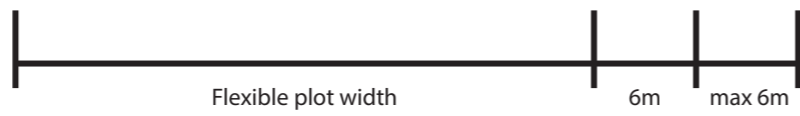
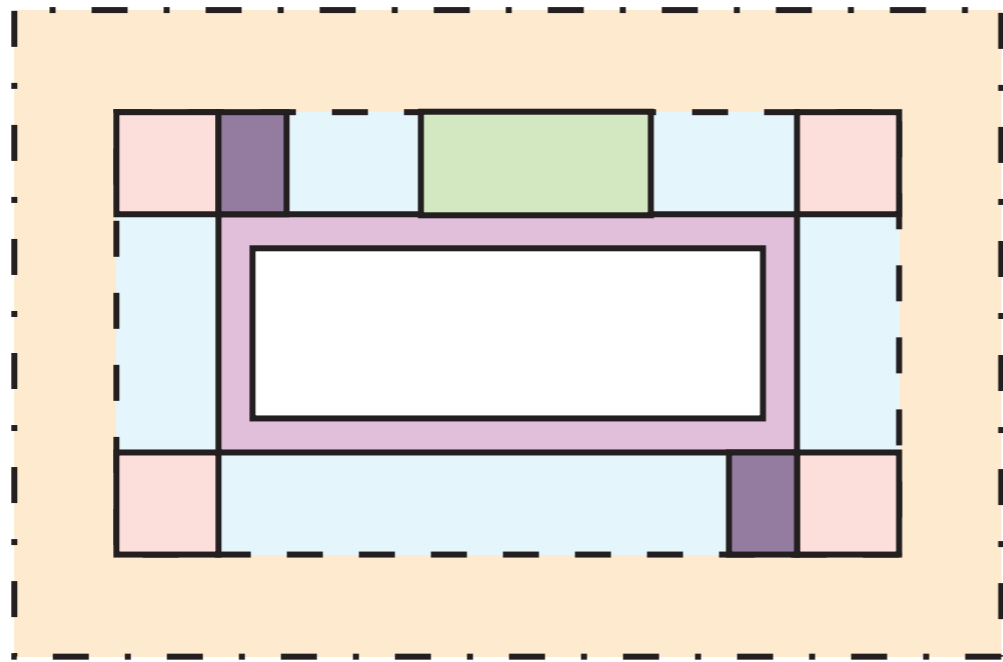


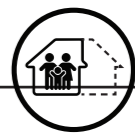
Vertical Garden City



# Vertical Urban Plan

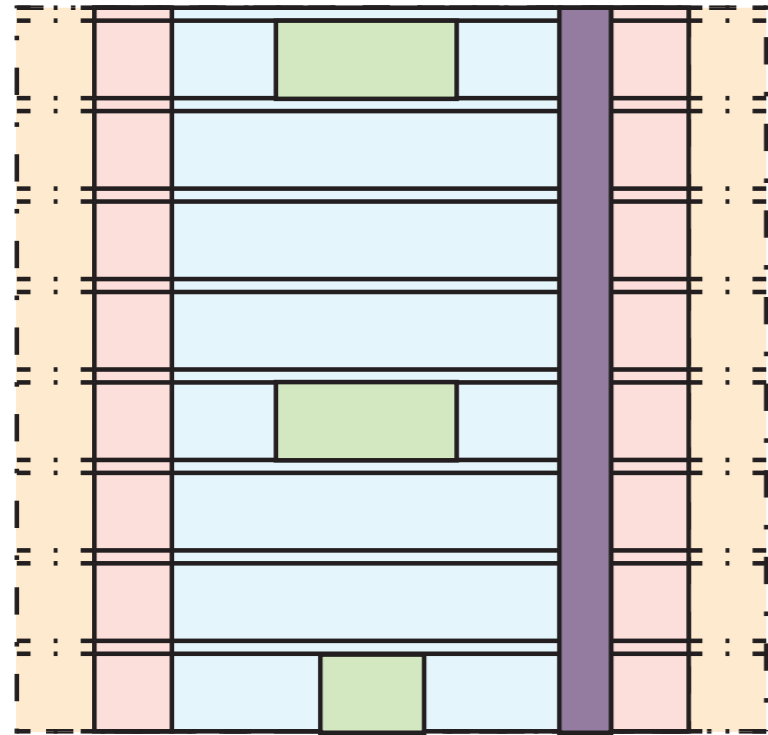
Subtitle



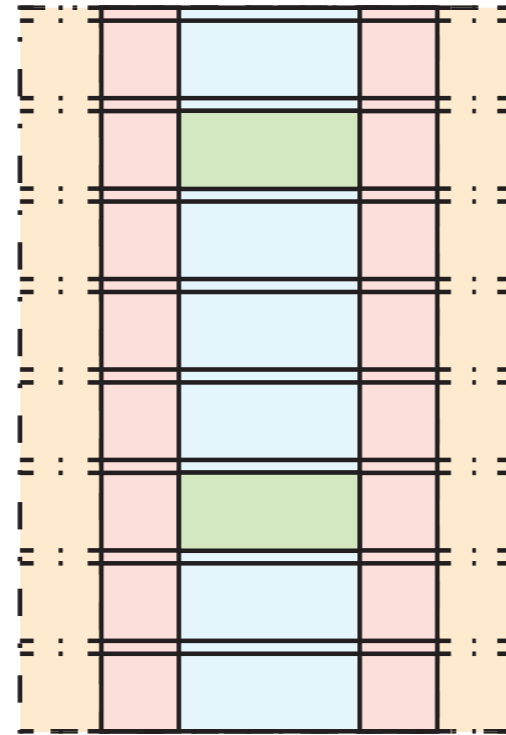


# Plot allocation Facades

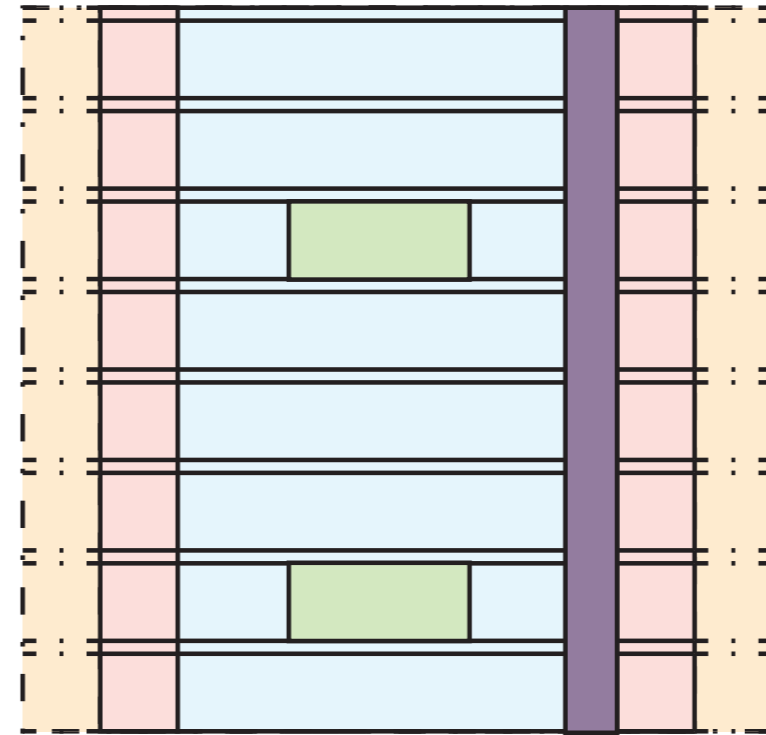
Subtitle



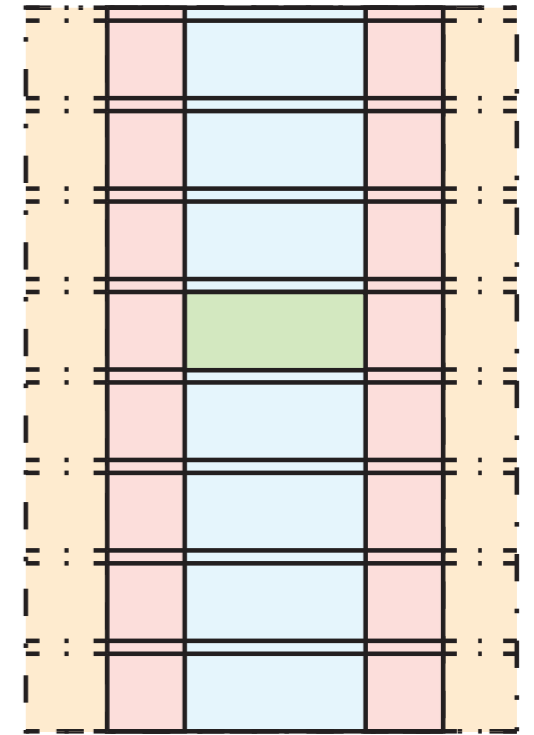
South



East



North



West

# Optional facade configuration

## South and East Facade





# Otional Facade Configuration

## North and West Facade



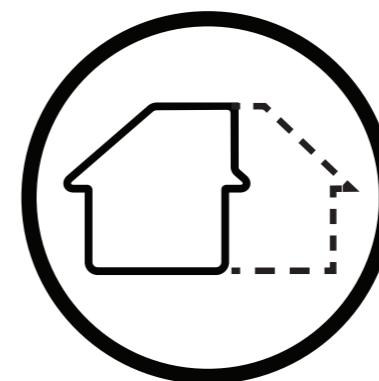


# Flexible building System

Mass Customisable Buildings

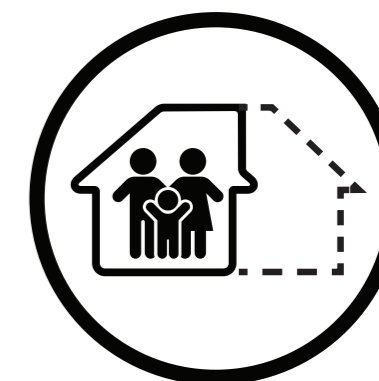
## Individual priorities

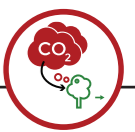
Household size  
rather live outside  
likes gardening



## Identity

Identify yourself with your home  
Recognisable  
Express yourself with your home





# Identity

Identify yourself with your home





# Optional Floorplan Smallest

## 3x6 Studio Apartment

### 3m x 6m Studio Apartment

Vertical Garden City Amsterdam  
Marineterrein Amsterdam

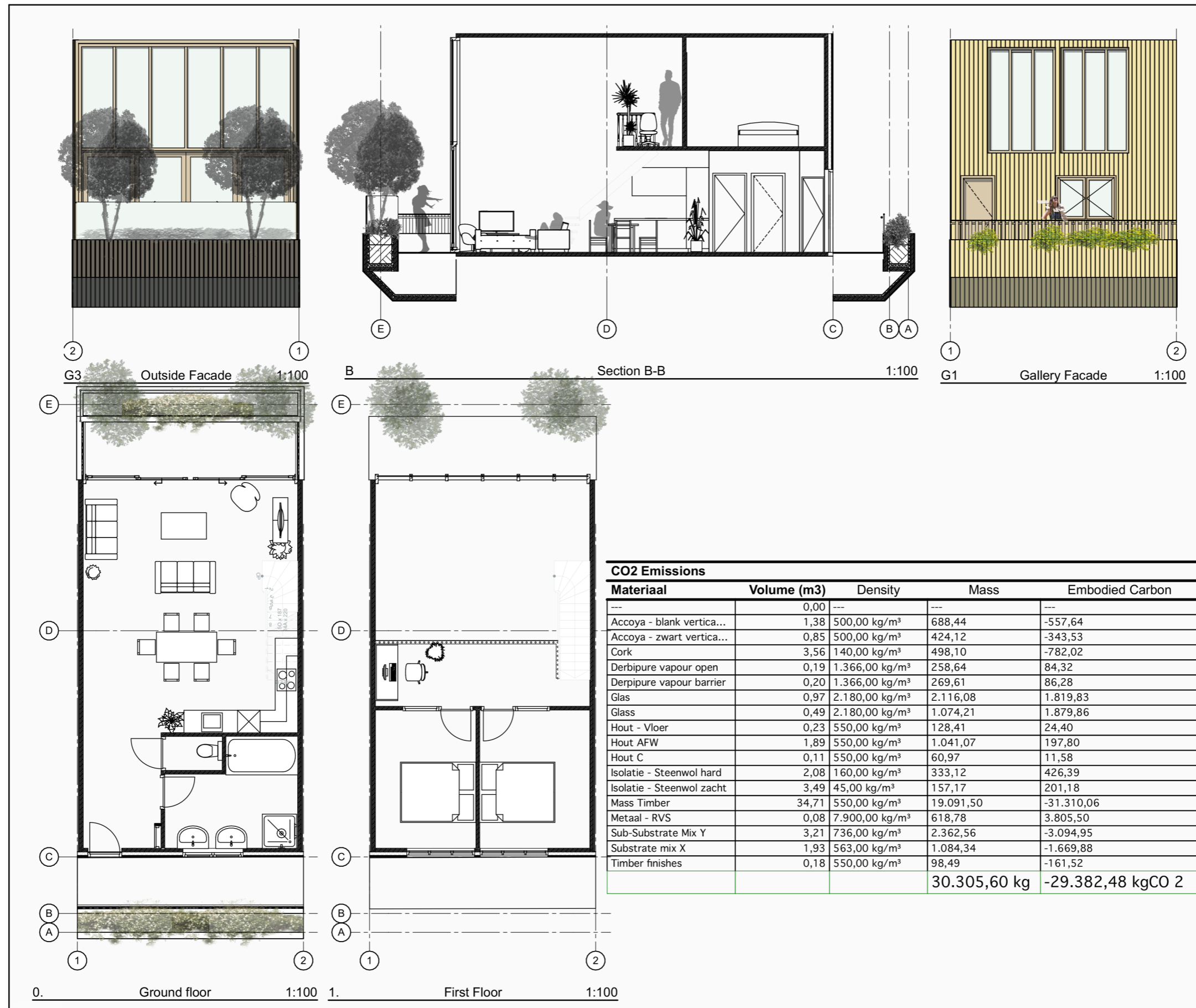


| CO2 Emissions             |             |                            |              |                              |
|---------------------------|-------------|----------------------------|--------------|------------------------------|
| Materiaal                 | Volume (m3) | Density                    | Mass         | Embodied Carbon              |
| ---                       | 0,00        | ---                        | ---          | ---                          |
| Accoya - blank vertica... | 0,66        | 500,00 kg/m <sup>3</sup>   | 328,97       | -266,47                      |
| Accoya - zwart vertica... | 0,52        | 500,00 kg/m <sup>3</sup>   | 259,29       | -210,02                      |
| Cork                      | 1,91        | 140,00 kg/m <sup>3</sup>   | 267,79       | -420,43                      |
| Derbipure vapour open     | 0,11        | 1.366,00 kg/m <sup>3</sup> | 145,51       | 47,44                        |
| Derbipure vapour barrier  | 0,11        | 1.366,00 kg/m <sup>3</sup> | 147,10       | 47,07                        |
| Glass                     | 0,74        | 2.180,00 kg/m <sup>3</sup> | 1.621,09     | 2.836,91                     |
| Isolatie - Steenwol hard  | 0,92        | 160,00 kg/m <sup>3</sup>   | 146,86       | 187,99                       |
| Isolatie - Steenwol zacht | 2,11        | 45,00 kg/m <sup>3</sup>    | 95,07        | 121,69                       |
| Mass Timber               | 15,36       | 550,00 kg/m <sup>3</sup>   | 8.448,75     | -13.855,95                   |
| Mass timber floor         | 0,38        | 550,00 kg/m <sup>3</sup>   | 207,75       | -340,71                      |
| Metaal - RVS              | 0,00        | 7.900,00 kg/m <sup>3</sup> | 31,77        | 195,39                       |
| Sub-Substrate Mix Y       | 1,56        | 736,00 kg/m <sup>3</sup>   | 1.148,99     | -1.505,17                    |
| Substrate mix X           | 0,94        | 563,00 kg/m <sup>3</sup>   | 527,35       | -812,11                      |
| Timber finishes           | 1,21        | 550,00 kg/m <sup>3</sup>   | 667,07       | -1.093,99                    |
|                           |             |                            | 14.043,35 kg | -15.068,38 kgCO <sub>2</sub> |



# Optional Floorplan Max floorspace

## 6x10 Apartment small garden



6m x 10m  
House min  
garden

Vertical Garden City  
Amsterdam  
Marineterrein Amsterdam

| CO2 Emissions             |             |                            |                     |                          |
|---------------------------|-------------|----------------------------|---------------------|--------------------------|
| Material                  | Volume (m3) | Density                    | Mass                | Embodied Carbon          |
| ---                       | 0,00        | ---                        | ---                 | ---                      |
| Accoya - blank vertica... | 1,38        | 500,00 kg/m <sup>3</sup>   | 688,44              | -557,64                  |
| Accoya - zwart vertica... | 0,85        | 500,00 kg/m <sup>3</sup>   | 424,12              | -343,53                  |
| Cork                      | 3,56        | 140,00 kg/m <sup>3</sup>   | 498,10              | -782,02                  |
| Derbipure vapour open     | 0,19        | 1.366,00 kg/m <sup>3</sup> | 258,64              | 84,32                    |
| Derbipure vapour barrier  | 0,20        | 1.366,00 kg/m <sup>3</sup> | 269,61              | 86,28                    |
| Glas                      | 0,97        | 2.180,00 kg/m <sup>3</sup> | 2.116,08            | 1.819,83                 |
| Glass                     | 0,49        | 2.180,00 kg/m <sup>3</sup> | 1.074,21            | 1.879,86                 |
| Hout - Vloer              | 0,23        | 550,00 kg/m <sup>3</sup>   | 128,41              | 24,40                    |
| Hout AFW                  | 1,89        | 550,00 kg/m <sup>3</sup>   | 1.041,07            | 197,80                   |
| Hout C                    | 0,11        | 550,00 kg/m <sup>3</sup>   | 60,97               | 11,58                    |
| Isolatie - Steenwol hard  | 2,08        | 160,00 kg/m <sup>3</sup>   | 333,12              | 426,39                   |
| Isolatie - Steenwol zacht | 3,49        | 45,00 kg/m <sup>3</sup>    | 157,17              | 201,18                   |
| Mass Timber               | 34,71       | 550,00 kg/m <sup>3</sup>   | 19.091,50           | -31.310,06               |
| Metaal - RVS              | 0,08        | 7.900,00 kg/m <sup>3</sup> | 618,78              | 3.805,50                 |
| Sub-Substrate Mix Y       | 3,21        | 736,00 kg/m <sup>3</sup>   | 2.362,56            | -3.094,95                |
| Substrate mix X           | 1,93        | 563,00 kg/m <sup>3</sup>   | 1.084,34            | -1.669,88                |
| Timber finishes           | 0,18        | 550,00 kg/m <sup>3</sup>   | 98,49               | -161,52                  |
|                           |             |                            | <b>30.305,60 kg</b> | <b>-29.382,48 kgCO 2</b> |

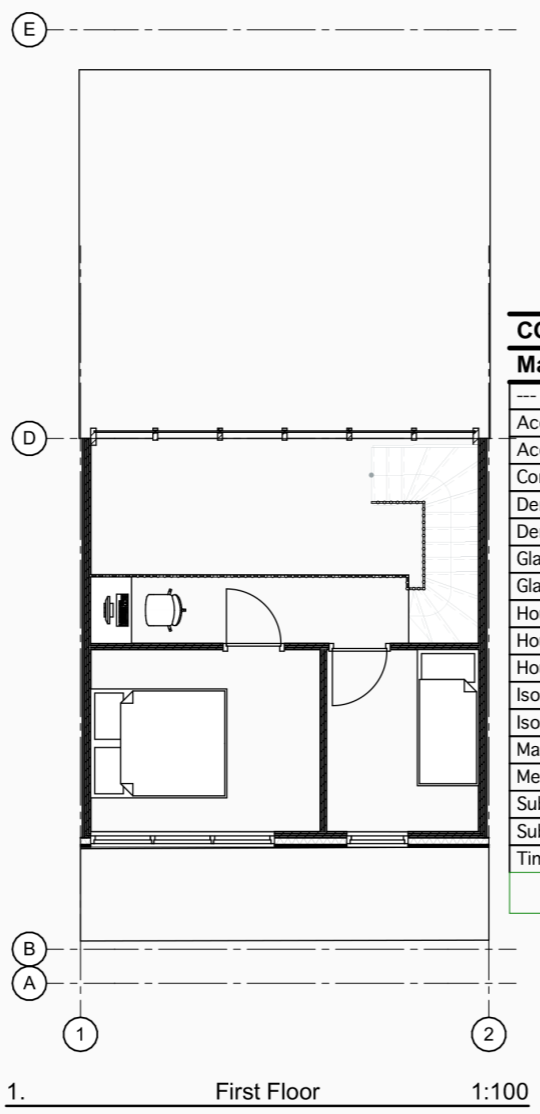
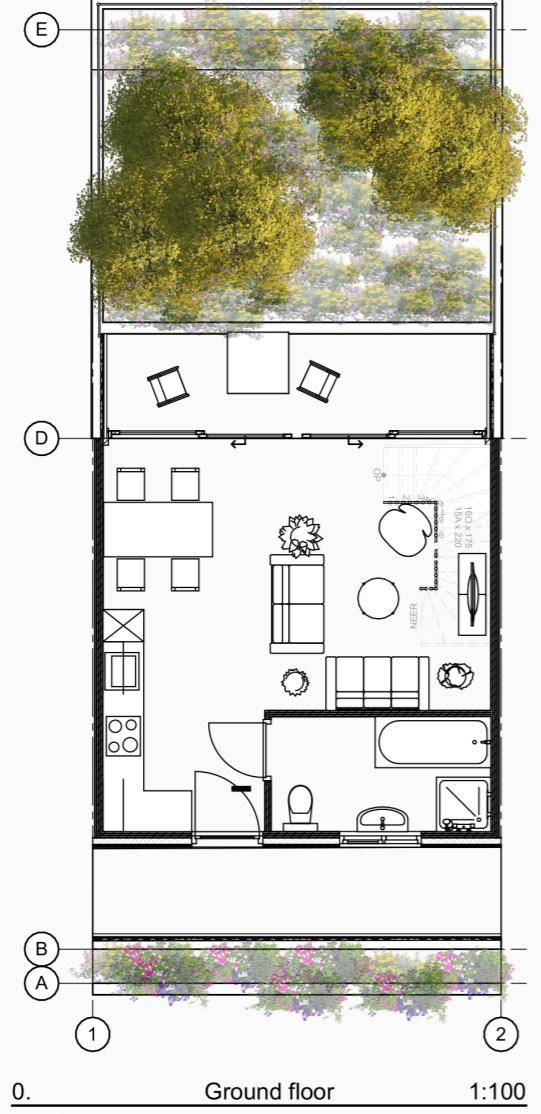
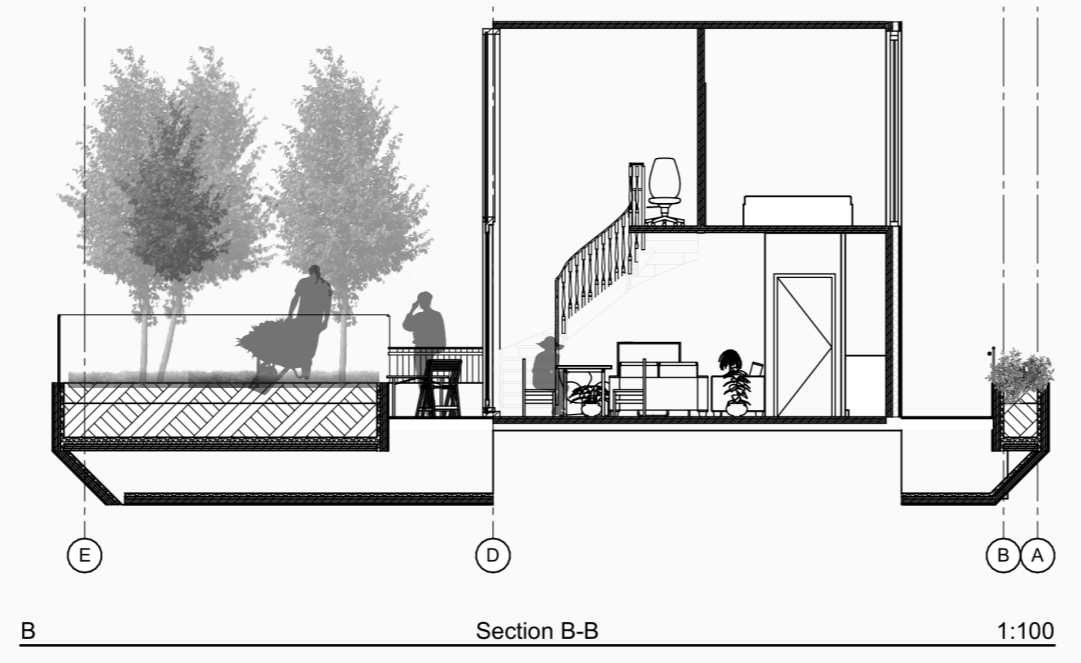


# Optional Floorplan Max Garden

Subtitle

6m x 6m  
House max  
garden

Vertical Garden City  
Amsterdam  
Marineterrein Amsterdam



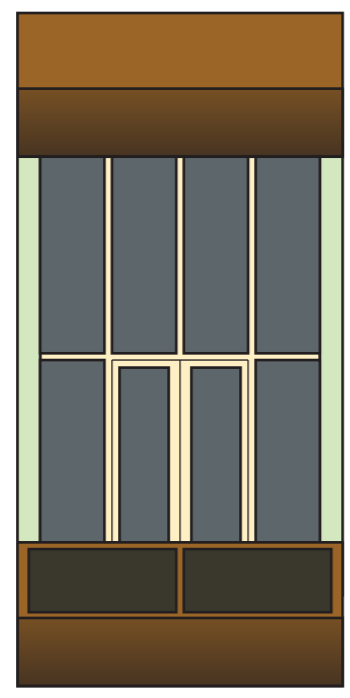
**CO2 Emissions**

| Materiaal                 | Volume (m3) | Density                    | Mass                | Embodied Carbon          |
|---------------------------|-------------|----------------------------|---------------------|--------------------------|
| ---                       | 0,00        | ---                        | ---                 | ---                      |
| Accoya - blank vertica... | 1,38        | 500,00 kg/m <sup>3</sup>   | 690,11              | -558,99                  |
| Accoya - zwart vertica... | 1,69        | 500,00 kg/m <sup>3</sup>   | 847,05              | -686,11                  |
| Cork                      | 7,65        | 140,00 kg/m <sup>3</sup>   | 1.070,36            | -1.680,46                |
| Derpiture vapour open     | 0,30        | 1.366,00 kg/m <sup>3</sup> | 409,13              | 133,38                   |
| Derpiture vapour barrier  | 0,37        | 1.366,00 kg/m <sup>3</sup> | 511,77              | 163,77                   |
| Glas                      | 0,97        | 2.180,00 kg/m <sup>3</sup> | 2.116,08            | 1.819,83                 |
| Glass                     | 1,03        | 2.180,00 kg/m <sup>3</sup> | 2.235,97            | 3.912,94                 |
| Hout - Vloer              | 0,36        | 550,00 kg/m <sup>3</sup>   | 199,38              | 37,88                    |
| Hout AFW                  | 1,98        | 550,00 kg/m <sup>3</sup>   | 1.091,57            | 207,40                   |
| Hout C                    | 0,17        | 550,00 kg/m <sup>3</sup>   | 93,27               | 17,72                    |
| Isolatie - Steenwol hard  | 2,10        | 160,00 kg/m <sup>3</sup>   | 335,79              | 429,81                   |
| Isolatie - Steenwol zacht | 2,11        | 45,00 kg/m <sup>3</sup>    | 95,07               | 121,69                   |
| Mass Timber               | 30,49       | 550,00 kg/m <sup>3</sup>   | 16.768,67           | -27.500,62               |
| Metaal - RVS              | 0,01        | 7.900,00 kg/m <sup>3</sup> | 110,49              | 679,53                   |
| Sub-Substrate Mix Y       | 14,61       | 736,00 kg/m <sup>3</sup>   | 10.752,96           | -14.086,38               |
| Substrate mix X           | 8,77        | 563,00 kg/m <sup>3</sup>   | 4.935,26            | -7.600,30                |
| Timber finishes           | 0,18        | 550,00 kg/m <sup>3</sup>   | 98,49               | -161,52                  |
|                           |             |                            | <b>42.361,41 kg</b> | <b>-44.750,43 kgCO 2</b> |

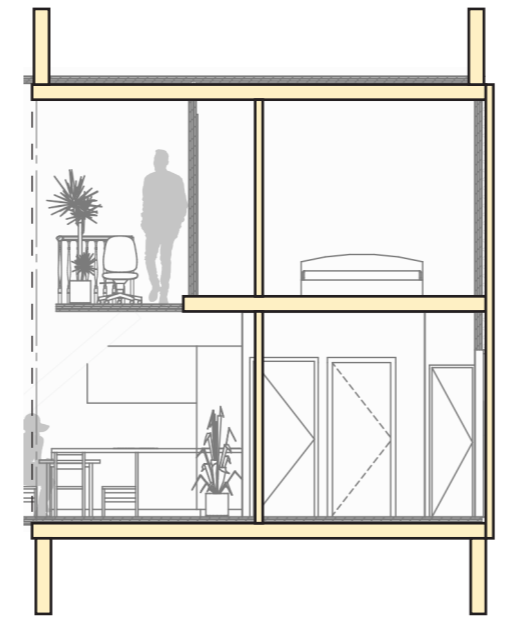
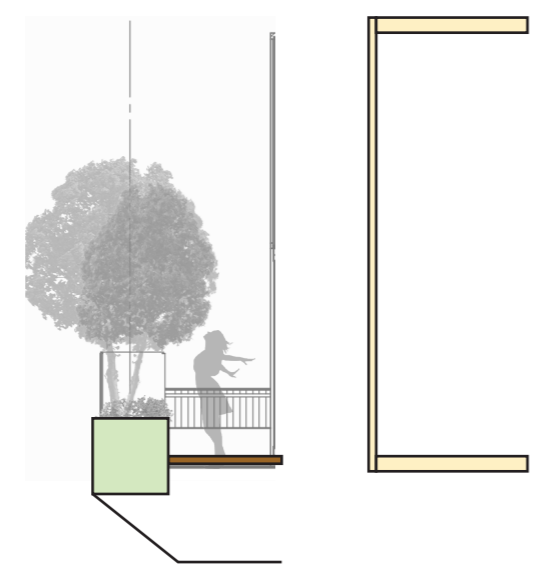


# optional House design limits

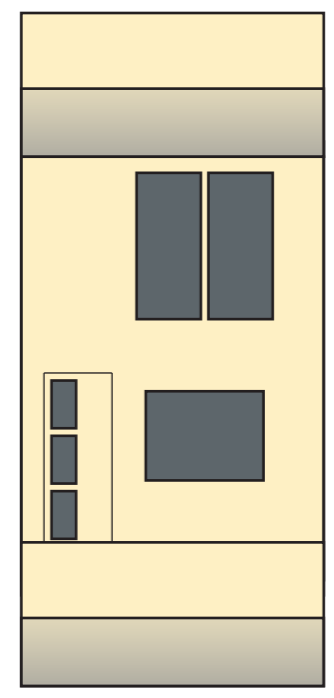
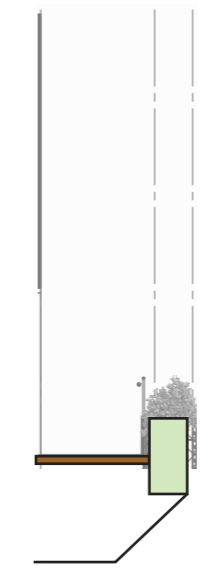
Variable plot houses



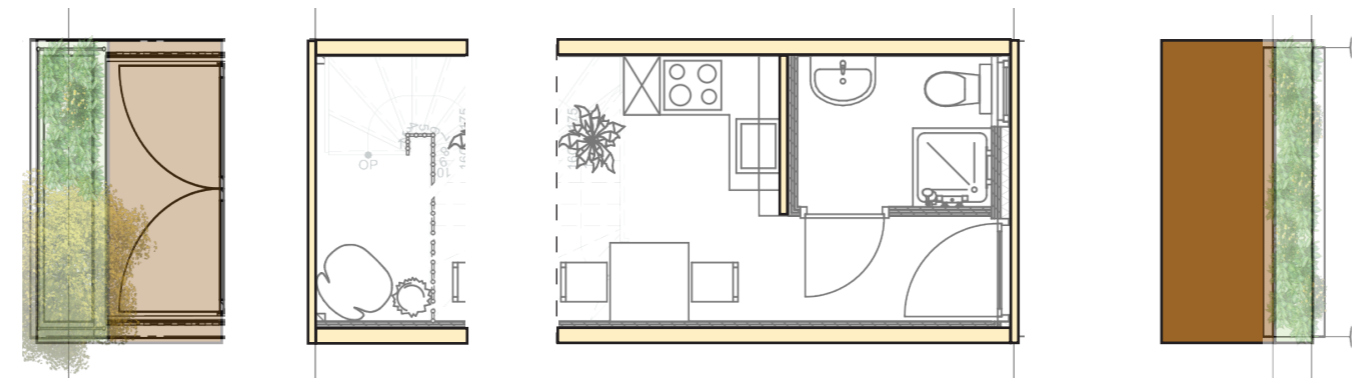
Outer Facade



Section



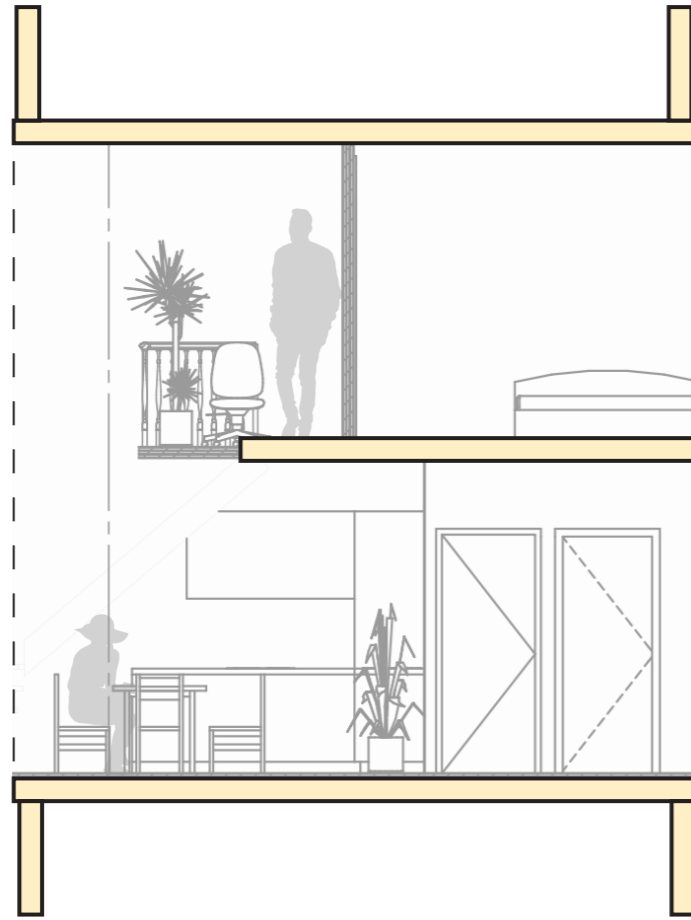
Streetside Facade



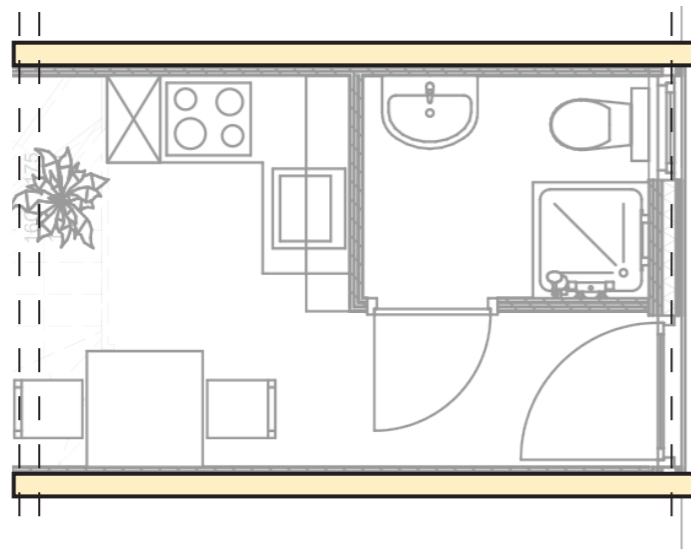
Floorplan

# Structure

## Structural concept

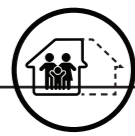


Section view



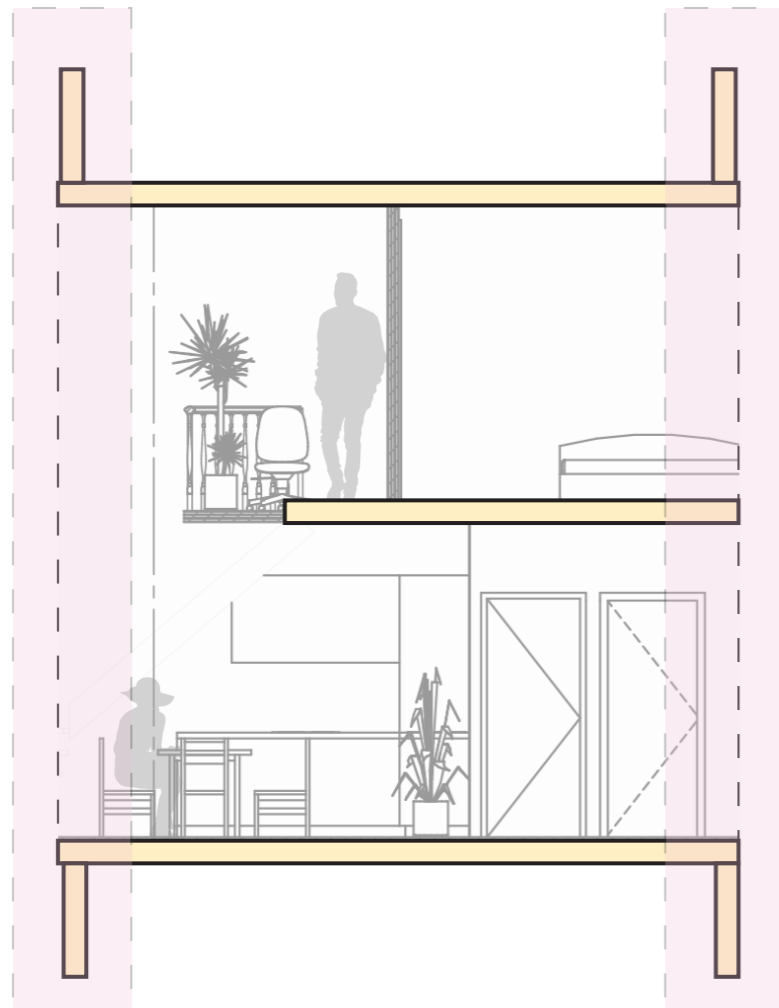
Plan view



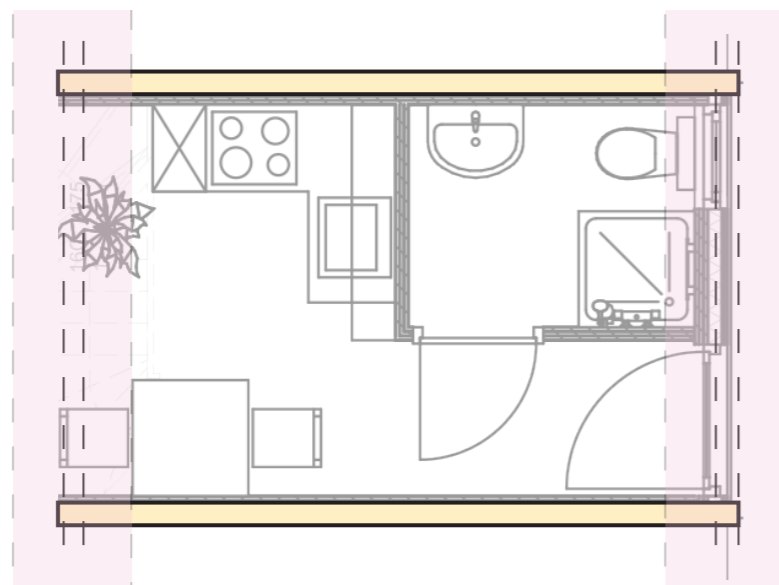


# Structure

## Structural Beams



Section view

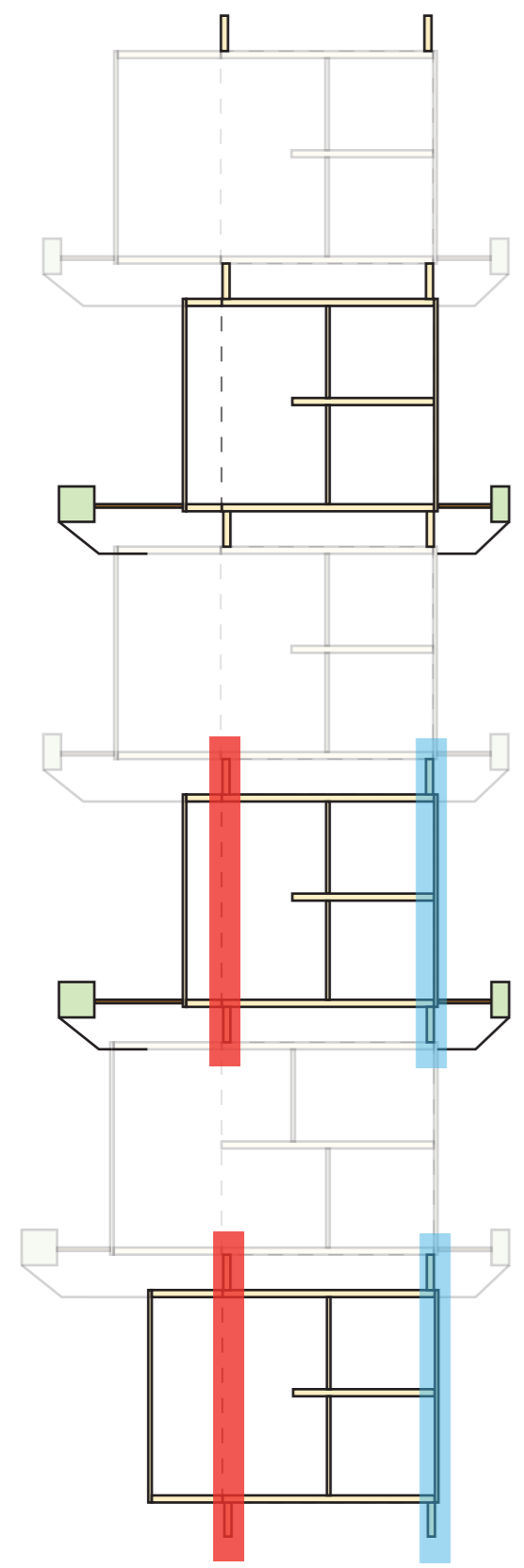


Plan view

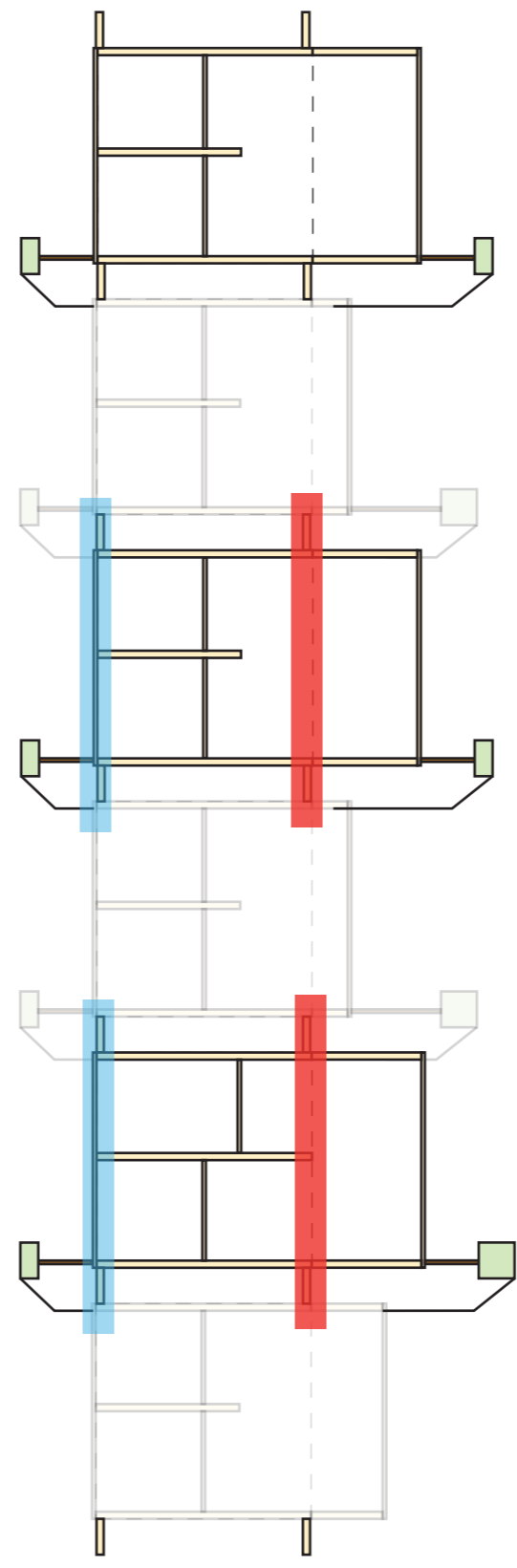
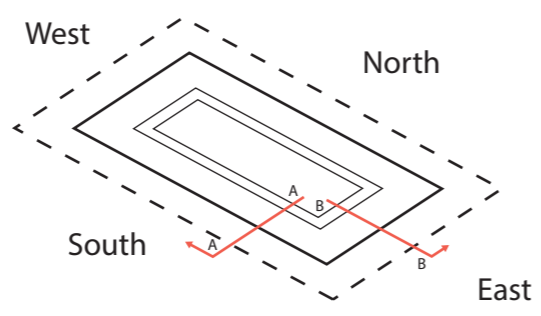
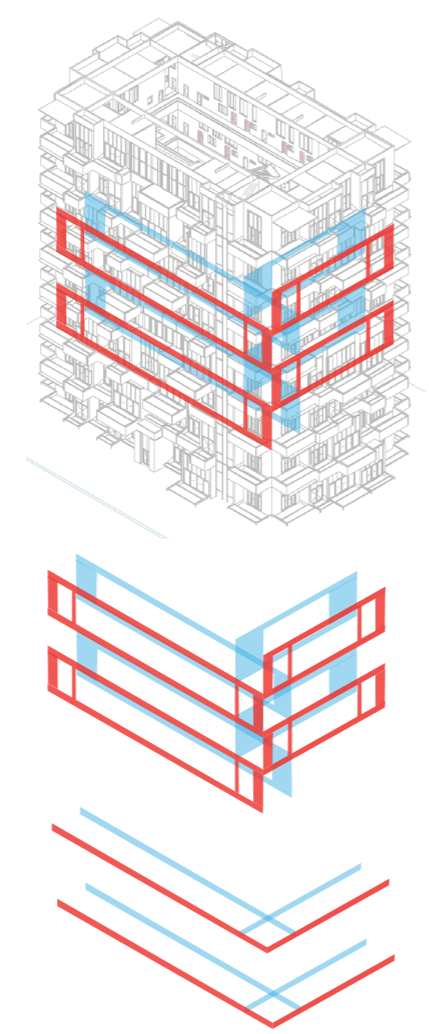


# Structure

## Main structural combined beams



Section A-A  
North and South facade

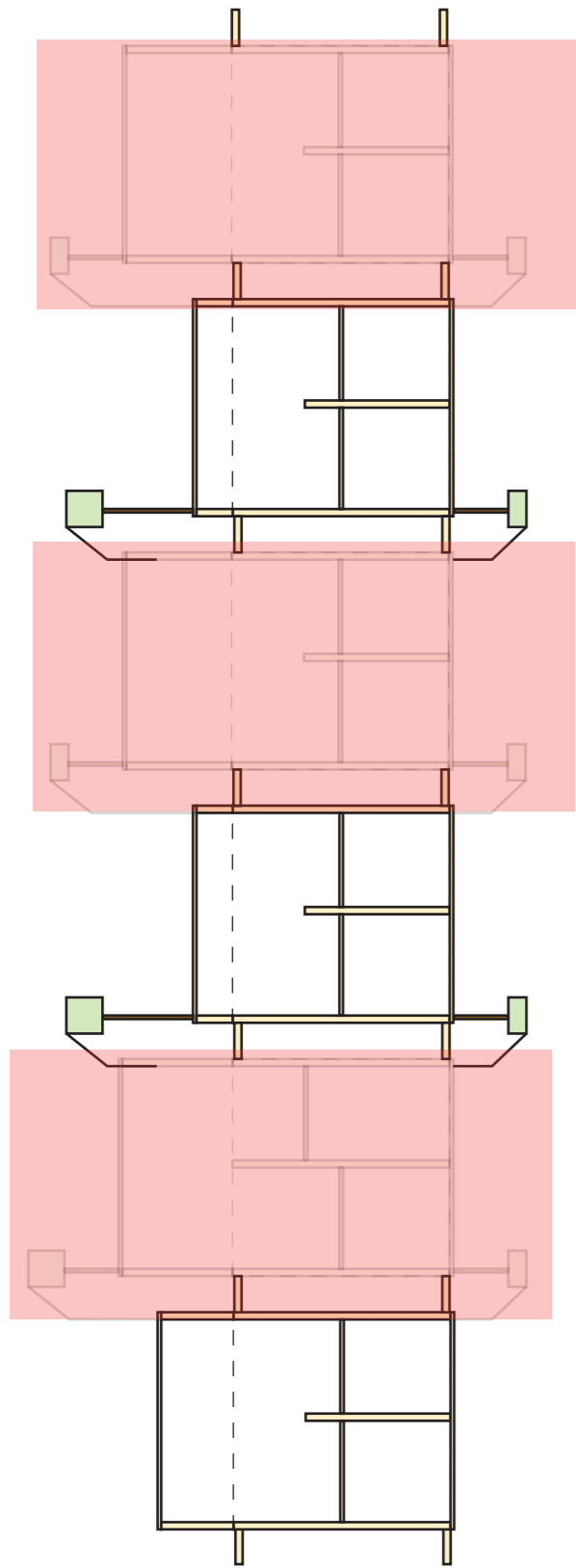


Section B-B  
East and west facade

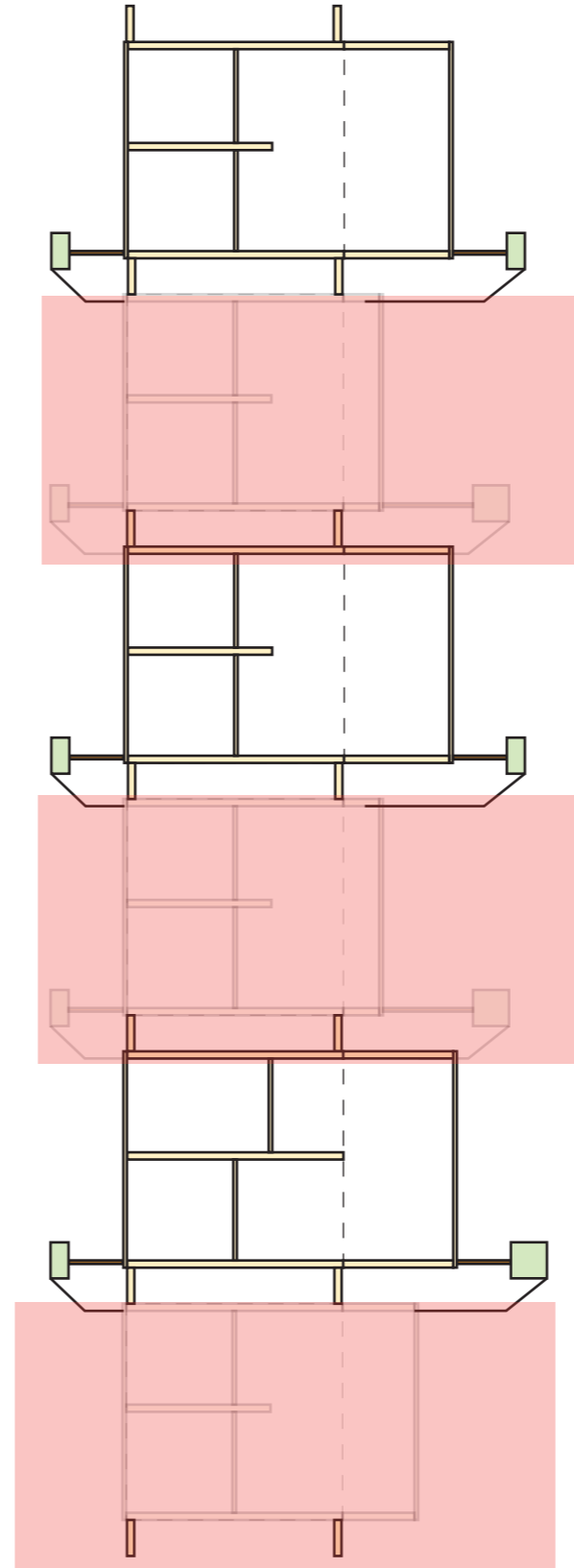
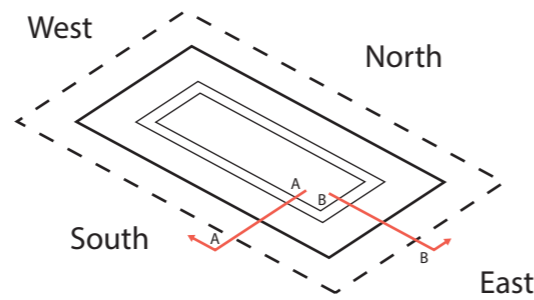
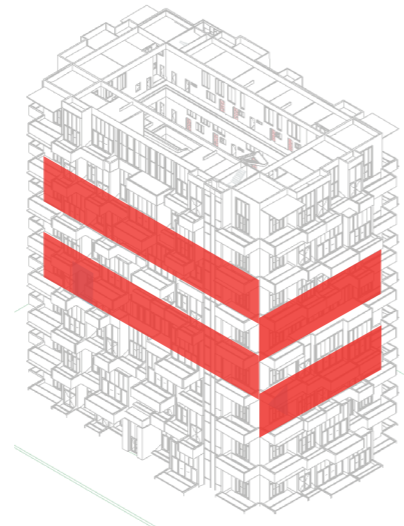


# Structure

## Infill spaces between structural houses



Section A-A  
North and South facade

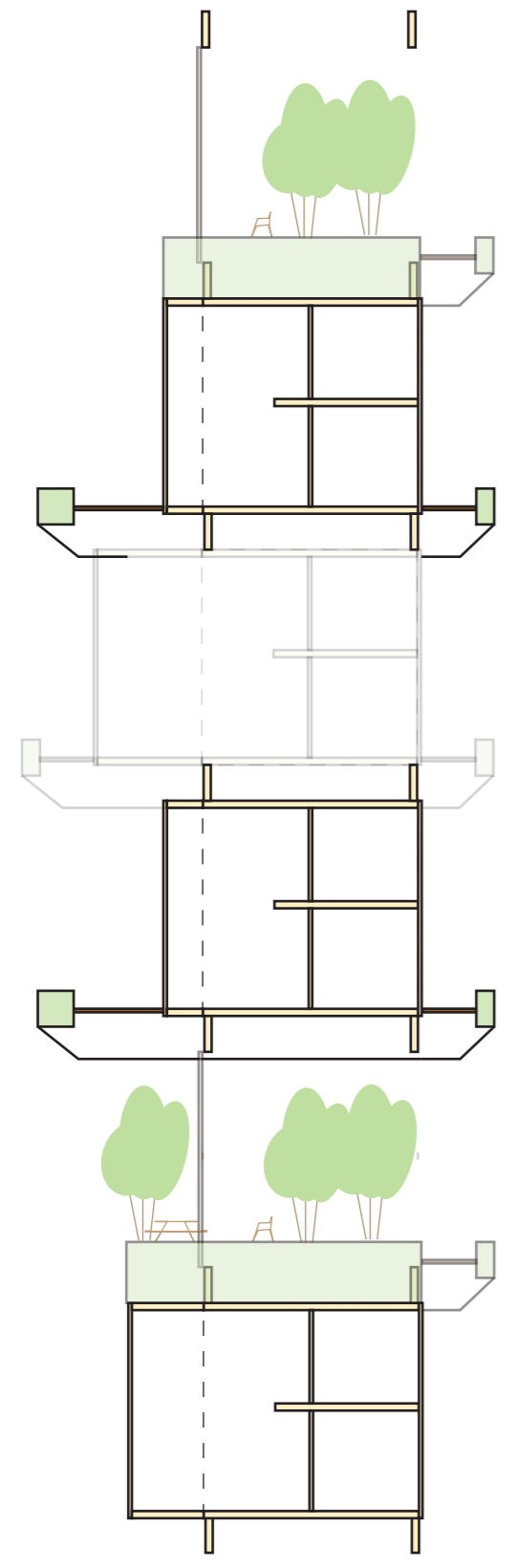


Section B-B  
East and west facade

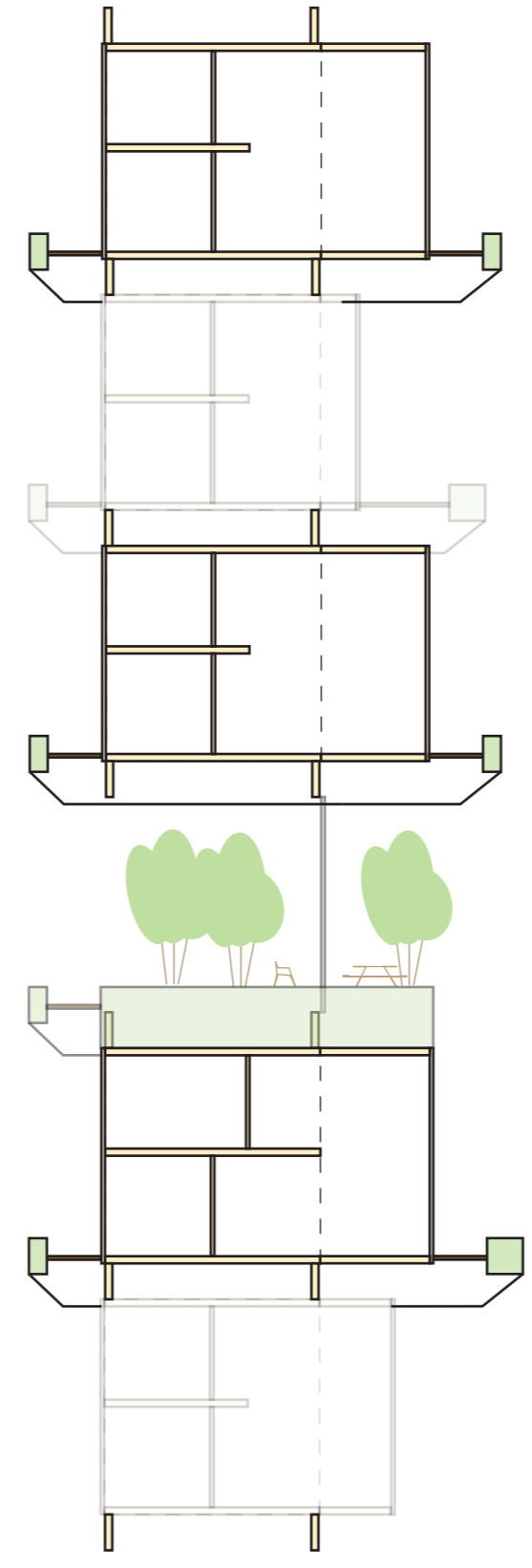
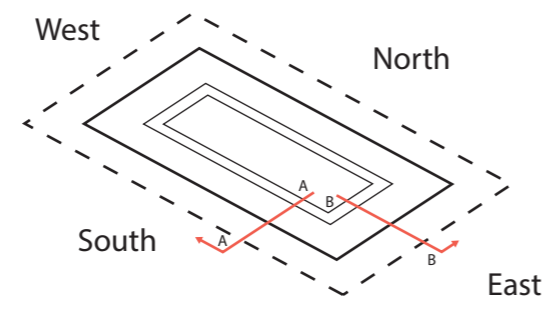
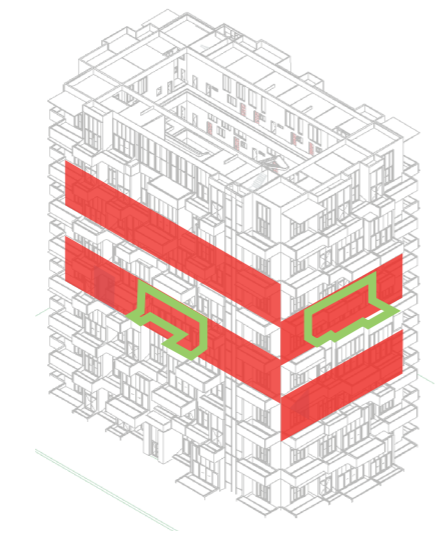
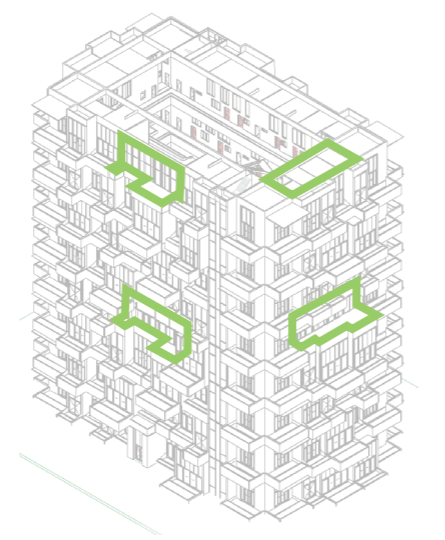


# Gardens

Gardens are only possible in infill spaces

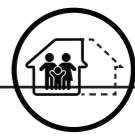


Section A-A  
North and South facade



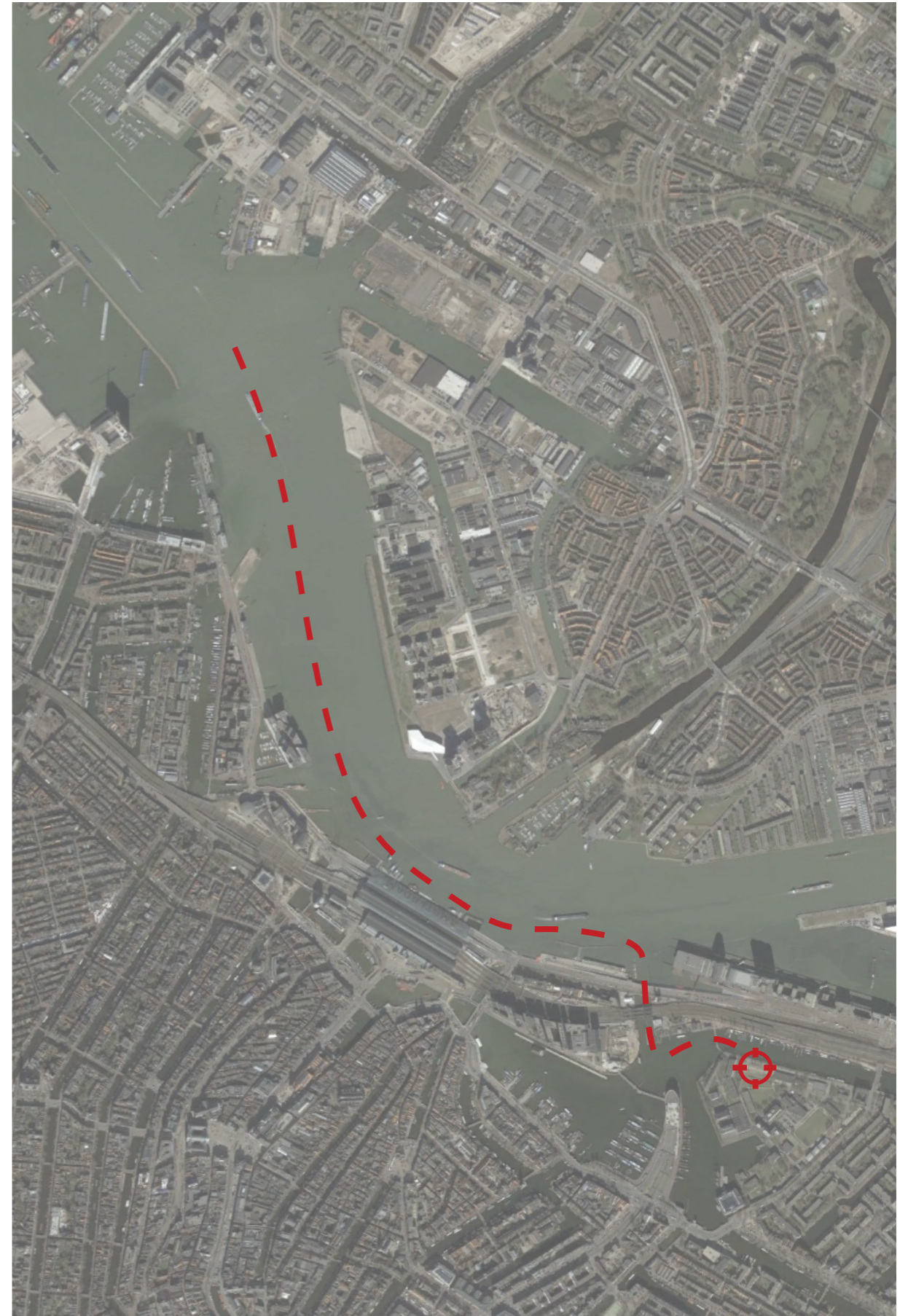
Section B-B  
East and west facade

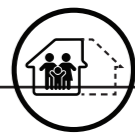




# Build Order

shipped to site

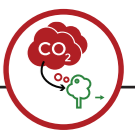
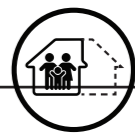




# Build Order

prefabricated Stability Core

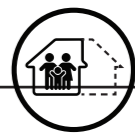




# Build Order

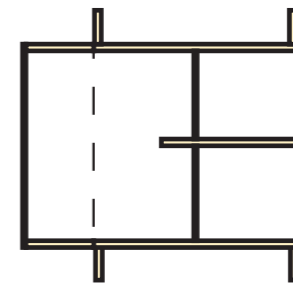
Base apartment with beams on top

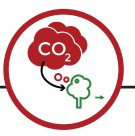
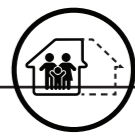




# Build Order

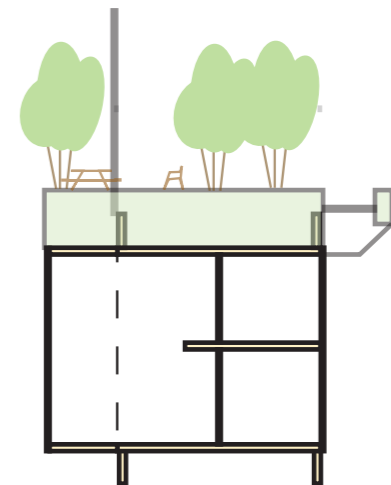
Base apartment with beams on top





# Build Order

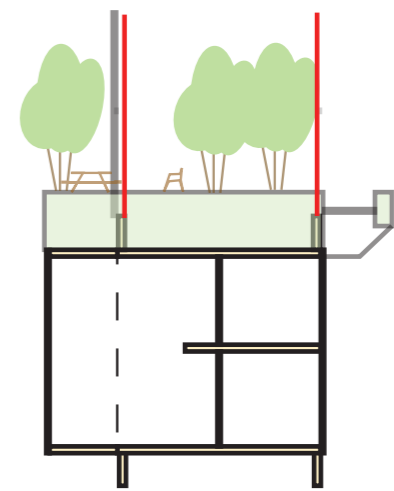
Garden on top of structural beams

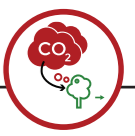
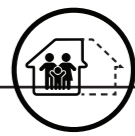




# Build Order

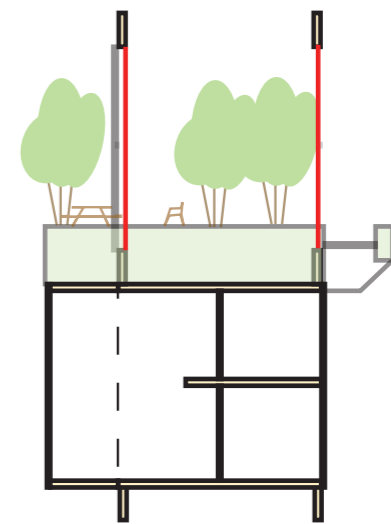
Place temporary structure





# Build Order

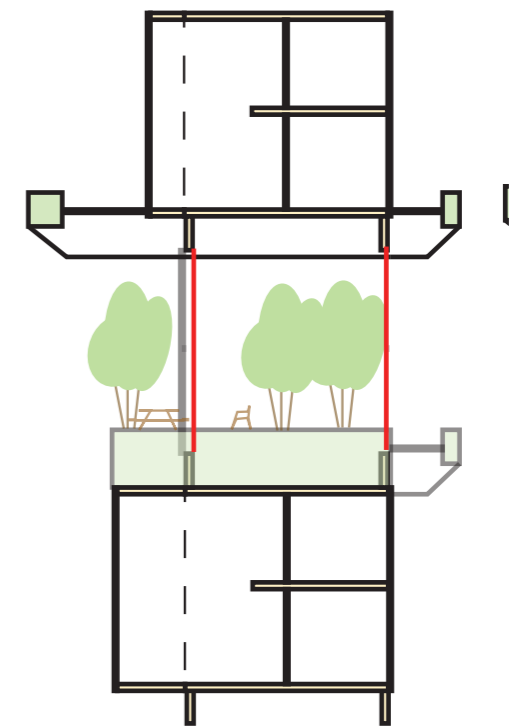
Place Structural beams for next floor





# Build Order

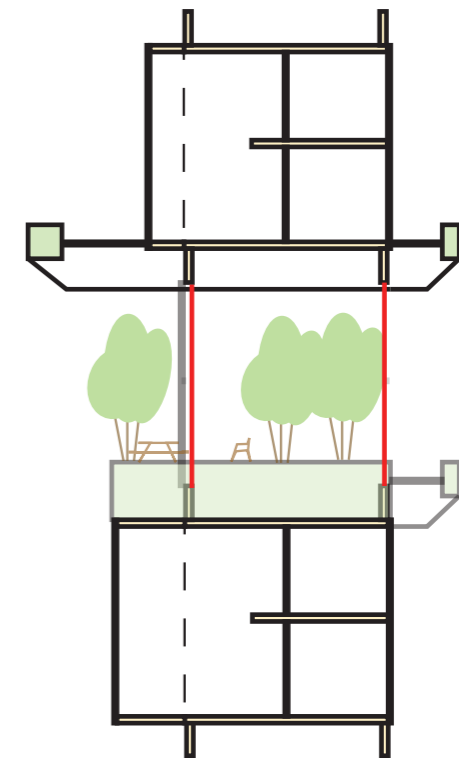
Place prefabricated houses on structural beams and fasten them

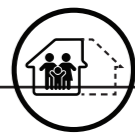




# Build Order

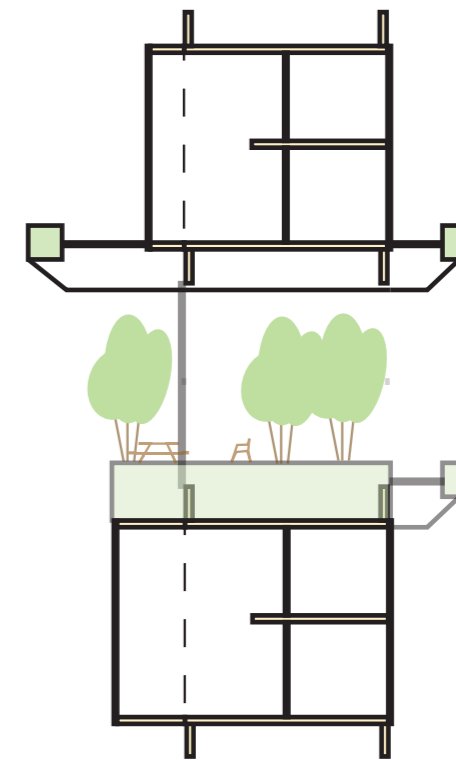
Place structural beams and fasten them to prefabricated house

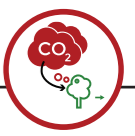
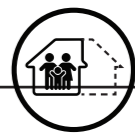




# Build Order

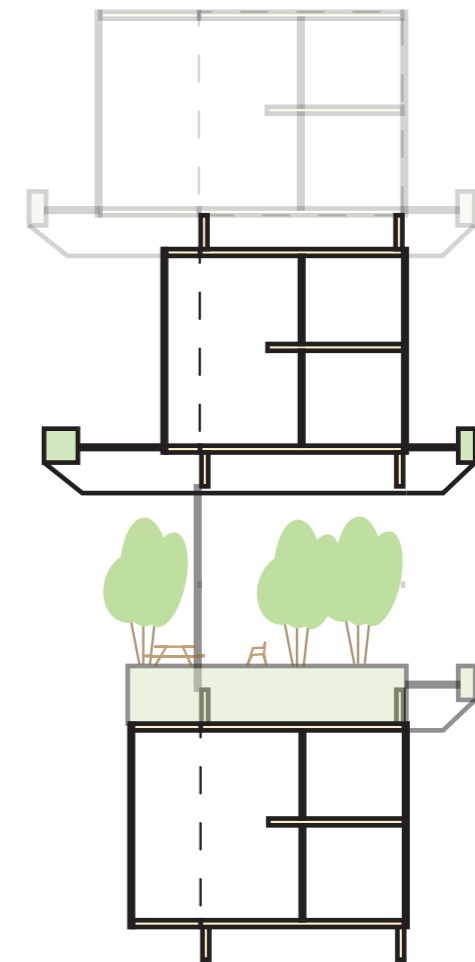
Remove temporary structure





# Build Order

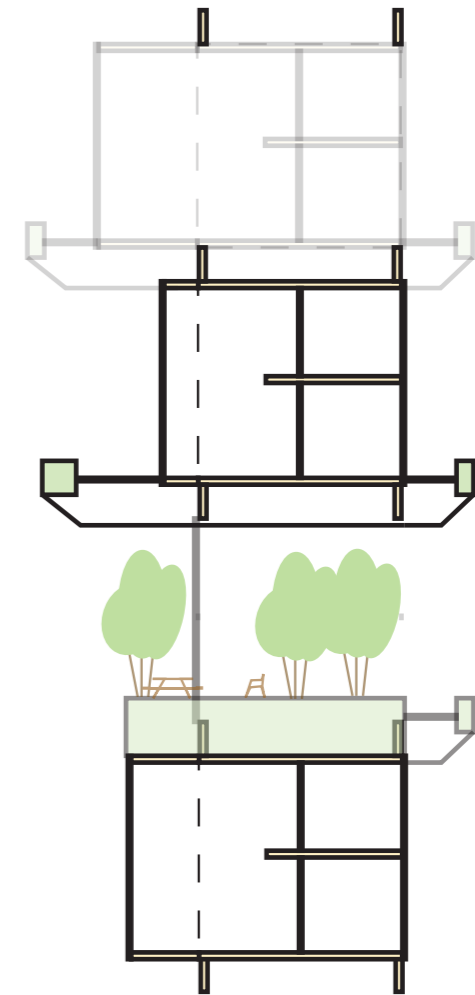
Place Prefabricated house (No structural function)

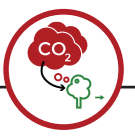
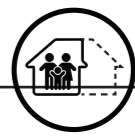




# Build Order

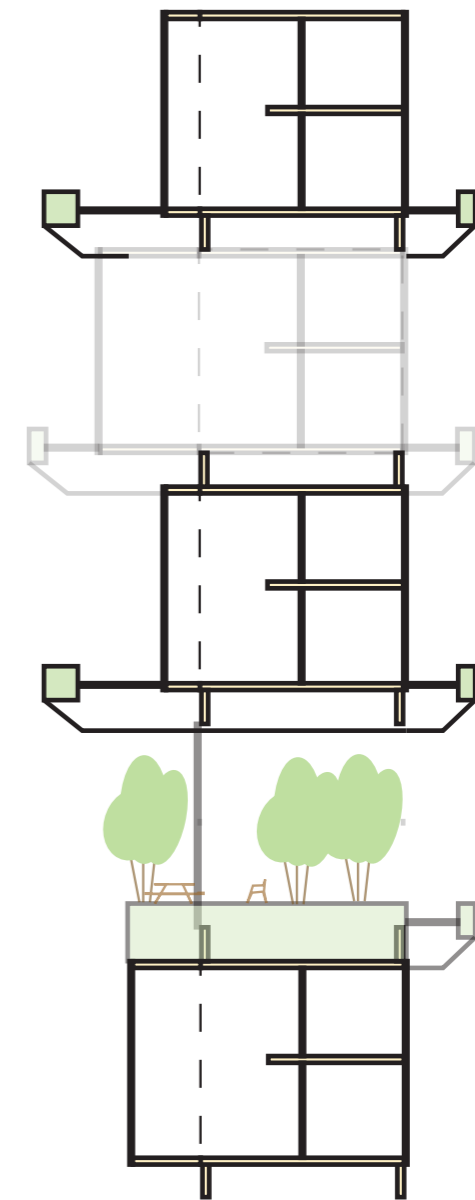
Place beams on top of non structural prefab houses





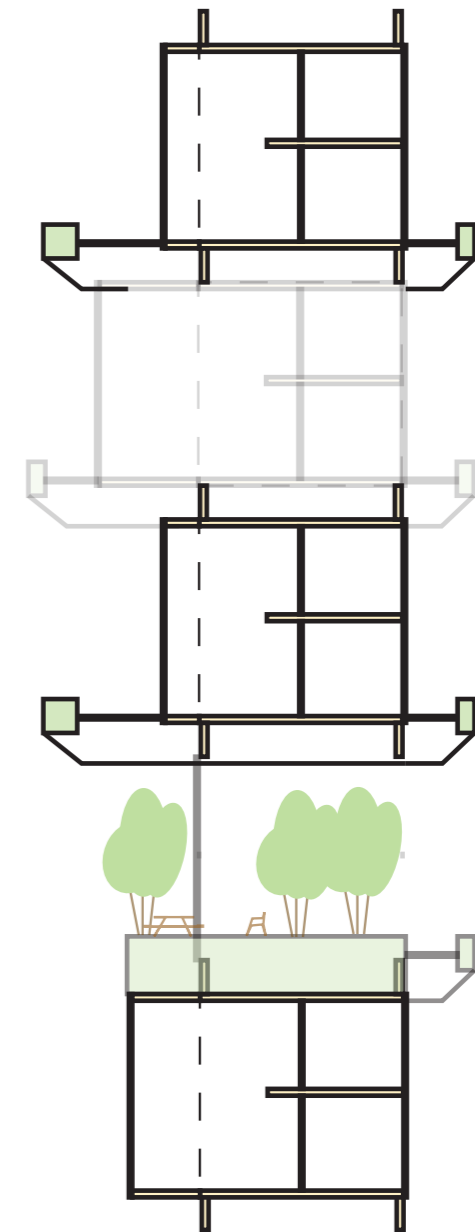
# Build Order

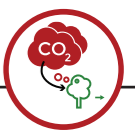
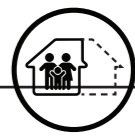
Place prefabricated house on structural beams and connect it



# Build Order

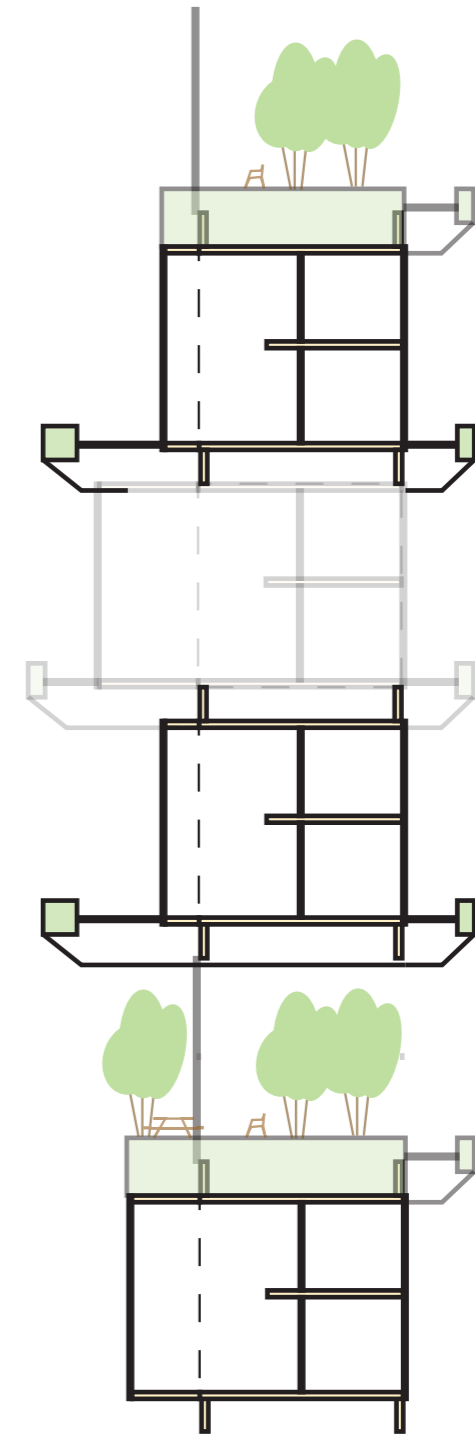
Place structural beams and connect them

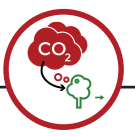
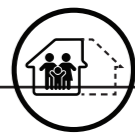




# Build Order

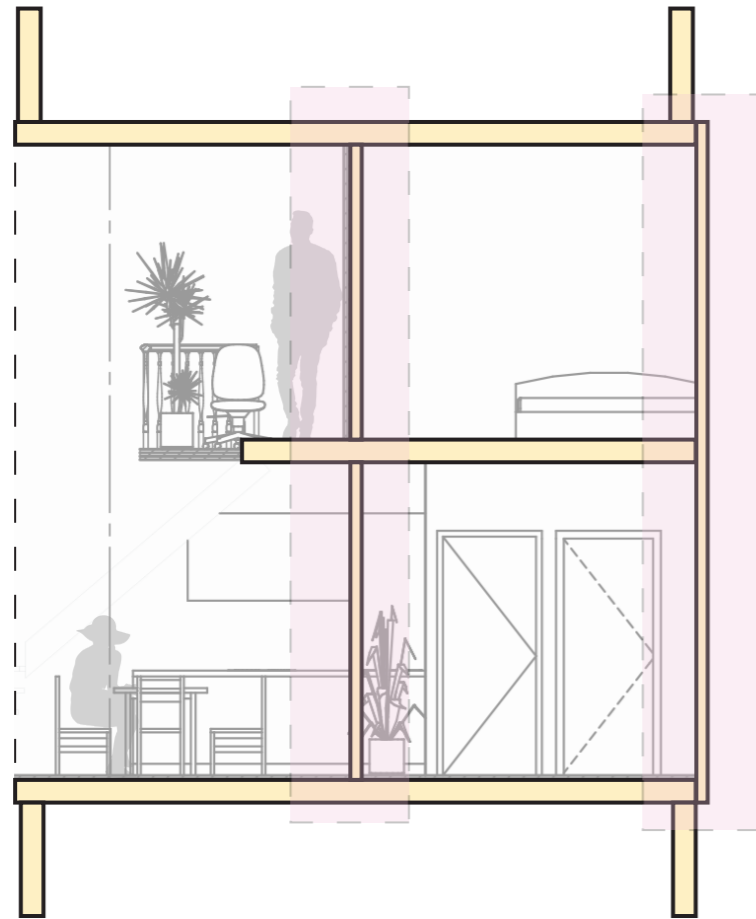
Place garden and start from the top



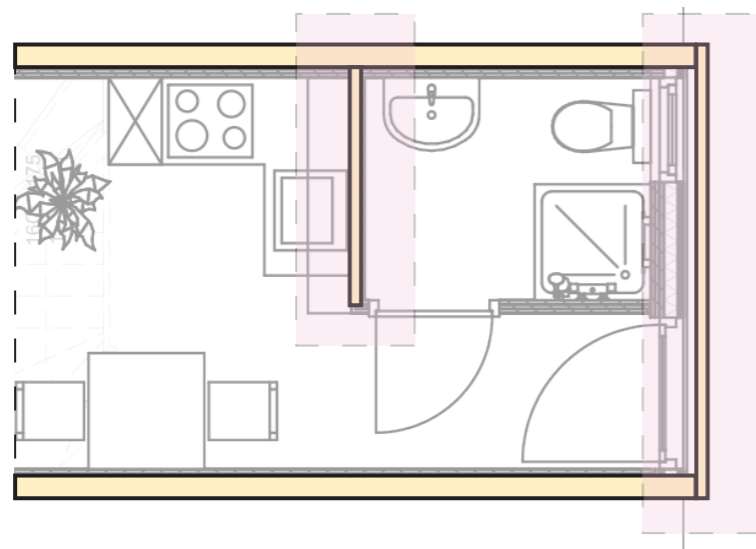


# Structure

## Stability walls



Section view



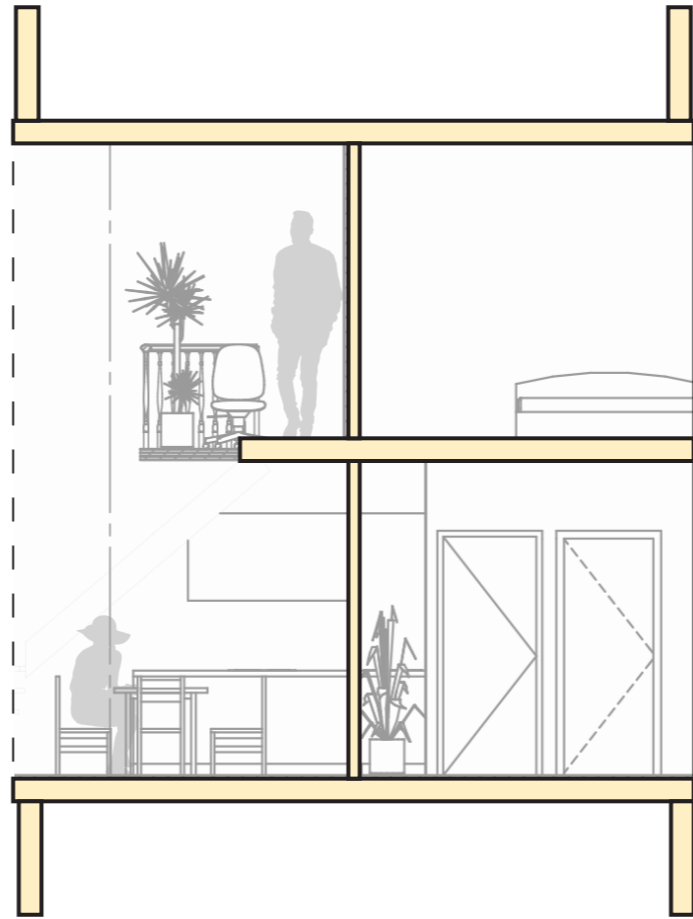
Plan view



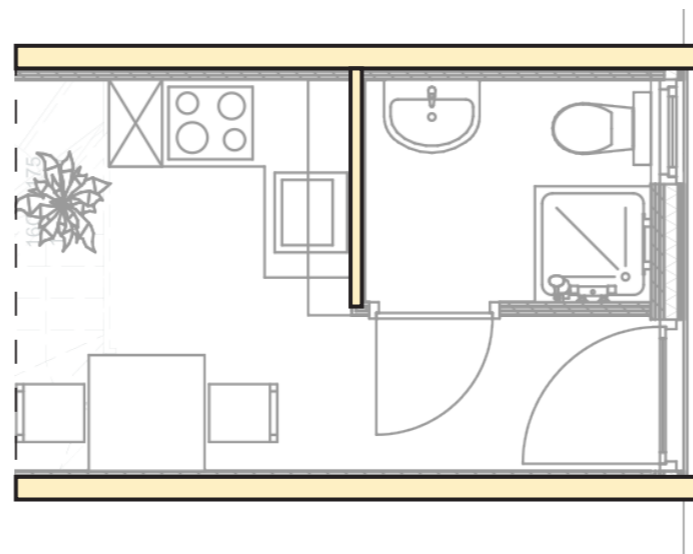


# Structure

## Stiff structural Box



Section view

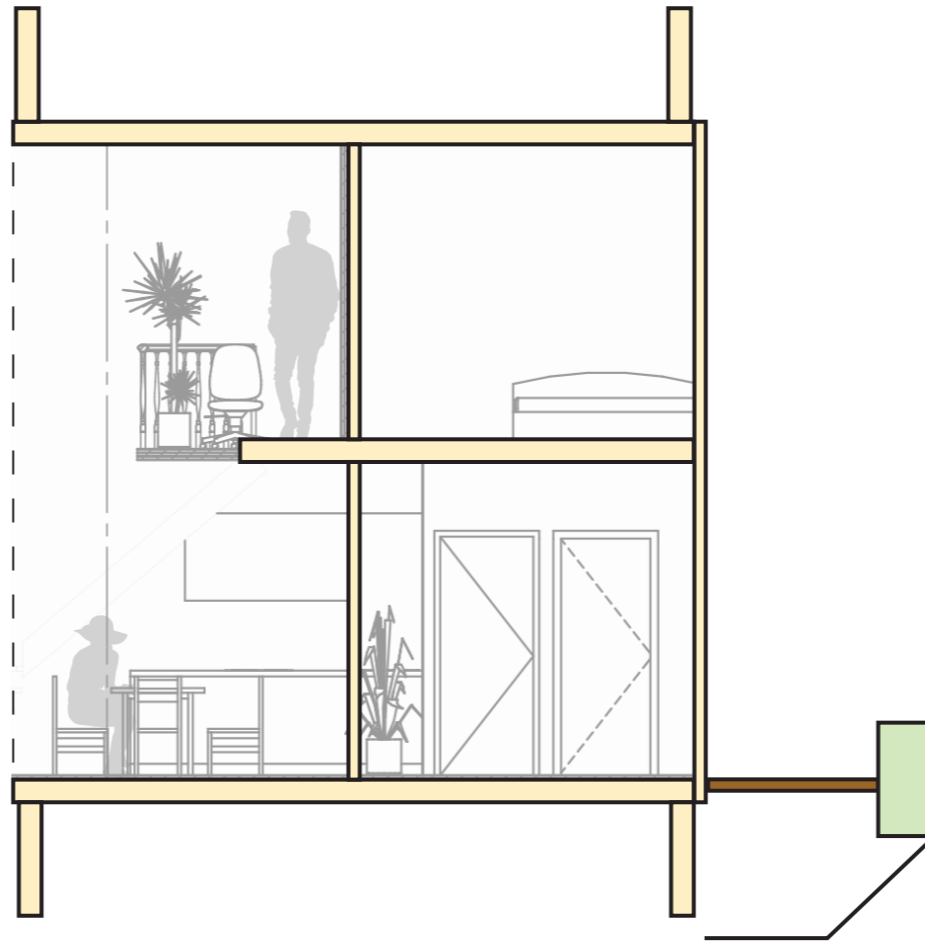


Plan view

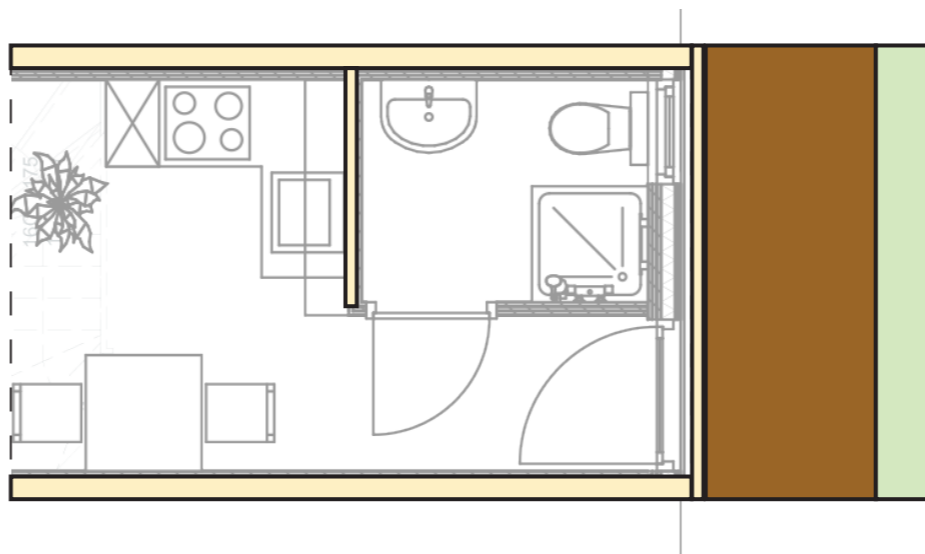


# Structure

## Raised Street



Section view

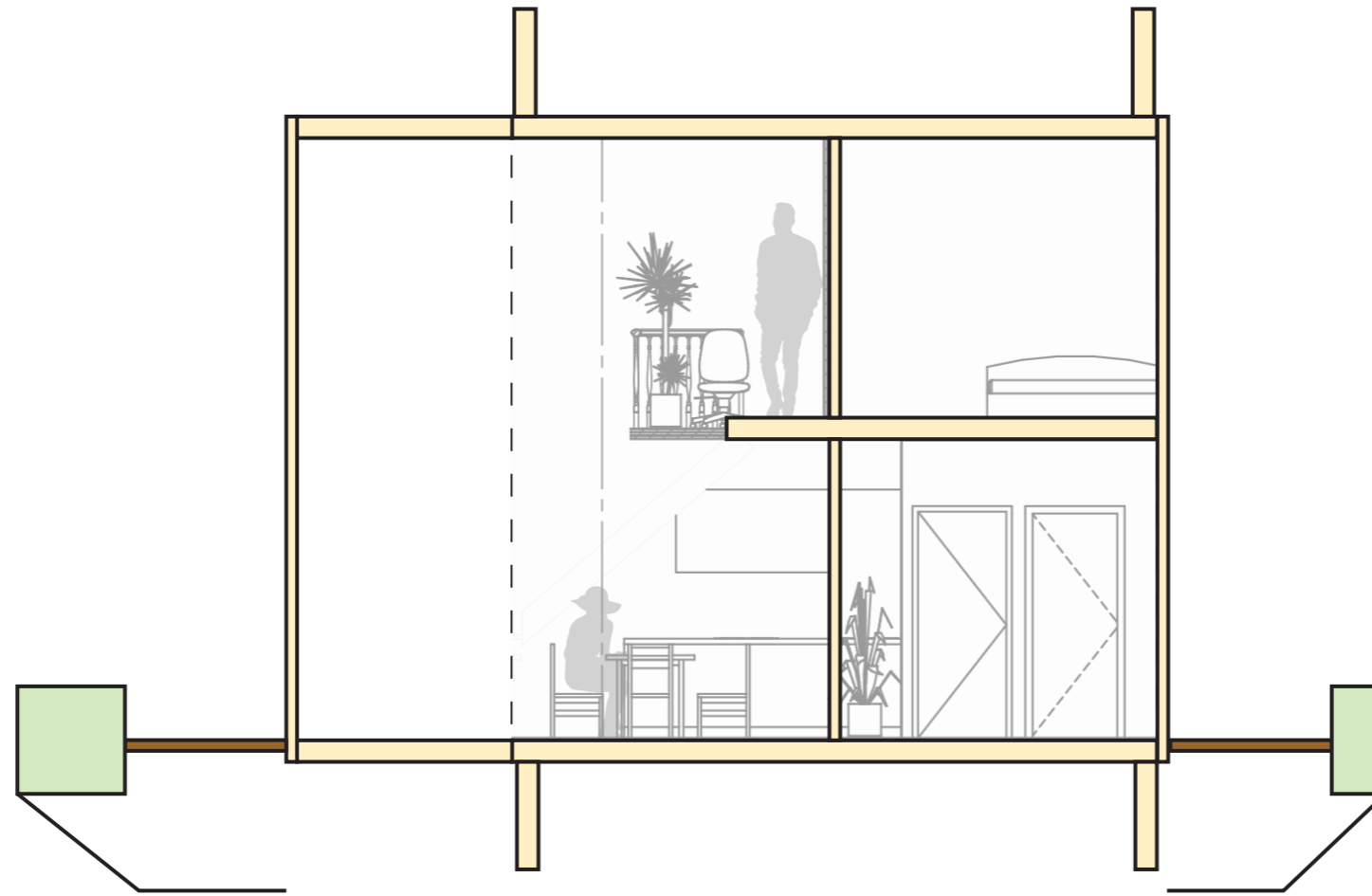


Plan view

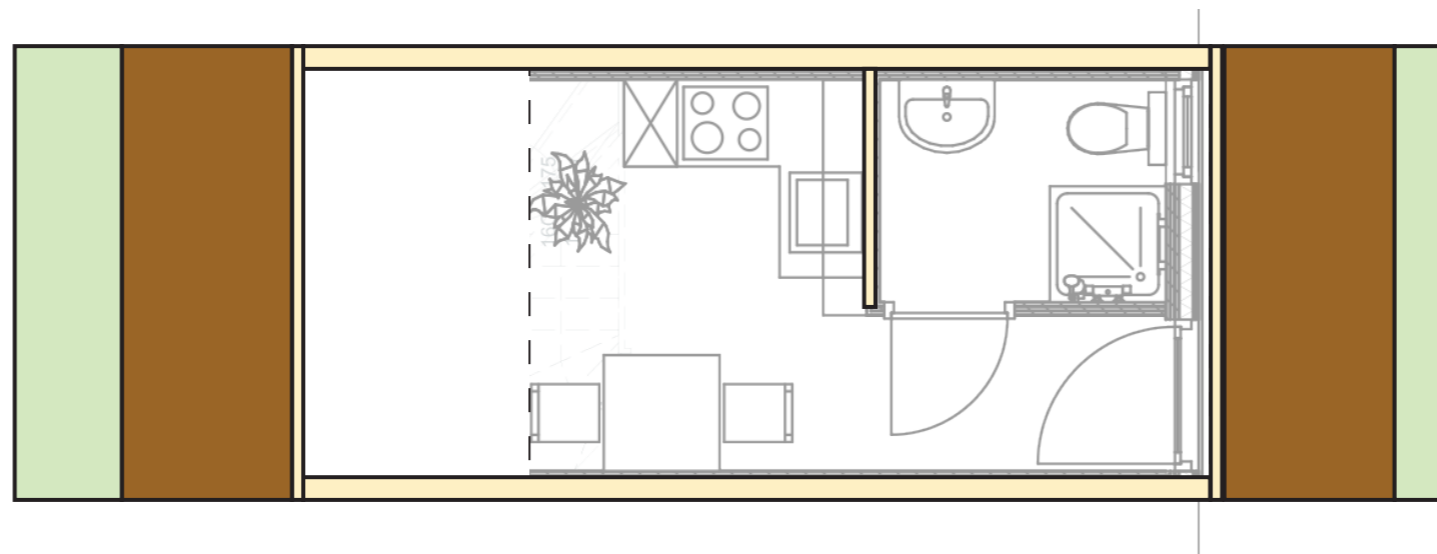


# Structure

## Extension and Private Garden



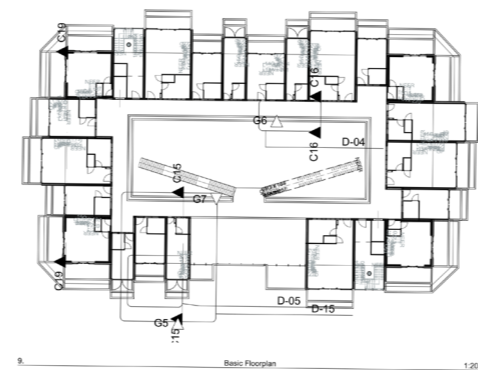
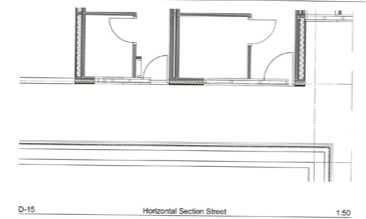
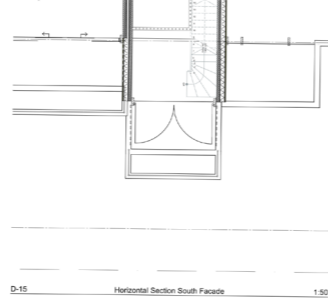
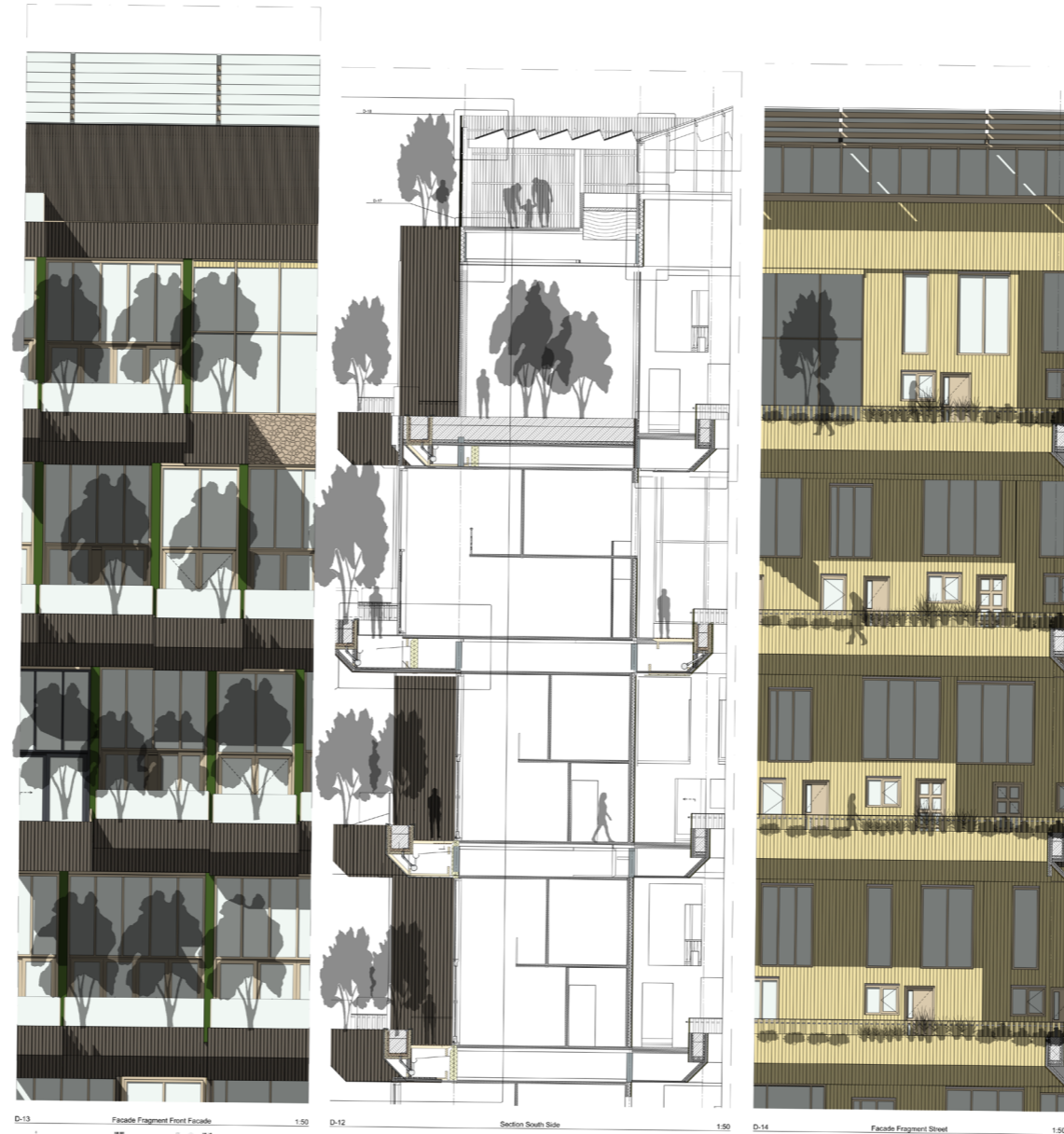
Section view

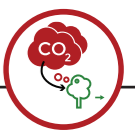
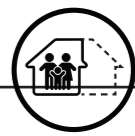


Plan view

# Fragment

## Facade section and frangment 1:50

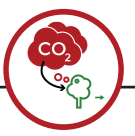
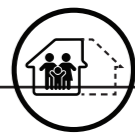




# Urban Plan

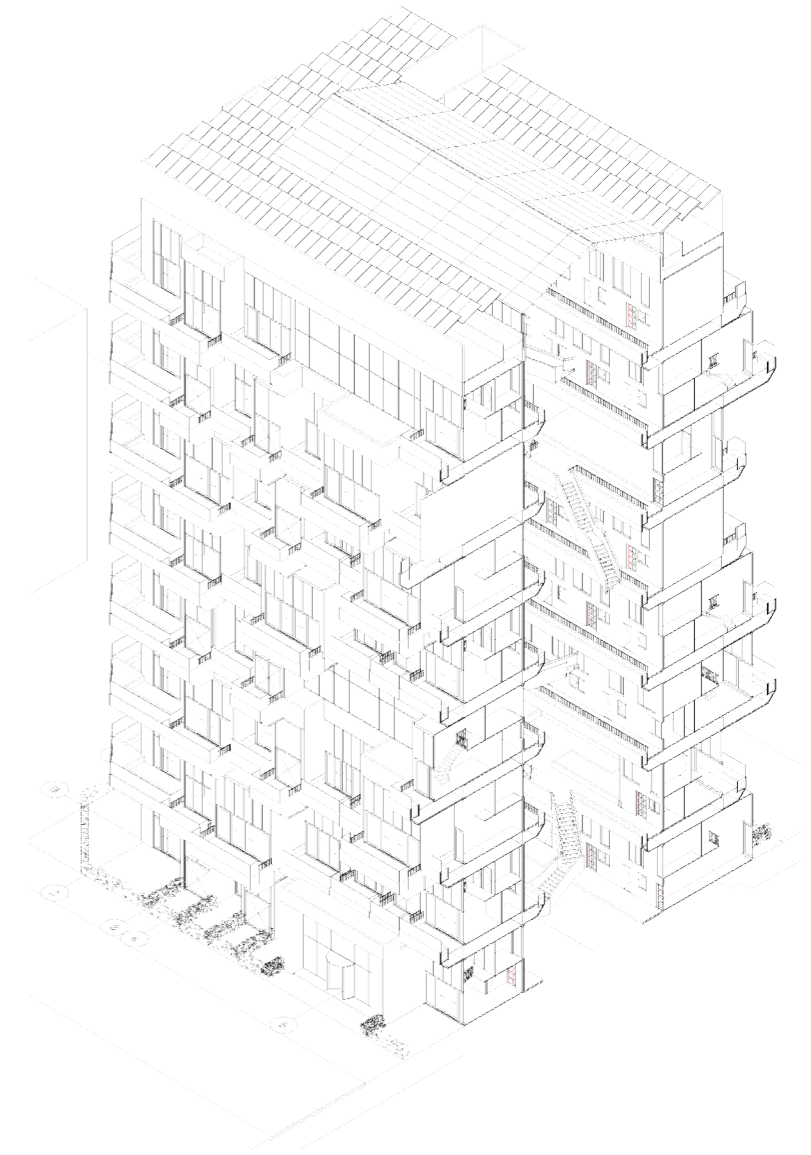
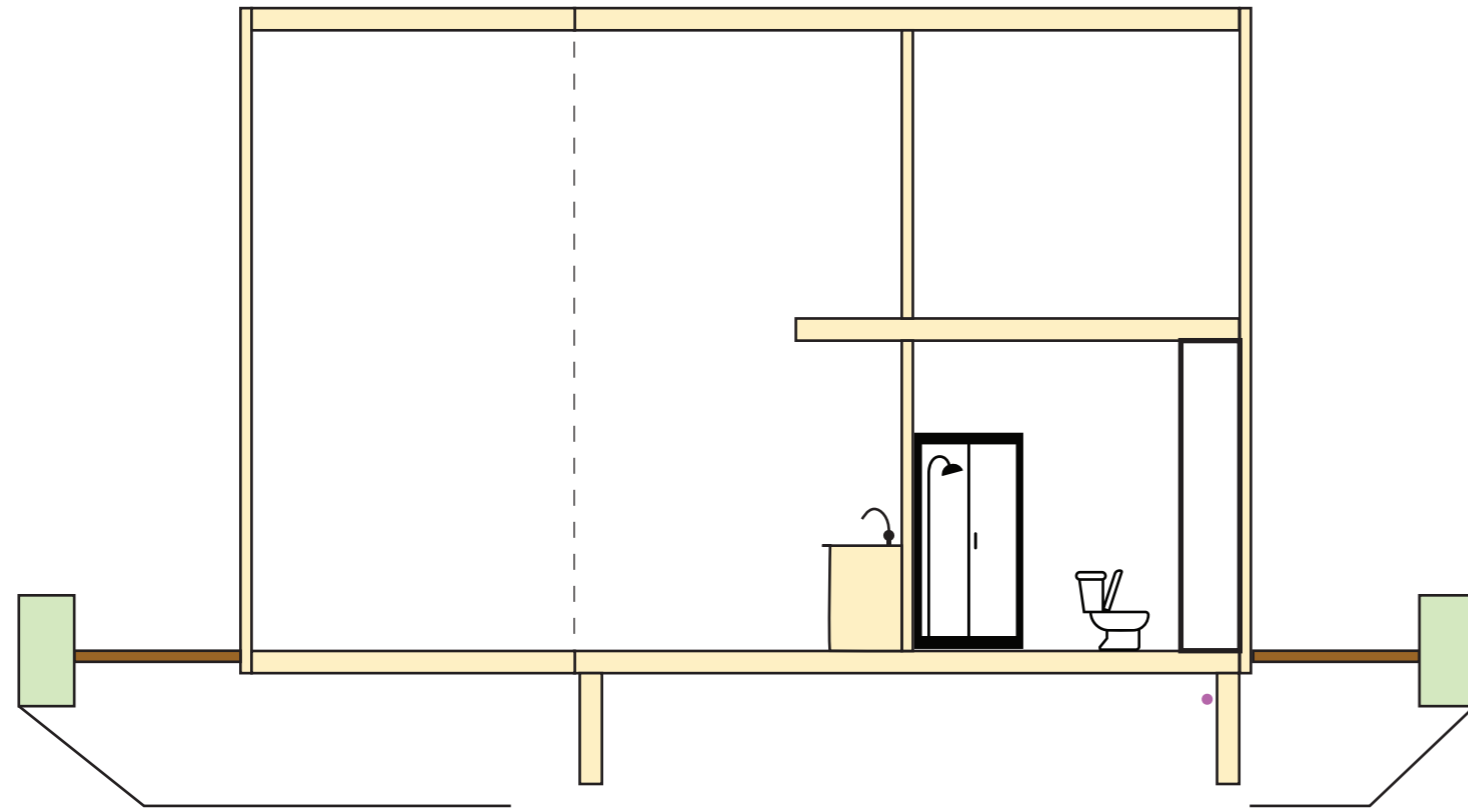
1:2000 A0

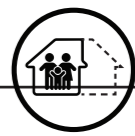




# Climate Systems

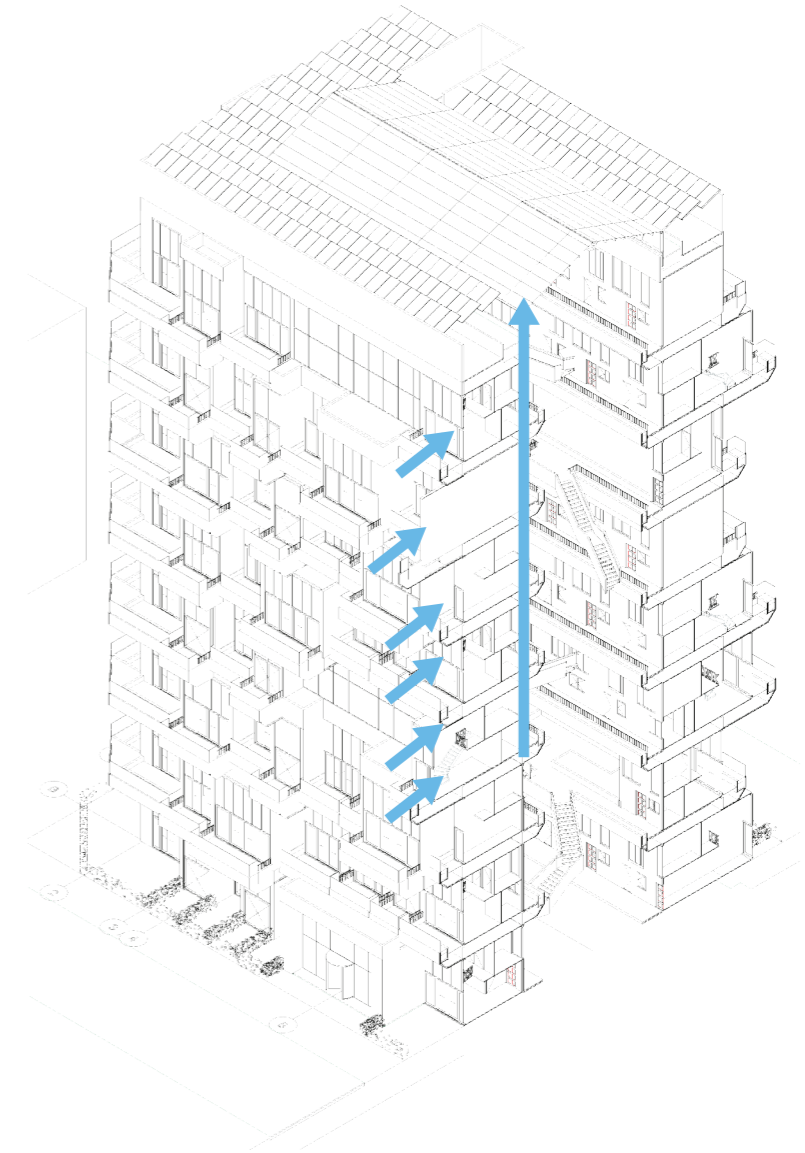
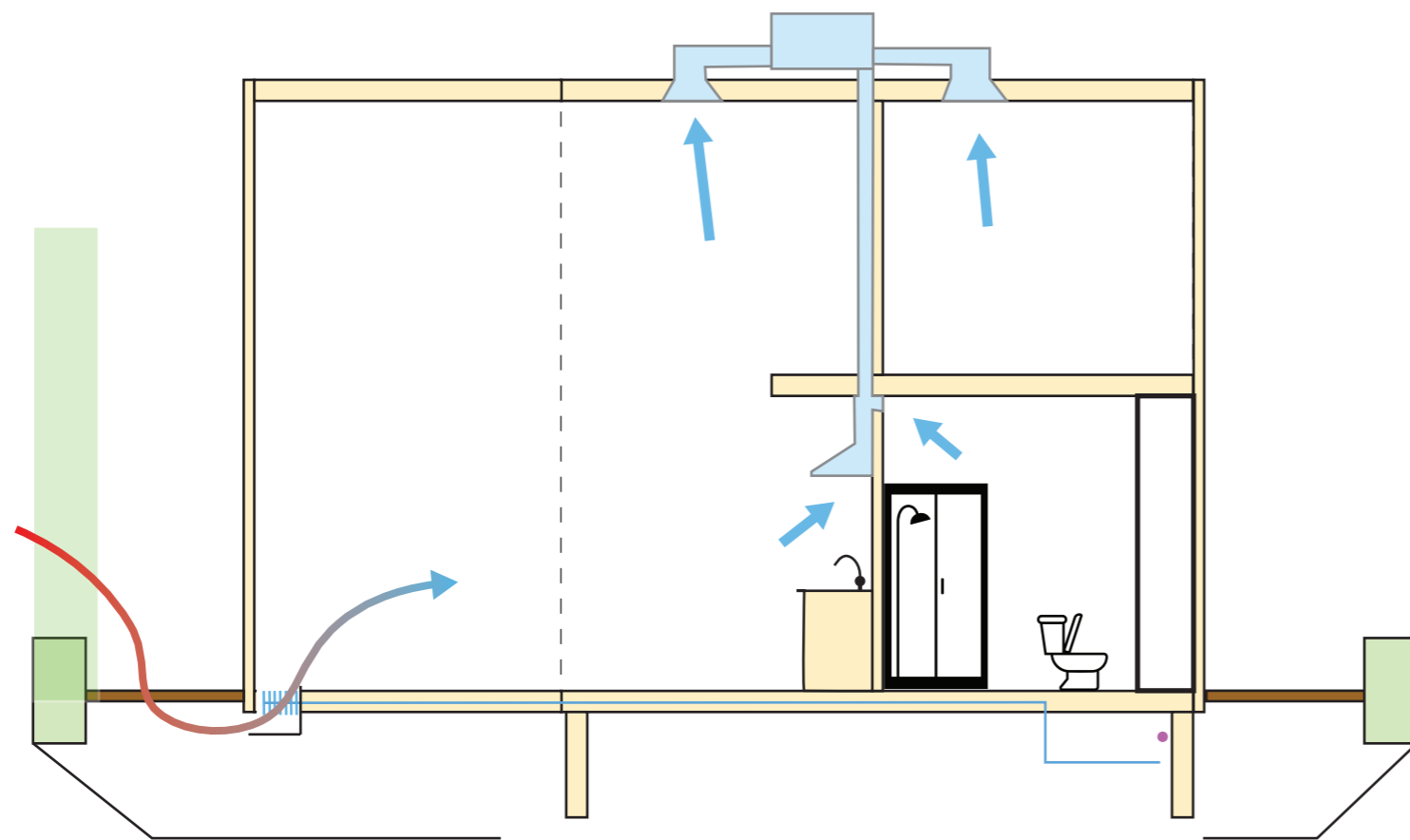
## Schematic Section

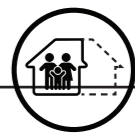




# Climate Systems

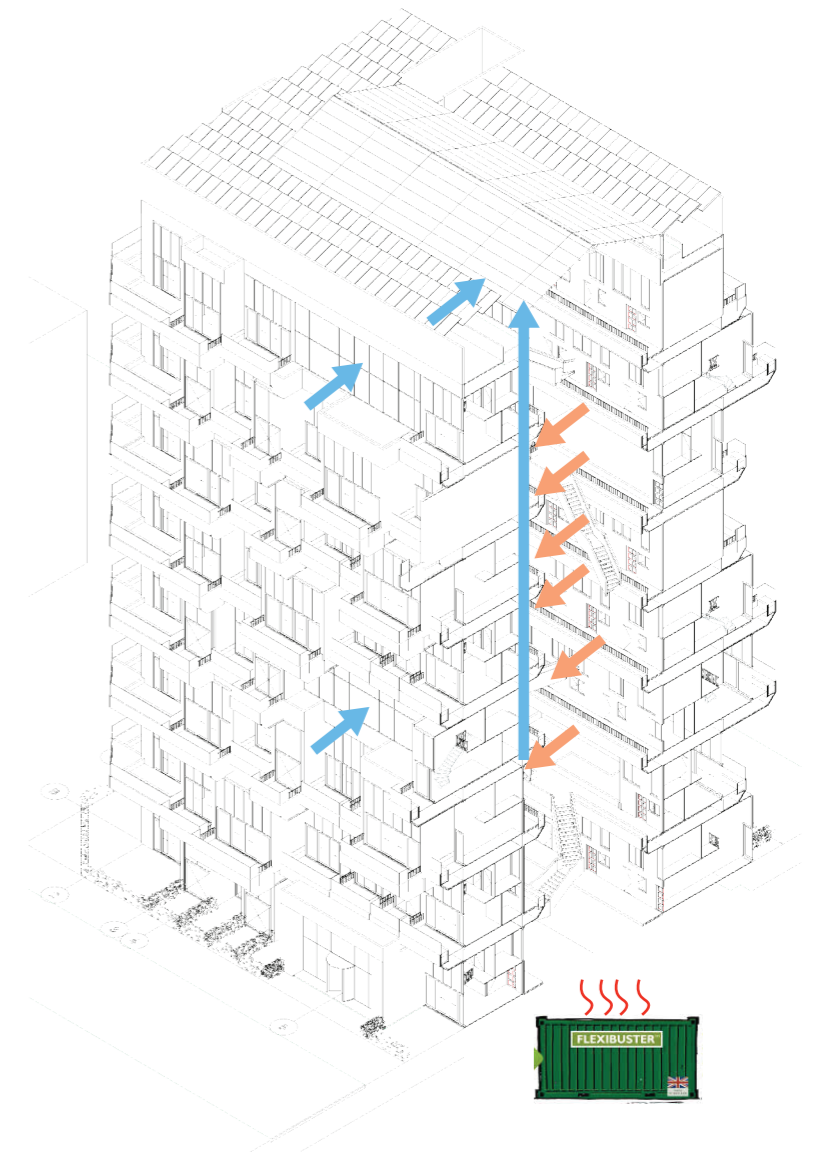
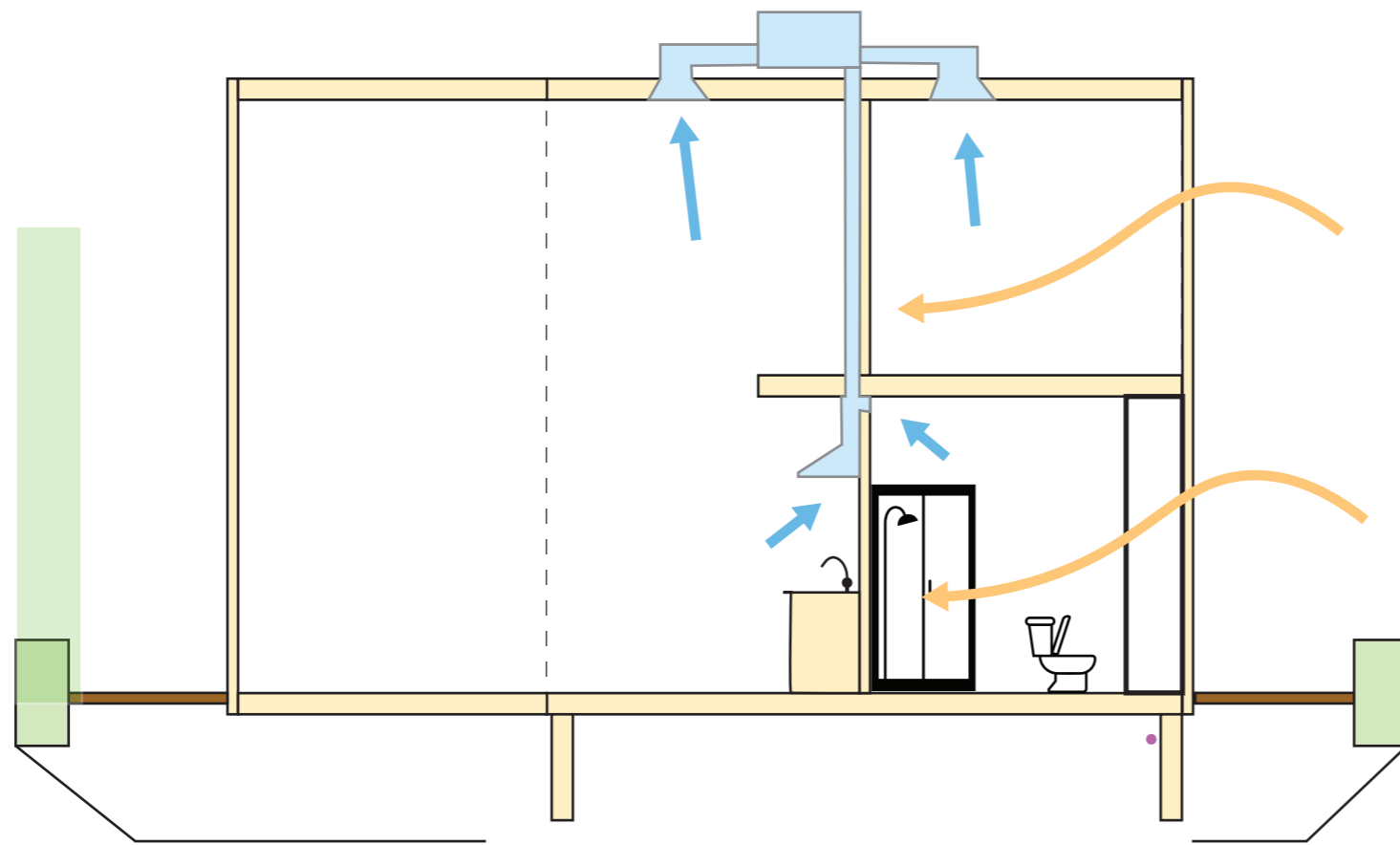
## Ventilation Summer

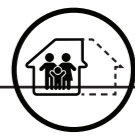




# Climate Systems

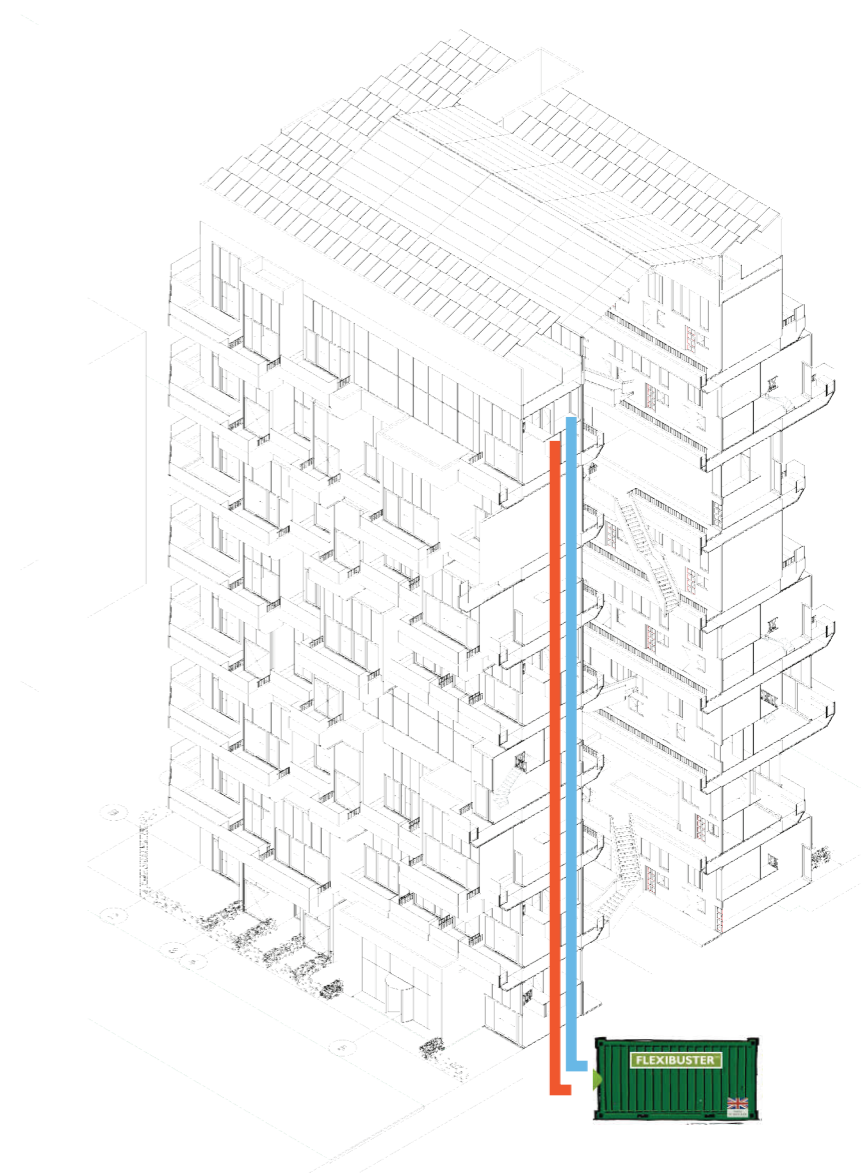
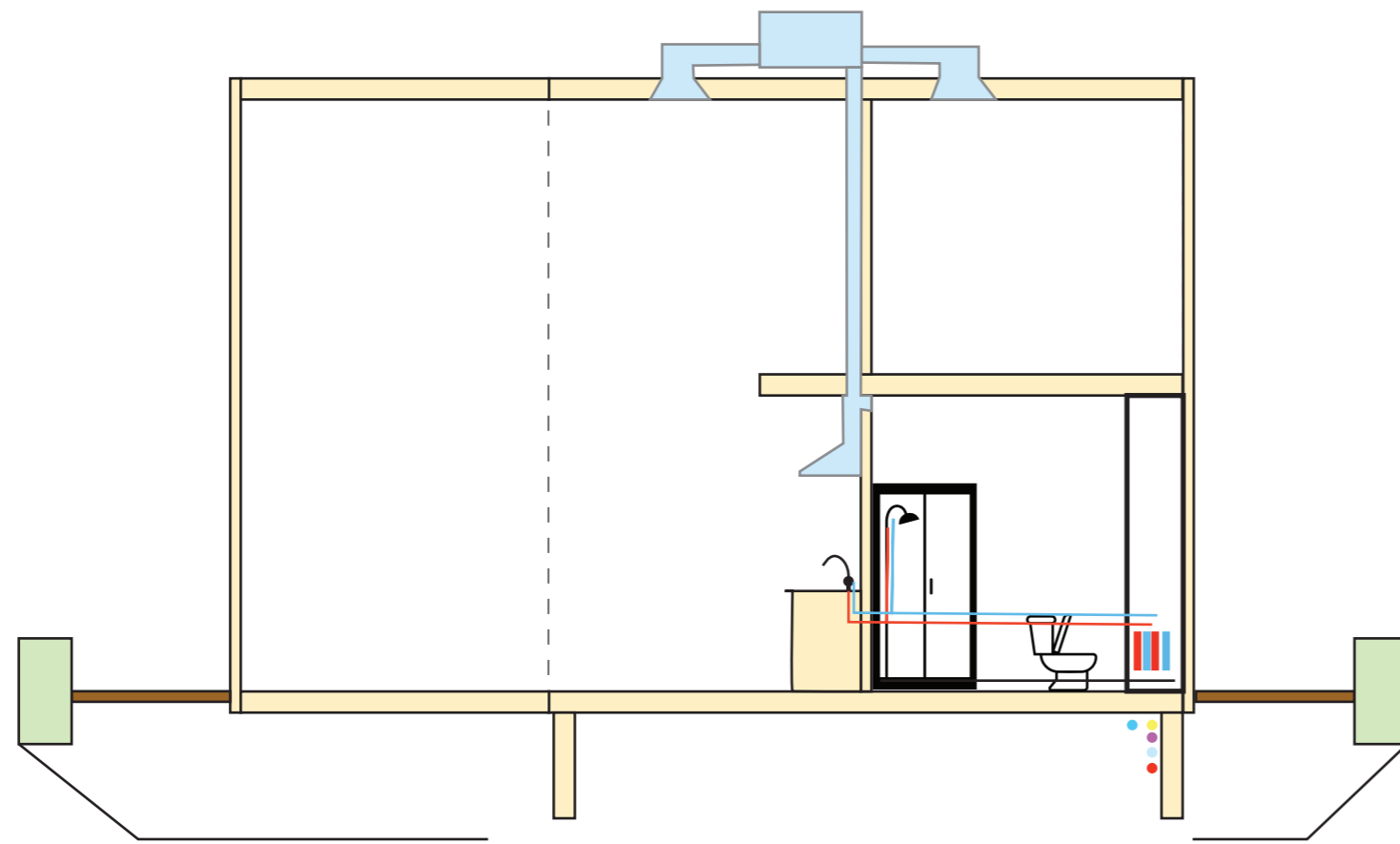
## Ventilation Winter

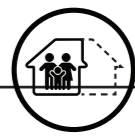




# Climate Systems

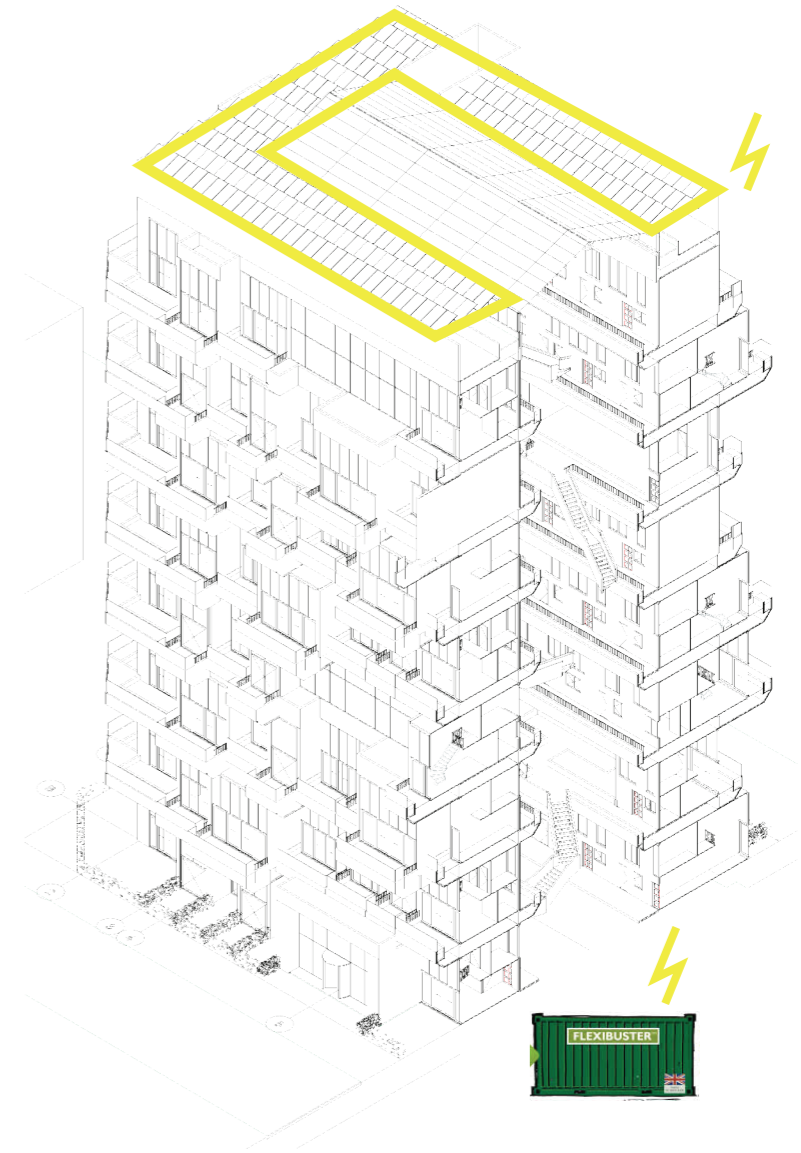
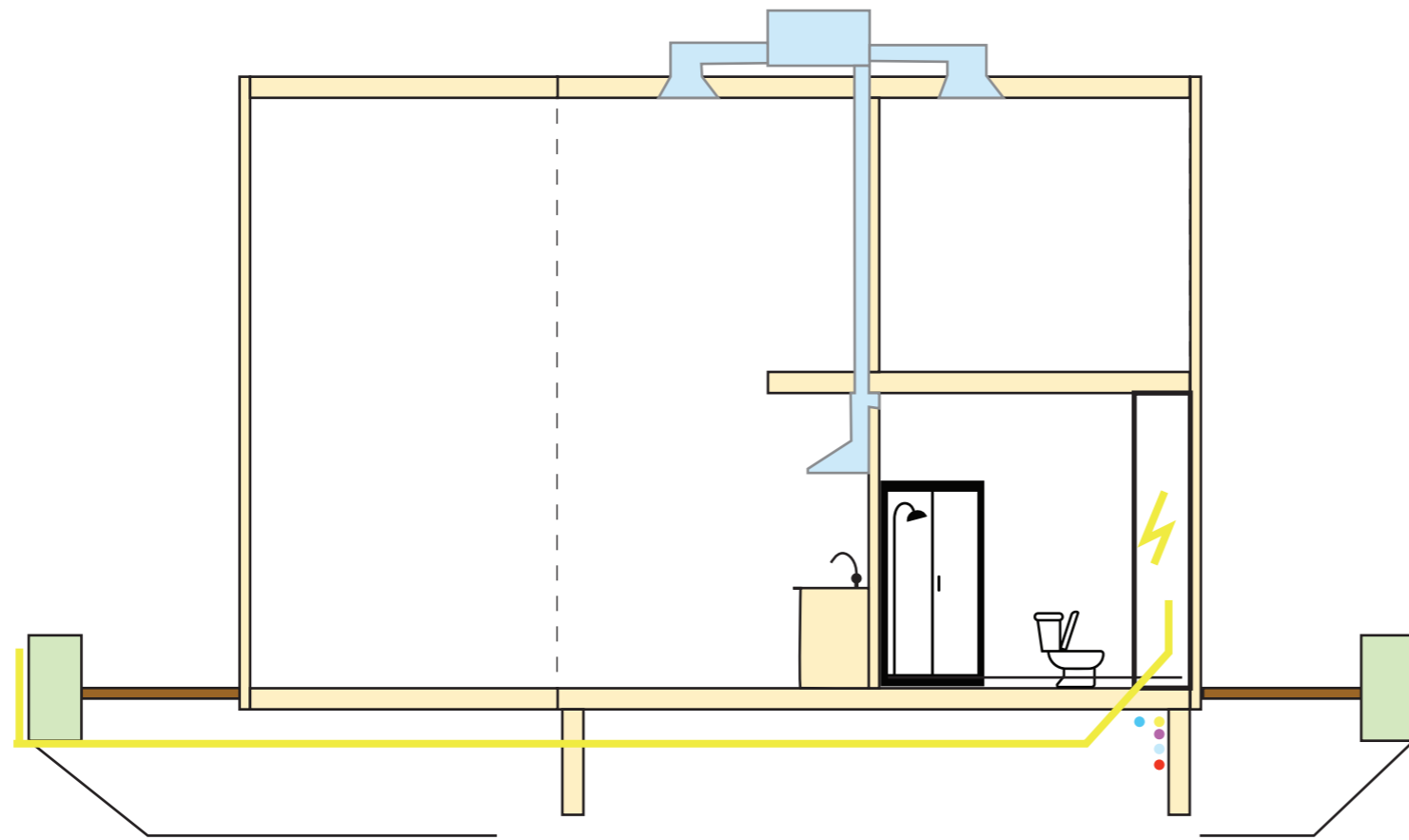
## Hot water

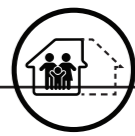




# Climate Systems

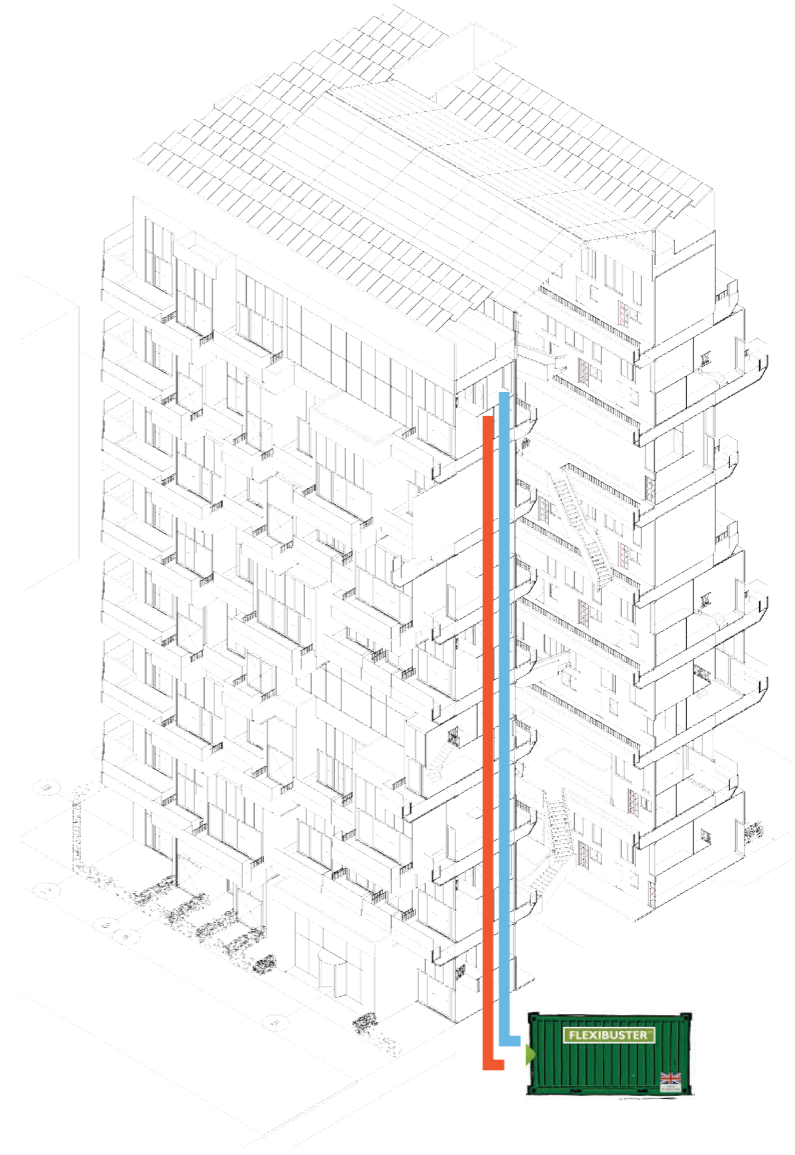
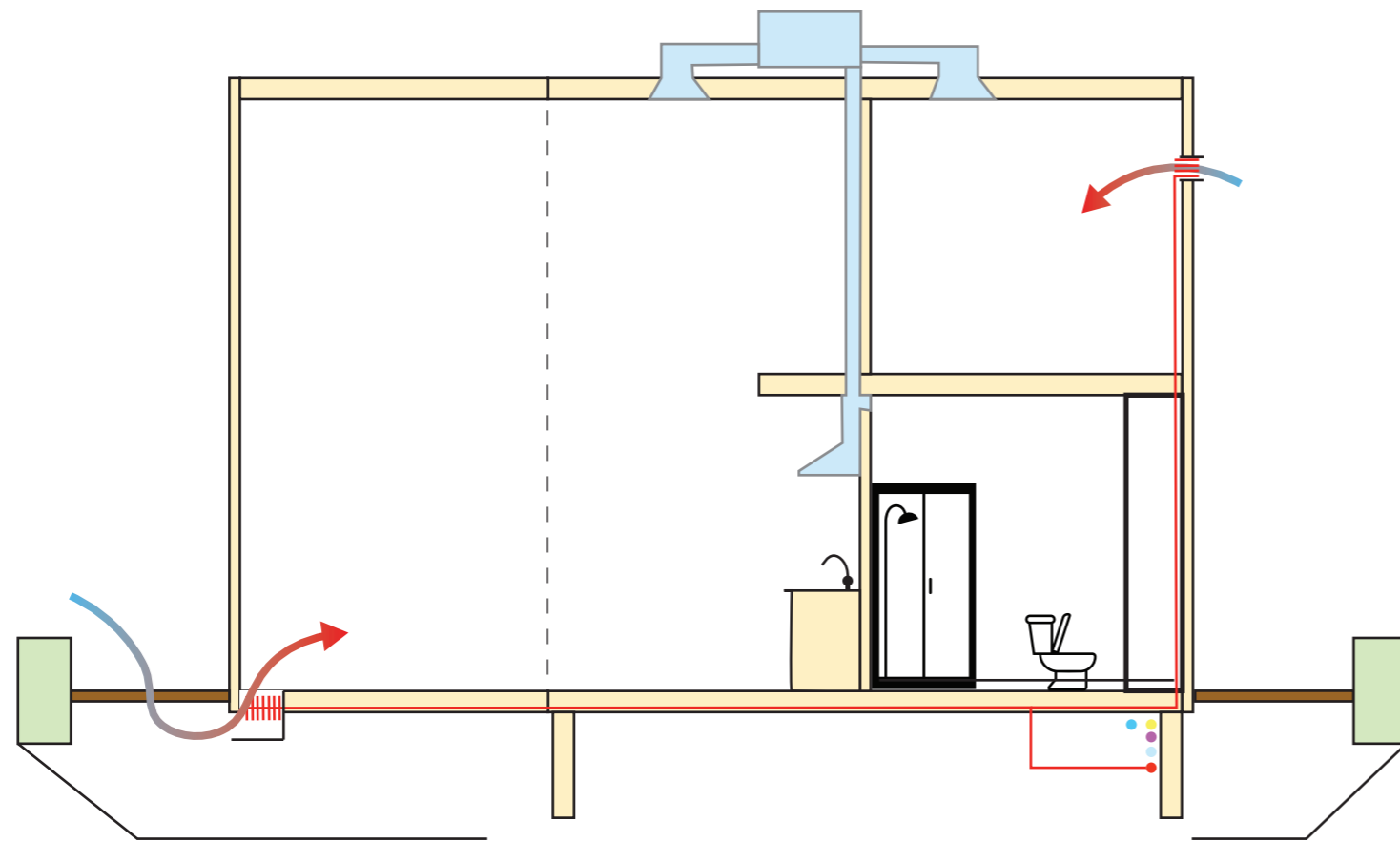
## Electricity

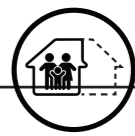




# Climate Systems

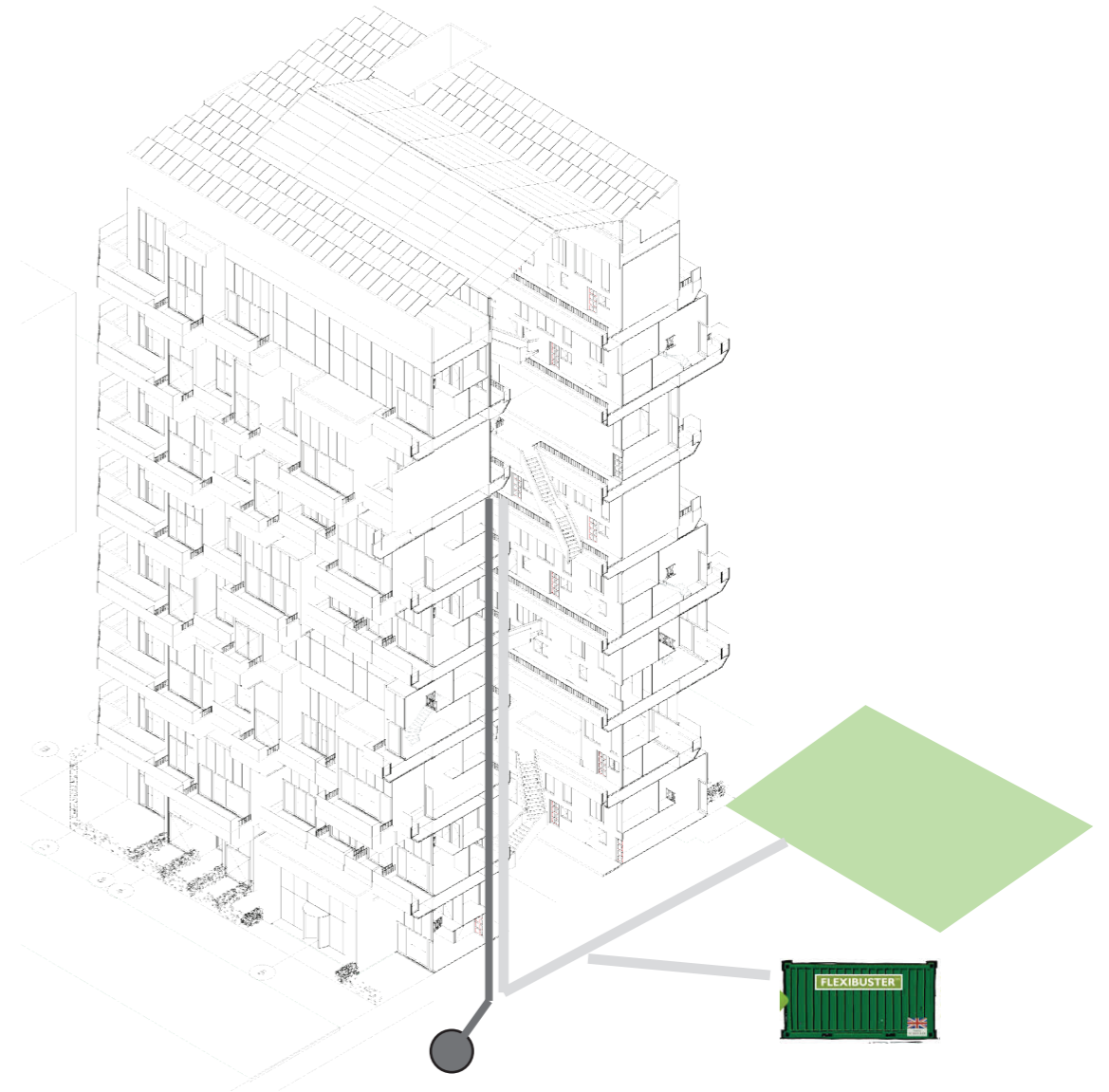
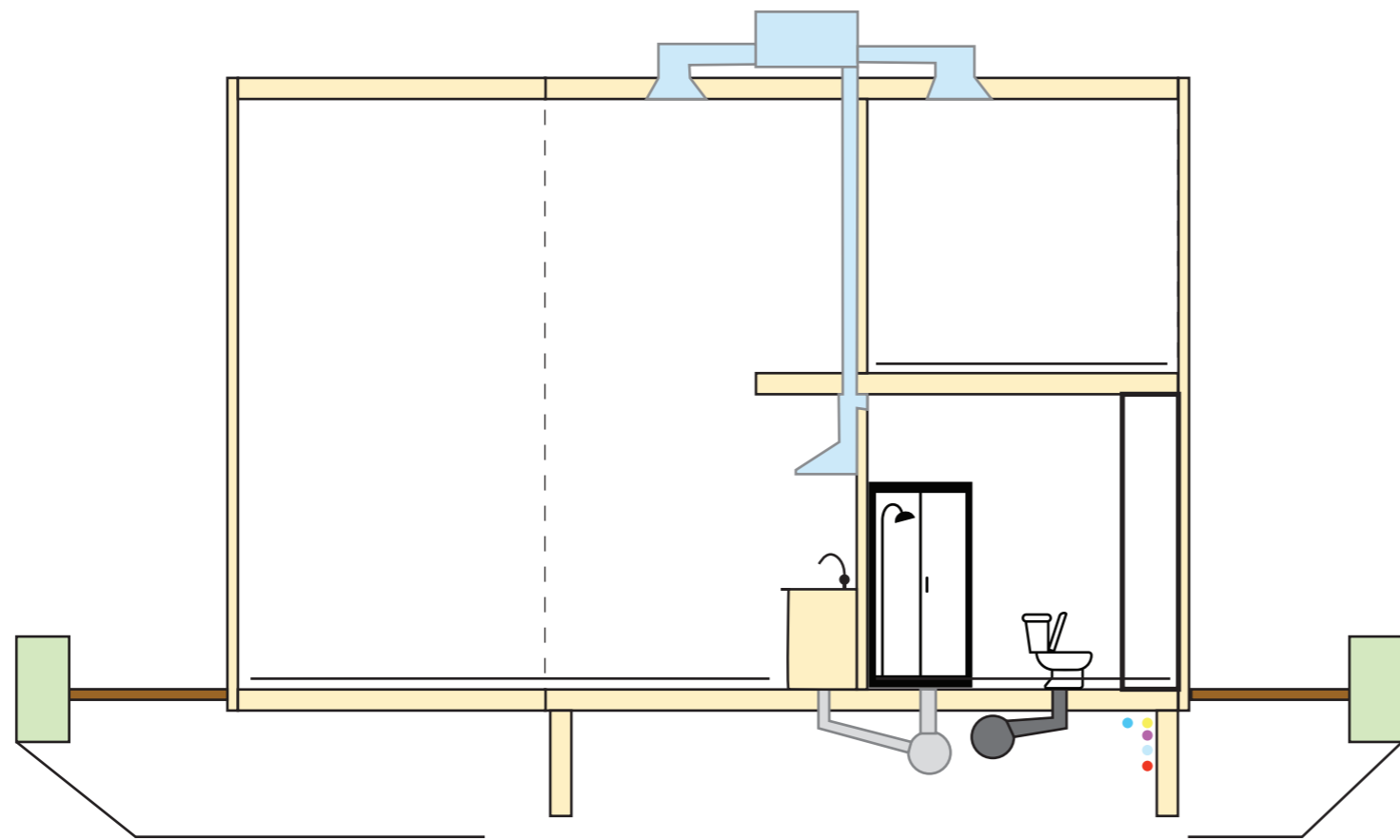
## heating system

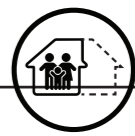




# Climate Systems

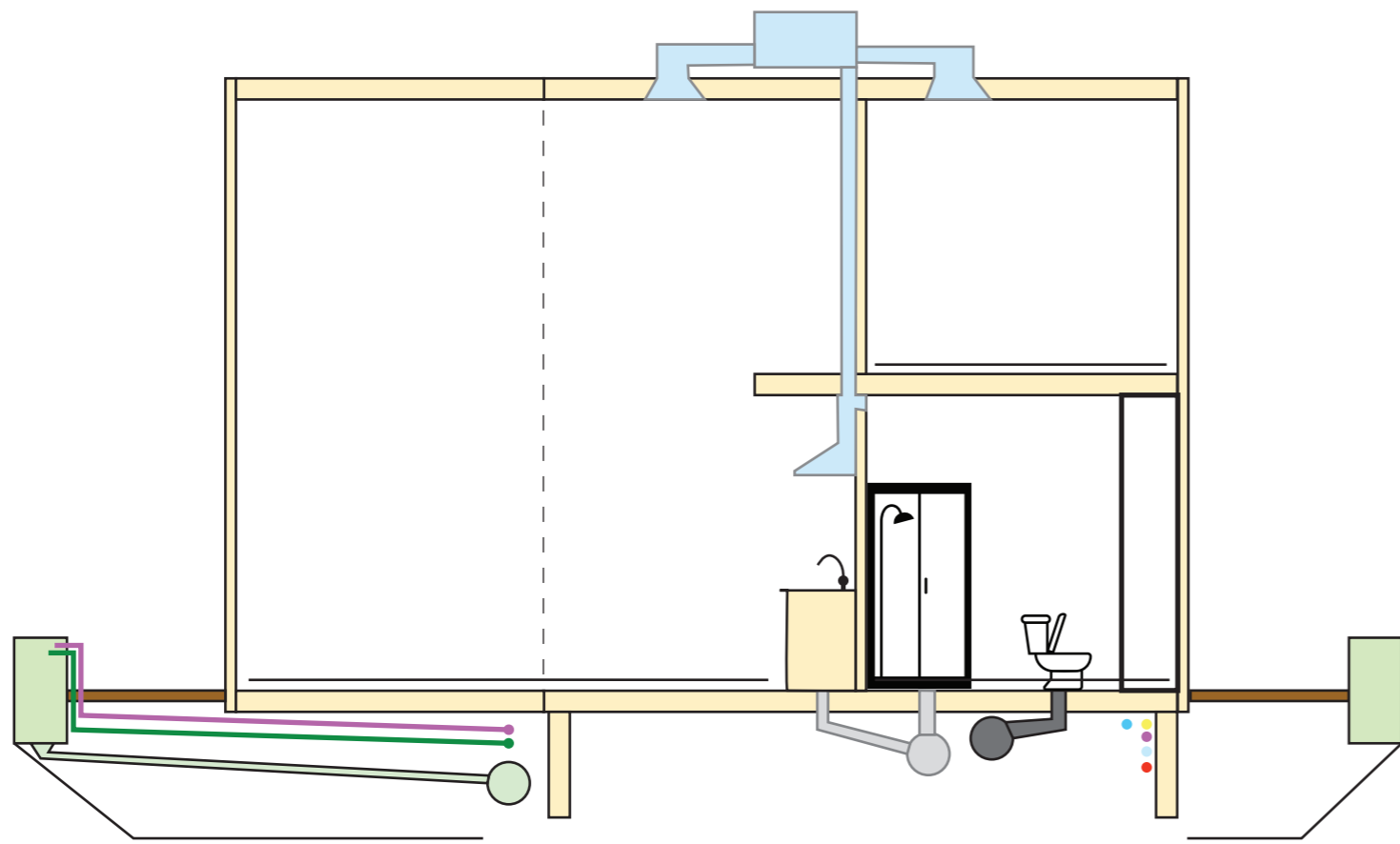
## Sewage





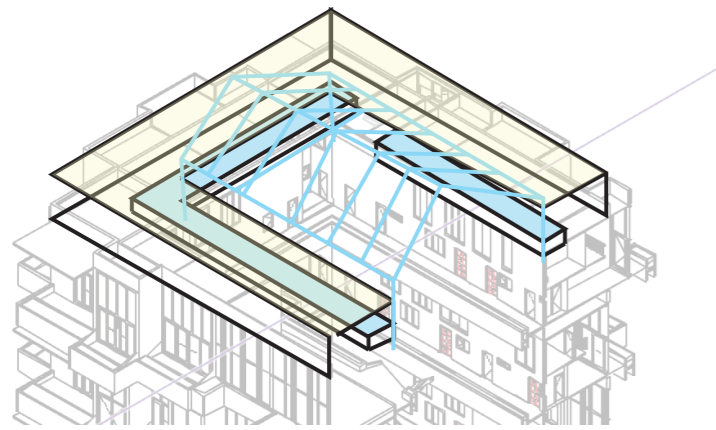
# Climate Systems

## Irrigation



# Climate Systems

## Water Systems



192m<sup>3</sup> water storage

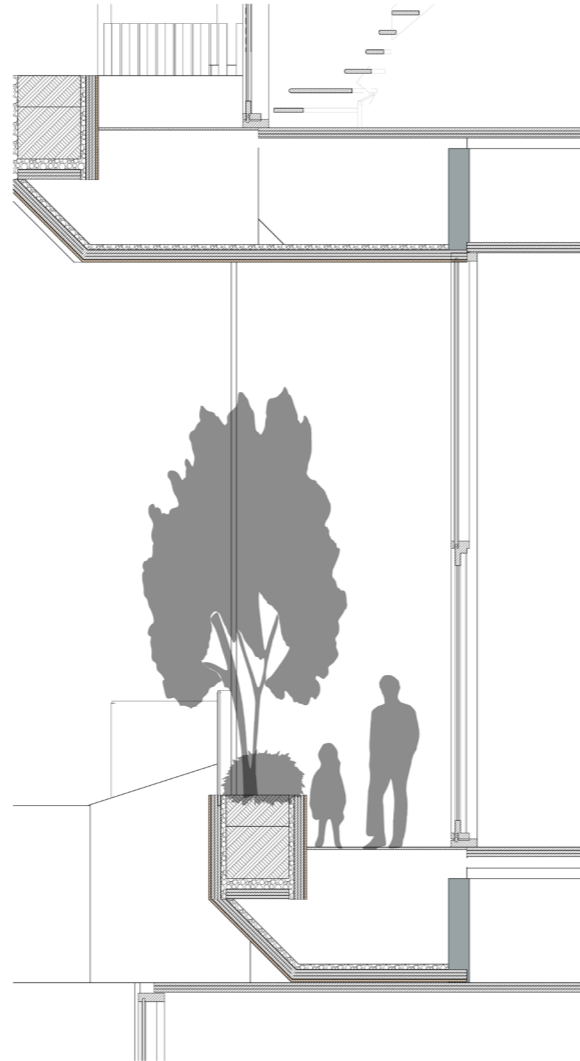


# Facade Fragment

1:20 Fasade Fragment outside facade and gallery facade



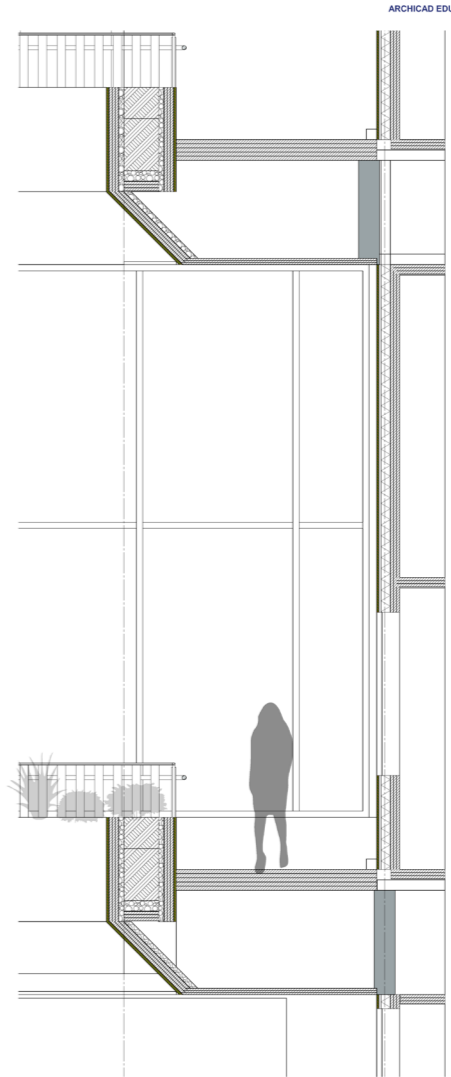
D-06 Facade Fragment South Facade 1:20



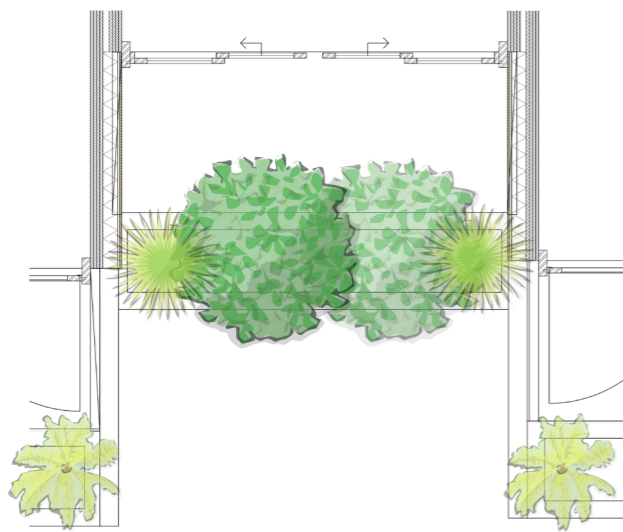
C15 Section South Facade 1:20



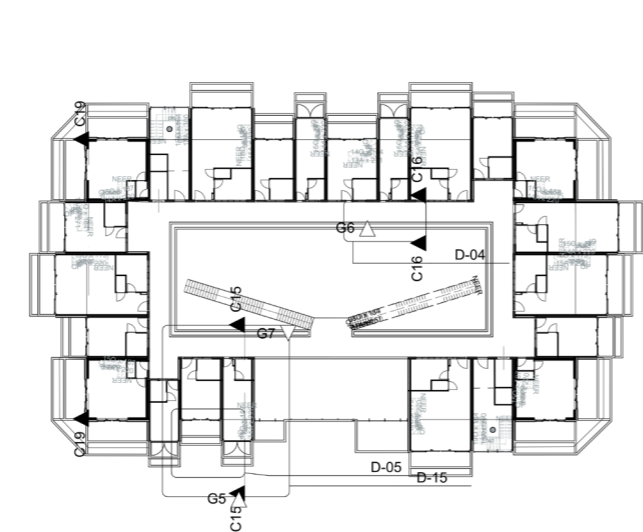
D-07 Gallery Facade Fragment 1:20



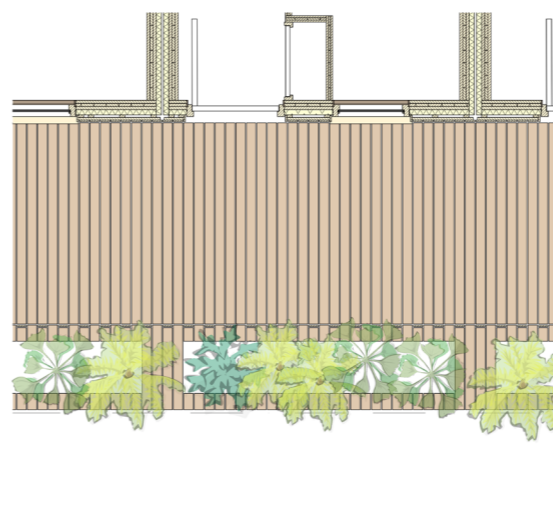
C16 Section Gallery Facade 1:20



D-05 Horizontal Section South Facade 1:20

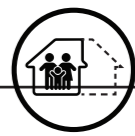


9. Basic Floorplan 1:20



D-04 Horizontal Section Gallery Facade 1:20

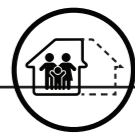
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# Route through the building

Perspective view of route

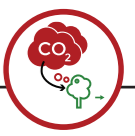
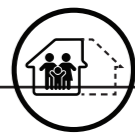




# Garden route trough building

## Route Section

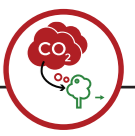
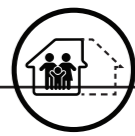




# Route through the building

Photo of route in model

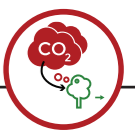
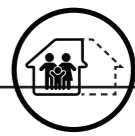




# Garden Route Trough Building

## Impression Entrance





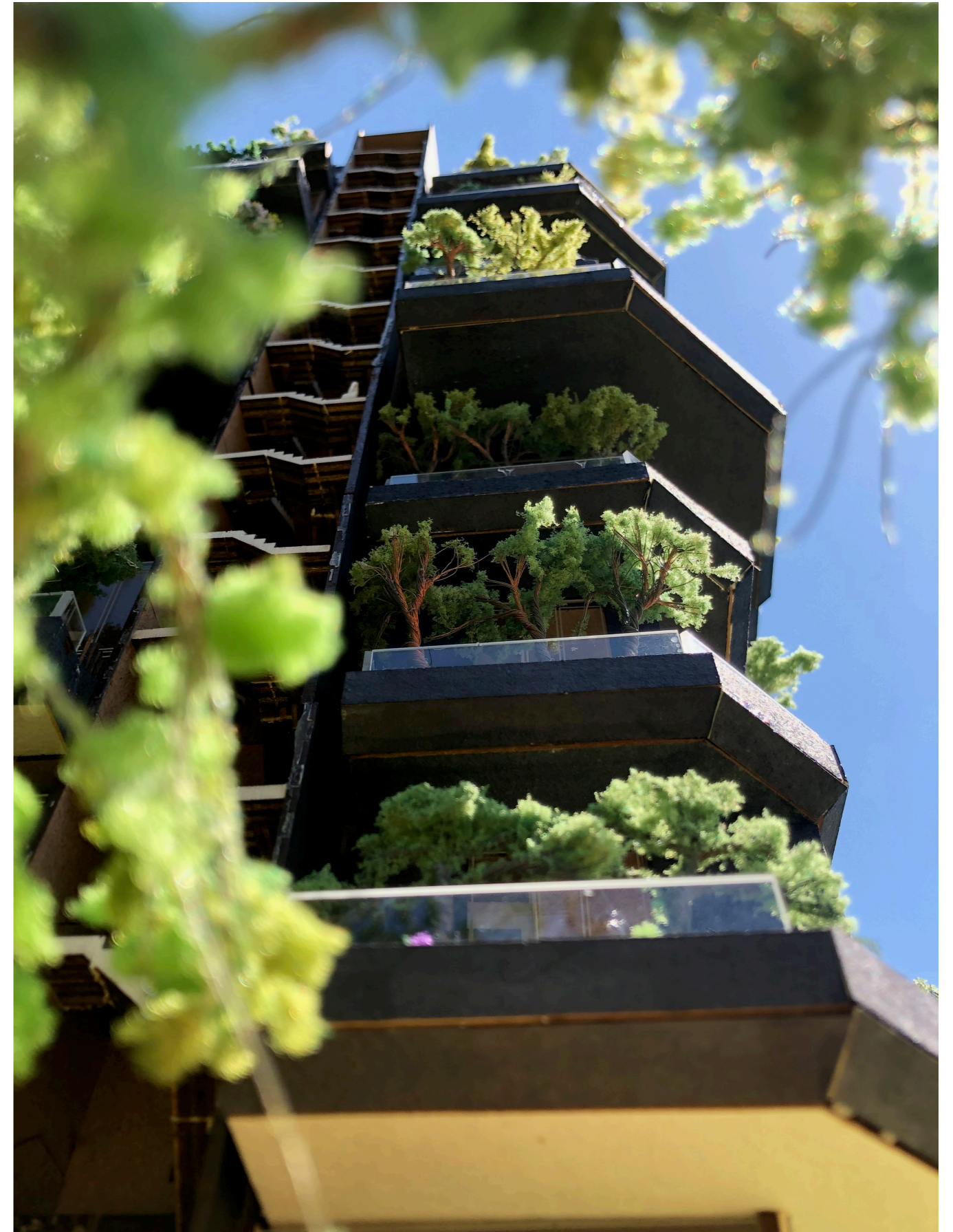
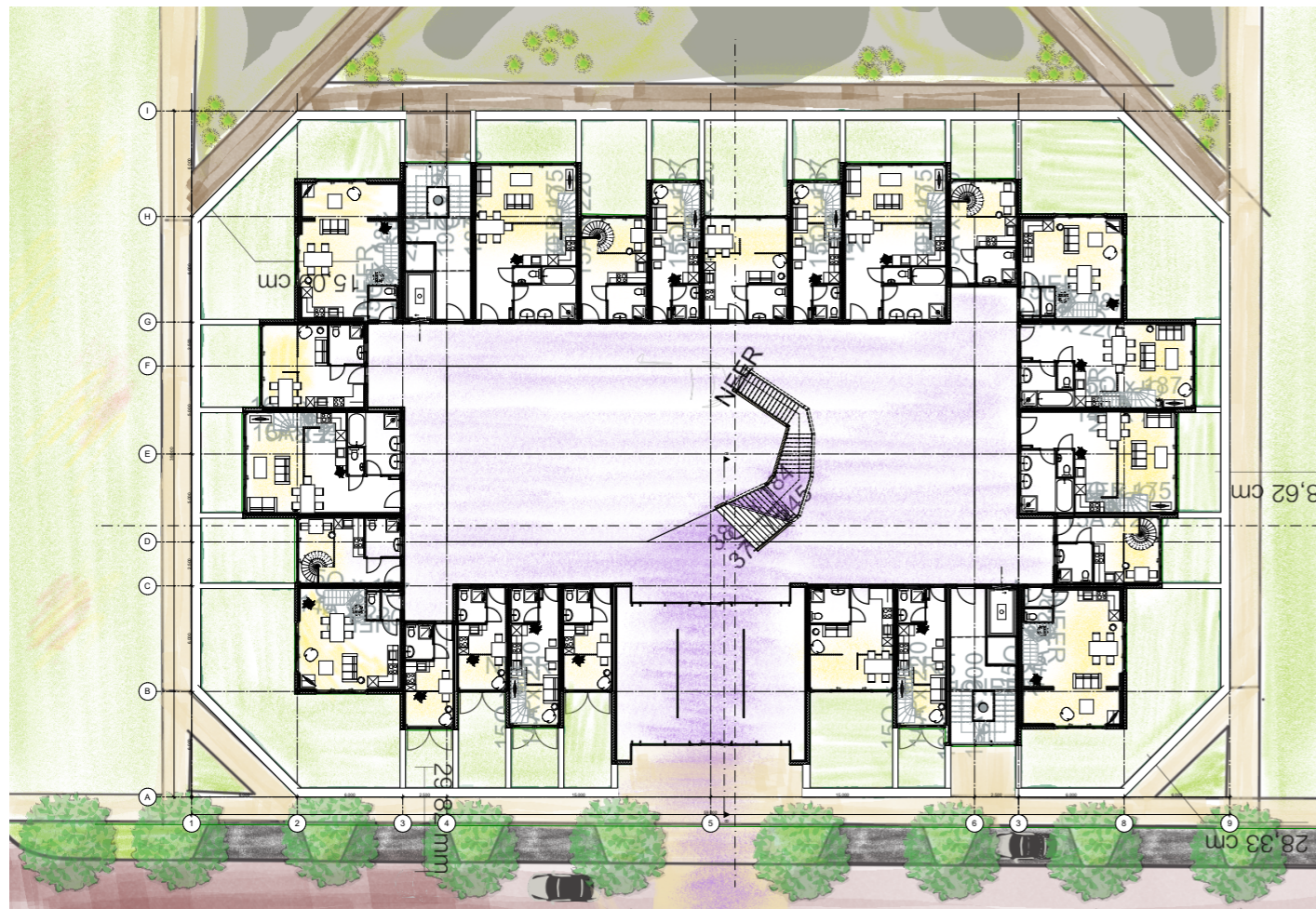
# Route Trough Building

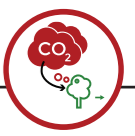
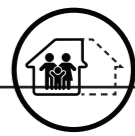
## Ground Floor



# Garden Route Trough Building

## Ground floorplan staircase northern Facade

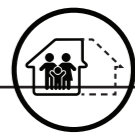




# Garden Route Trough Building

## Second floor North facing Garden

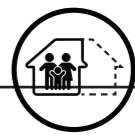




# Garden Route Trough Building

View from 14th floor inside

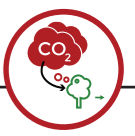
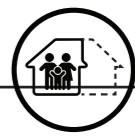




# Garden Route Trough Building

West-facing gardens at sunset

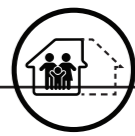




# Garden Route Trough Building

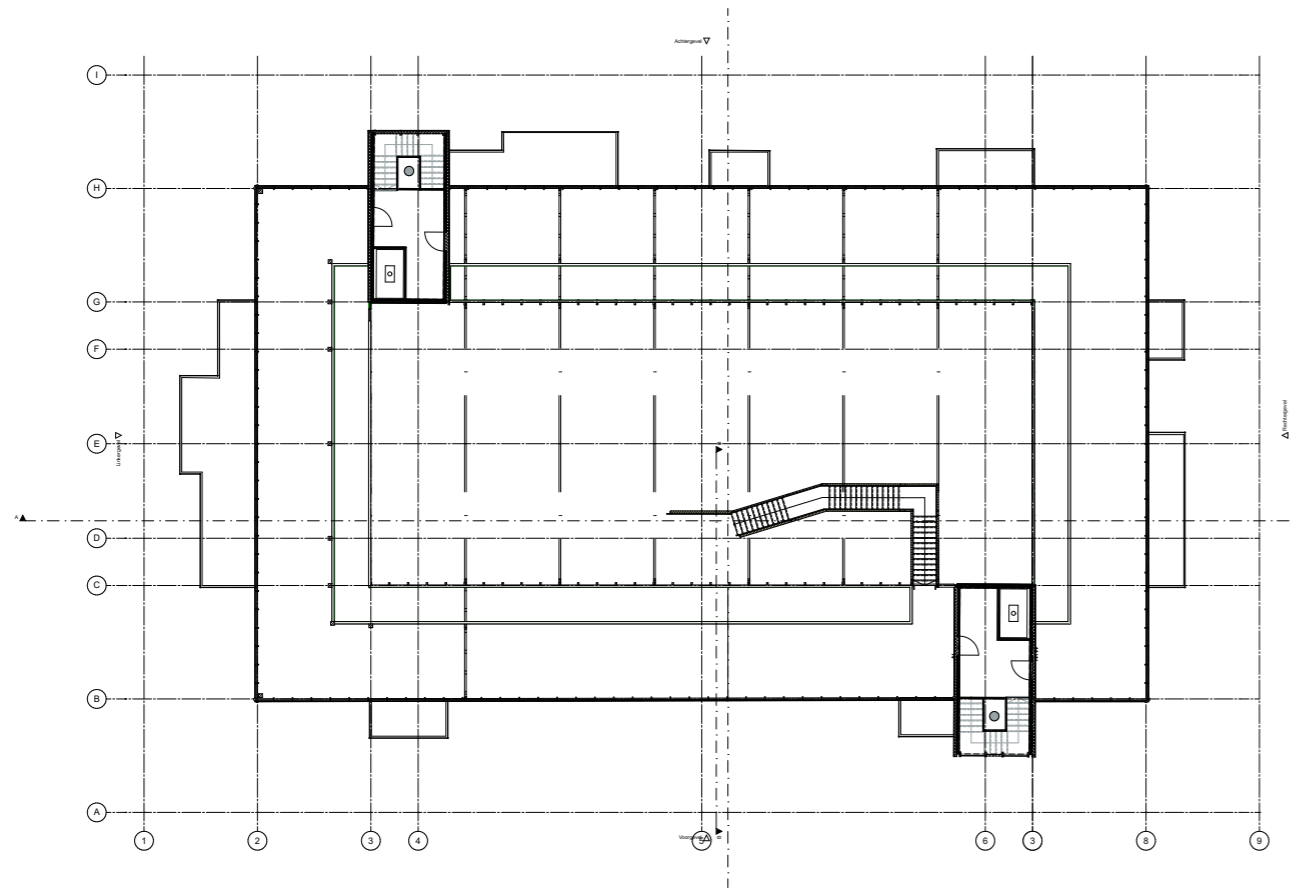
## Route to Roof terrace





# Garden Route Trough Building

## Roof Plan

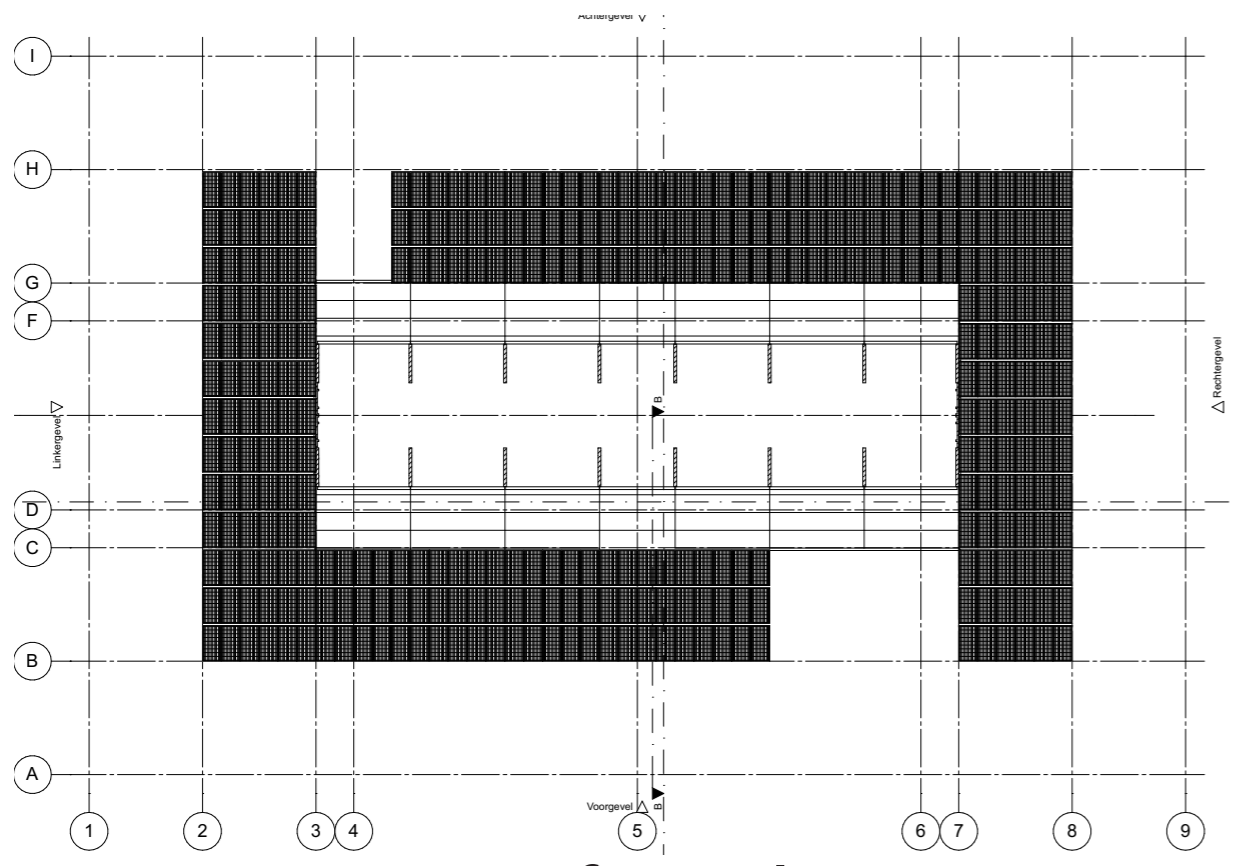


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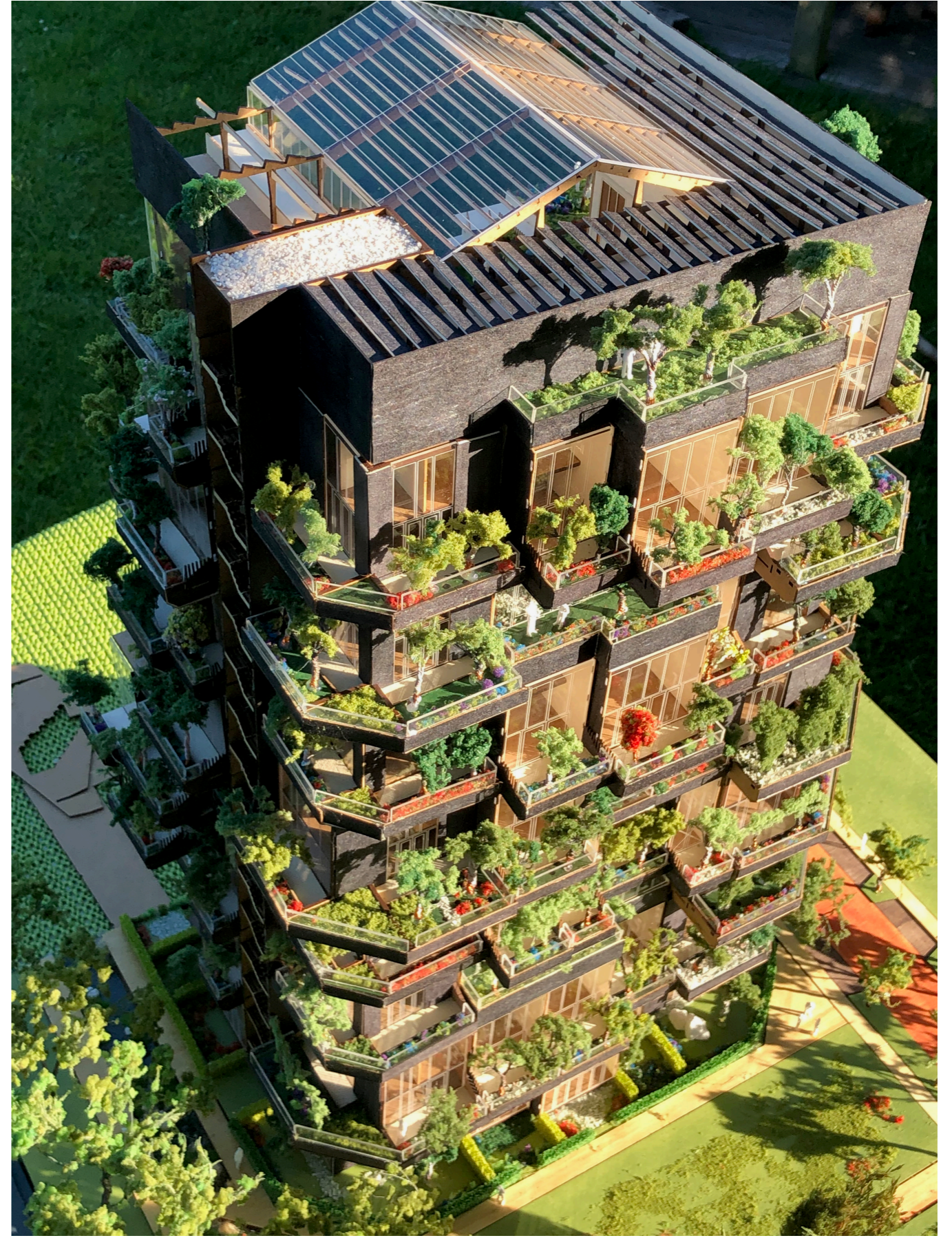


# Garden Route Trough Building

## View from roof terrace



Rooftop Plan



# Vertical Garden-City

Designing a green living environment  
in the centre of Amsterdam

