

# P5 | Solarpolis

Climate adaptive living

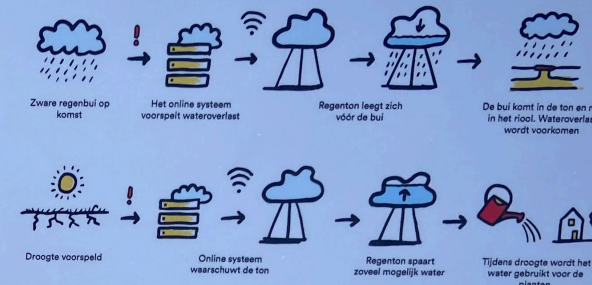
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AR3AE100 | Architectural Engineering Graduation Studio

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Building Technology Tutor | Paddy Tomesen  
Research Tutor | Christien Janssen

## DE SLIMME REGENTON

Werken aan het klimaat is vaak zo suf. Saai. We mogen dit niet of moeten dat. **Cloiq** heeft daar iets unieks op bedacht: een slimme regenton in de vorm van een wolk. Bij elkaar gespaard met ingezameld plastic en 3D geprint tot een wolk van een regenton. Deze reguleert op eigen houtje het ultieme waterpeil. Via internet leest ze het weerbericht en leegt zichzelf voor de hoosbui. In periodes van droogte gaat ze zelf regenen en bewatert zo de planten. Cloiq is opgericht door ontwerper Bas Sala en werkt samen met professionals en bewoners aan een toekomstbestendige, gezonde klimaatadaptieve stad.



This rain barrel shaped like a cloud is a solution from **Cloiq**. Recycled plastic is 3D printed into a cloud that regulates its own water level. Checking the weather report through the internet and emptying itself before a shower. During a drought she will start to rain and water the plants.



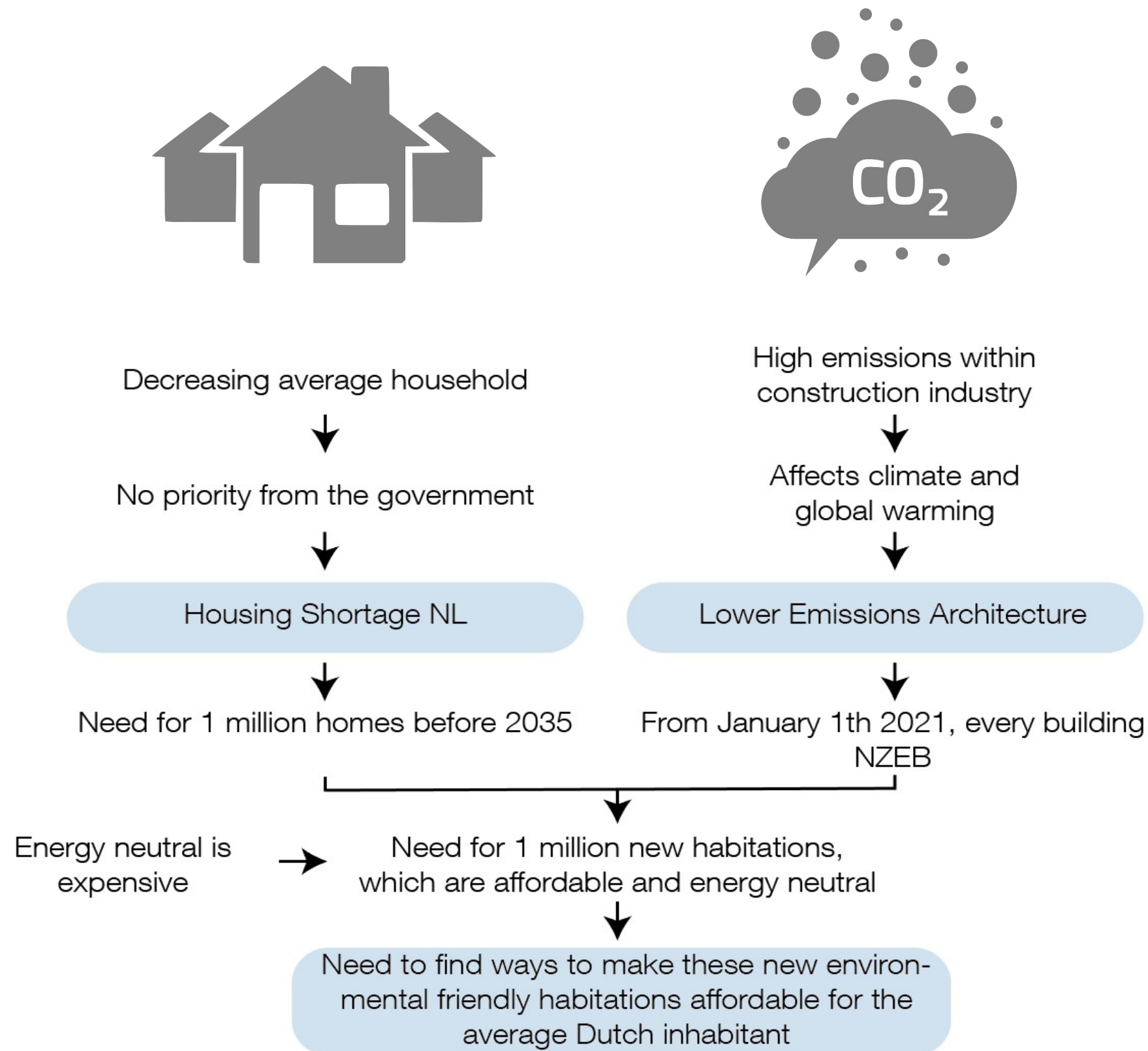
ROTTERDAM  
ROOFTOPWALK

PP PRINTERPRO.nl  
3D PRINTING IN ROTTERDAM

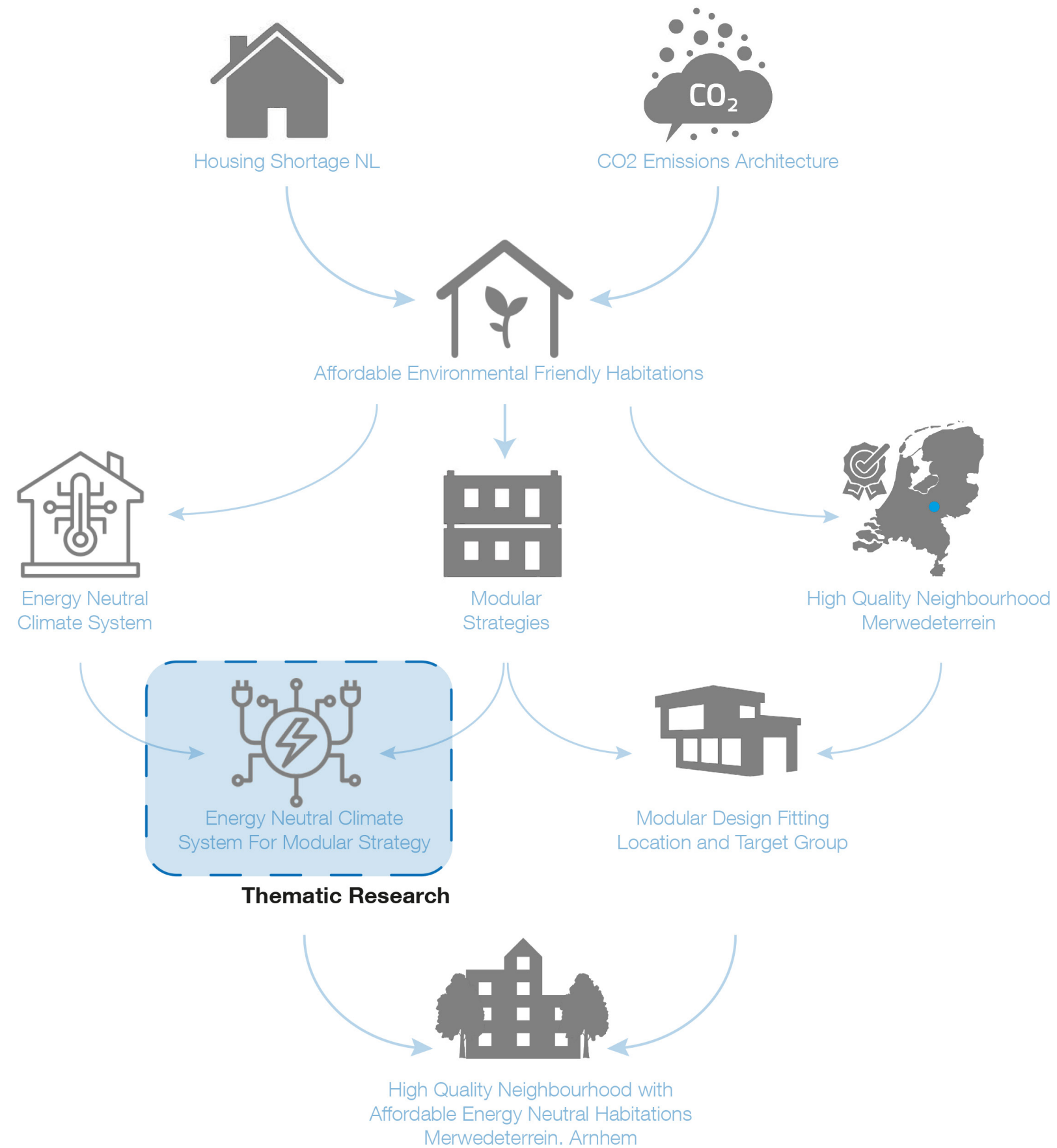
“Werken aan het klimaat is vaak zo suf. Saai.”  
“Working on the climate is often so dull. Boring.”



# Problem Statement



# Objective Graduation Project



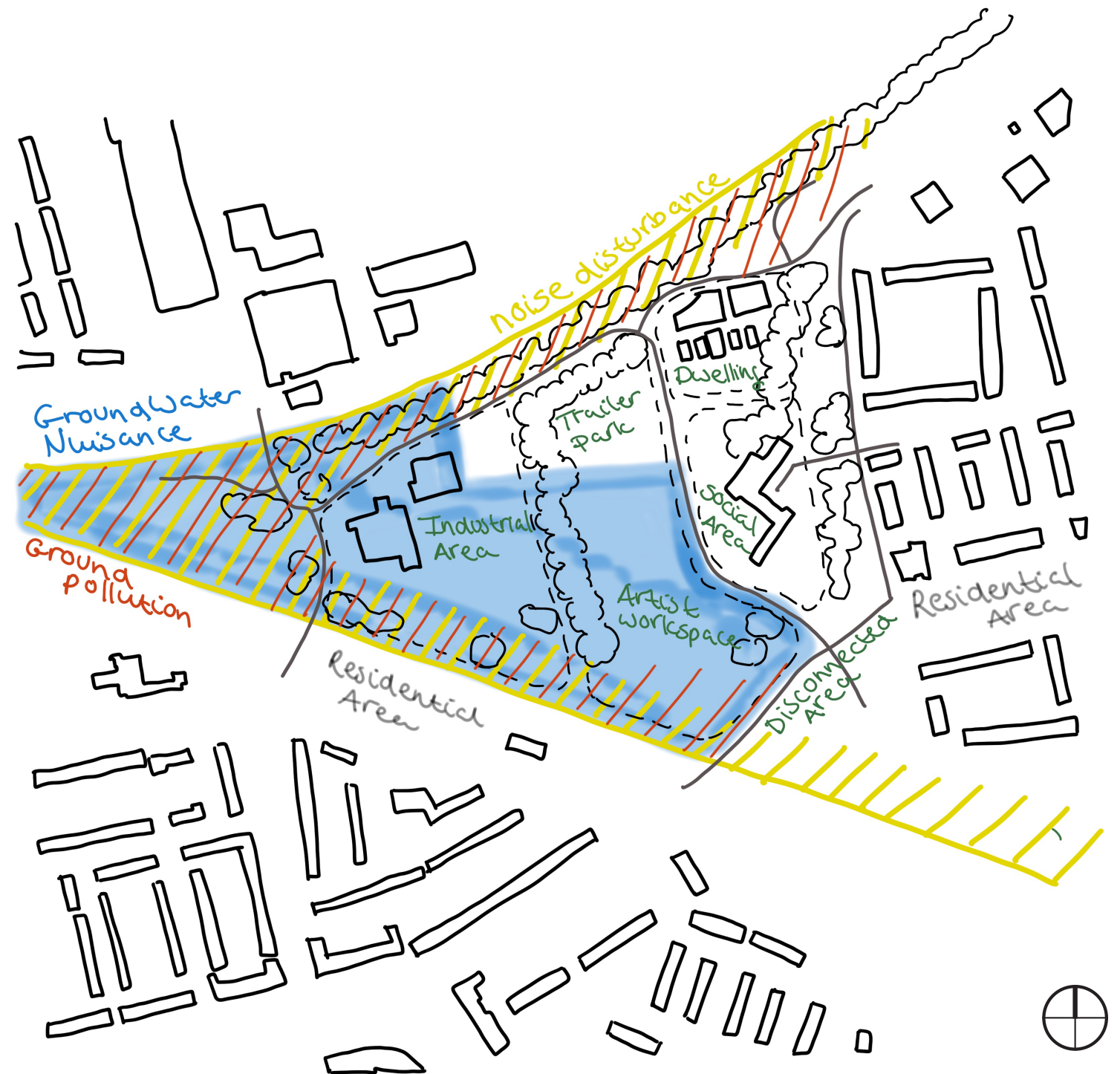


# Site | Merwedeterrein Arnhem (NL)





# Difficulties Merwedeterrein

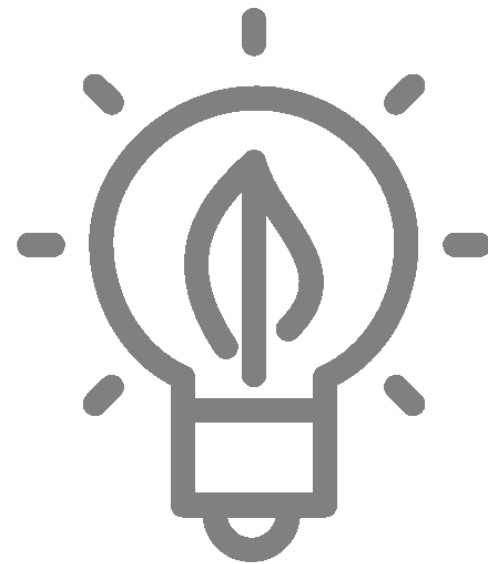




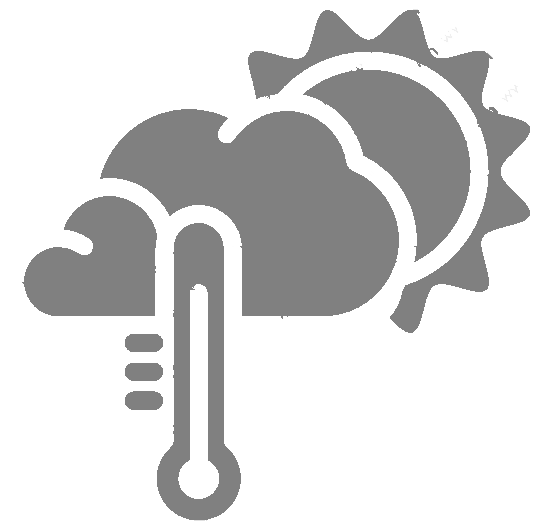
# Design Goal Merwedeterrein



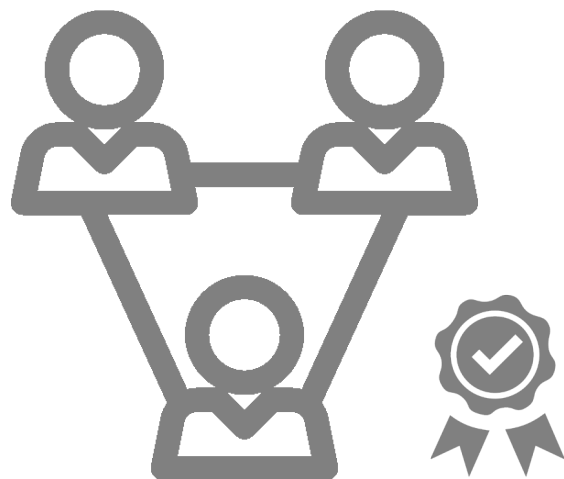
Decreasing Housing Shortage



Affordable Energy Neutral Housing



Climate Resilient Neighbourhood



High Quality Neighbourhood  
Social Cohesion



High Quality Neighbourhood  
Varied Housing

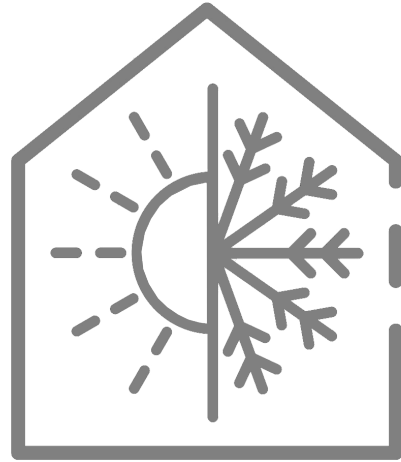
# Thematic Research Conclusions

- Integration of the climate system elements within the architecture of the building from the beginning is important to achieve a more affordable, effective climate system --> a climate design should be developed together with the architectural design.
- By first optimizing the building by using passive solutions on urban and architectural level, like orientation, shapes, insulation wall to window ratio, etc. and afterward adding the necessary effective active elements, a more affordable, effective and flexible climate system van be achieved for energy neutral modular buildings.
- In the Netherlands, Heating is the most important function of the climate system, and sunlight is the climatological element that affects the indoor climate the most.
- Affordability can be achieved through passive solutions and splitting elements between habitations.
- Flexibility can be achieved through giving every habitation their own climate system, creating smaller circuits, compact climate systems (through passive elements) and placing machines in the same place.

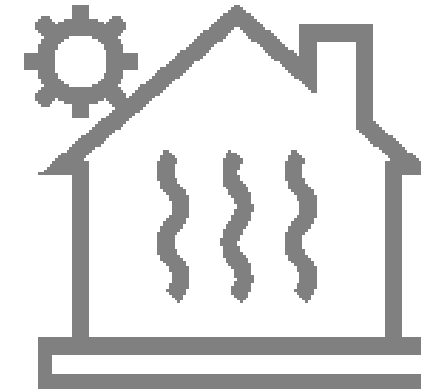
	Element	Active   Passive	Purpose	Effectiveness	Average Price	Flexibility
Heating/Cooling	Combi Air Heat Pump and Ventilation Unit Type C	Active   Passive	Heating, cooling and ventilation with back-up boiler and central heating, all-electric	<div><div></div><div></div><div></div><div></div><div></div><div></div></div>	<div><div></div><div></div><div></div><div></div><div></div><div></div></div>	<div><div></div><div></div><div></div><div></div><div></div><div></div></div>
	Electric Central Heating	Active   Passive	Heating system, not as effective as heat pump so can be used as back up or when small amounts of heat are needed	<div><div></div><div></div><div></div><div></div><div></div><div></div></div>	<div><div></div><div></div><div></div><div></div><div></div><div></div></div>	<div><div></div><div></div><div></div><div></div><div></div><div></div></div>
	Radiators	Active   Passive	Heat emissions in the building controlled by heat pump	<div><div></div><div></div><div></div><div></div><div></div><div></div></div>	<div><div></div><div></div><div></div><div></div><div></div><div></div></div>	<div><div></div><div></div><div></div><div></div><div></div><div></div></div>
	Ground Heat Pump	Active   Passive	Heating and cooling with back up electric central heating with ATES	<div><div></div><div></div><div></div><div></div><div></div><div></div></div>	<div><div></div><div></div><div></div><div></div><div></div><div></div></div>	<div><div></div><div></div><div></div><div></div><div></div><div></div></div>
	(Low Temperature) Floor Heating	Active   Passive	Heat emissions in the building controlled by heat pump	<div><div></div><div></div><div></div><div></div><div></div><div></div></div>	<div><div></div><div></div><div></div><div></div><div></div><div></div></div>	<div><div></div><div></div><div></div><div></div><div></div><div></div></div>
	Electric Radiators	Active   Passive	Heat emissions in the building controlled by heat pump, all-electric	<div><div></div><div></div><div></div><div></div><div></div><div></div></div>	<div><div></div><div></div><div></div><div></div><div></div><div></div></div>	<div><div></div><div></div><div></div><div></div><div></div><div></div></div>
	Infrared Ceiling Panels	Active   Passive	Heat emissions in the building controlled by heat pump, all-electric	<div><div></div><div></div><div></div><div></div><div></div><div></div></div>	<div><div></div><div></div><div></div><div></div><div></div><div></div></div>	<div><div></div><div></div><div></div><div></div><div></div><div></div></div>
	Air Heat Pump	Active   Passive	Heating and cooling through air, can be connected to MVHR	<div><div></div><div></div><div></div><div></div><div></div><div></div></div>	<div><div></div><div></div><div></div><div></div><div></div><div></div></div>	<div><div></div><div></div><div></div><div></div><div></div><div></div></div>
(Warm) Water	Electric Boiler 50 L	Active   Passive	Boiler for warm water, can be used as back up in case of over consumption	<div><div></div><div></div><div></div><div></div><div></div><div></div></div>	<div><div></div><div></div><div></div><div></div><div></div><div></div></div>	<div><div></div><div></div><div></div><div></div><div></div><div></div></div>
	Storage Vessel 150 L	Active   Passive	Boiler to warm water and storage	<div><div></div><div></div><div></div><div></div><div></div><div></div></div>	<div><div></div><div></div><div></div><div></div><div></div><div></div></div>	<div><div></div><div></div><div></div><div></div><div></div><div></div></div>
Electricity	PV panels 365 Wp	Active   Passive	Generates energy for the building and to supply the climate system	<div><div></div><div></div><div></div><div></div><div></div><div></div></div>	<div><div></div><div></div><div></div><div></div><div></div><div></div></div>	<div><div></div><div></div><div></div><div></div><div></div><div></div></div>
	PV panels 370 Wp	Active   Passive	Generates energy for the building and to supply the climate system	<div><div></div><div></div><div></div><div></div><div></div><div></div></div>	<div><div></div><div></div><div></div><div></div><div></div><div></div></div>	<div><div></div><div></div><div></div><div></div><div></div><div></div></div>
Ventilation	Combi Air Heat Pump and Ventilation Unit Type C	Active   Passive	Heating, cooling and ventilation with back-up boiler and central heating, all-electric	<div><div></div><div></div><div></div><div></div><div></div><div></div></div>	<div><div></div><div></div><div></div><div></div><div></div><div></div></div>	<div><div></div><div></div><div></div><div></div><div></div><div></div></div>
	Ventilation Unit Type D	Active   Passive	Mechanical ventilation system for fresh air supply, governed by CO <sub>2</sub>	<div><div></div><div></div><div></div><div></div><div></div><div></div></div>	<div><div></div><div></div><div></div><div></div><div></div><div></div></div>	<div><div></div><div></div><div></div><div></div><div></div><div></div></div>
Indoor Comfort	HR ++ Glass	Active   Passive	Insulating	<div><div></div><div></div><div></div><div></div><div></div><div></div></div>	<div><div></div><div></div><div></div><div></div><div></div><div></div></div>	<div><div></div><div></div><div></div><div></div><div></div><div></div></div>
	HR +++ Glass	Active   Passive	Insulating	<div><div></div><div></div><div></div><div></div><div></div><div></div></div>	<div><div></div><div></div><div></div><div></div><div></div><div></div></div>	<div><div></div><div></div><div></div><div></div><div></div><div></div></div>
	Mineral Wool Insulation	Active   Passive	Insulating	<div><div></div><div></div><div></div><div></div><div></div><div></div></div>	<div><div></div><div></div><div></div><div></div><div></div><div></div></div>	<div><div></div><div></div><div></div><div></div><div></div><div></div></div>
	EPS Insulation	Active   Passive	Insulating	<div><div></div><div></div><div></div><div></div><div></div><div></div></div>	<div><div></div><div></div><div></div><div></div><div></div><div></div></div>	<div><div></div><div></div><div></div><div></div><div></div><div></div></div>
	Air Tightness Tape	Active   Passive	Keeps building air tight	<div><div></div><div></div><div></div><div></div><div></div><div></div></div>	<div><div></div><div></div><div></div><div></div><div></div><div></div></div>	<div><div></div><div></div><div></div><div></div><div></div><div></div></div>
Innovative Elements	Smarty Air Clean	Active   Passive	Passive ventilation unit, filters air and creates natural humidity	<div><div></div><div></div><div></div><div></div><div></div><div></div></div>	<div><div></div><div></div><div></div><div></div><div></div><div></div></div>	<div><div></div><div></div><div></div><div></div><div></div><div></div></div>
	Modul-AIR Blue	Active   Passive	All-electric air heat pump that actively cools and heats, ventilates (C/D) and warms water	<div><div></div><div></div><div></div><div></div><div></div><div></div></div>	<div><div></div><div></div><div></div><div></div><div></div><div></div></div>	<div><div></div><div></div><div></div><div></div><div></div><div></div></div>
	Multi Air Supply System	Active   Passive	Ventilation unit without supply routes (Type D)	<div><div></div><div></div><div></div><div></div><div></div><div></div></div>	<div><div></div><div></div><div></div><div></div><div></div><div></div></div>	<div><div></div><div></div><div></div><div></div><div></div><div></div></div>
	Karbonic Heating Foil	Active   Passive	Easy applicable foil for floor heating, heat emissions in the building	<div><div></div><div></div><div></div><div></div><div></div><div></div></div>	<div><div></div><div></div><div></div><div></div><div></div><div></div></div>	<div><div></div><div></div><div></div><div></div><div></div><div></div></div>



# Design Principles



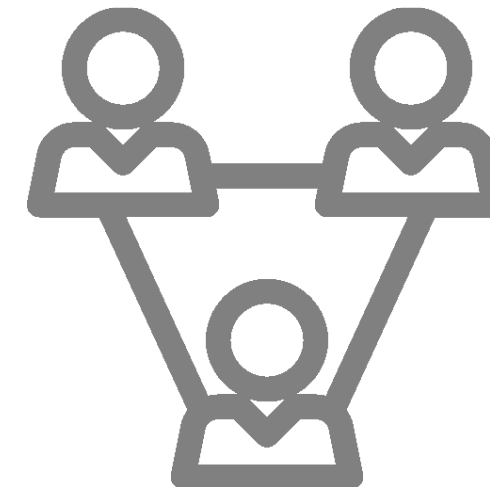
Integration of climate design with architectural and urban design (**Urban Ecology** & **Passive Climate**)



Application of **Passive Strategies** to develop an affordable, flexible building



Application of a **Modular Strategy** to develop flexible, varied housing



Application of different kind of public and private space to favour the **Social Cohesion**

# Content

Neighbourhood



Urban

Building



Architectural



# Urban Plan



Current Situation 1:2000



# Urban Plan



Urban Plan 1:2000

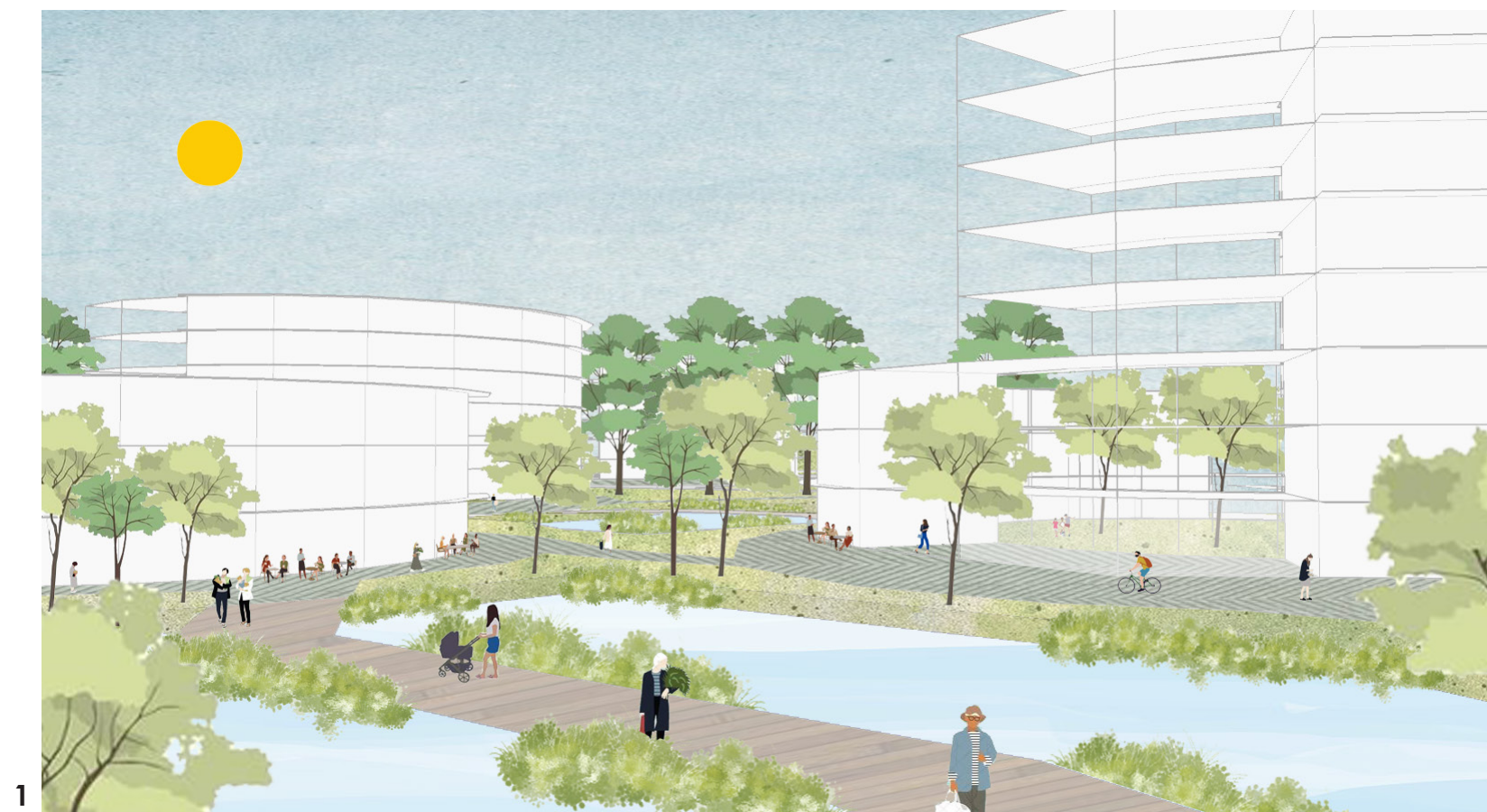




# Functions

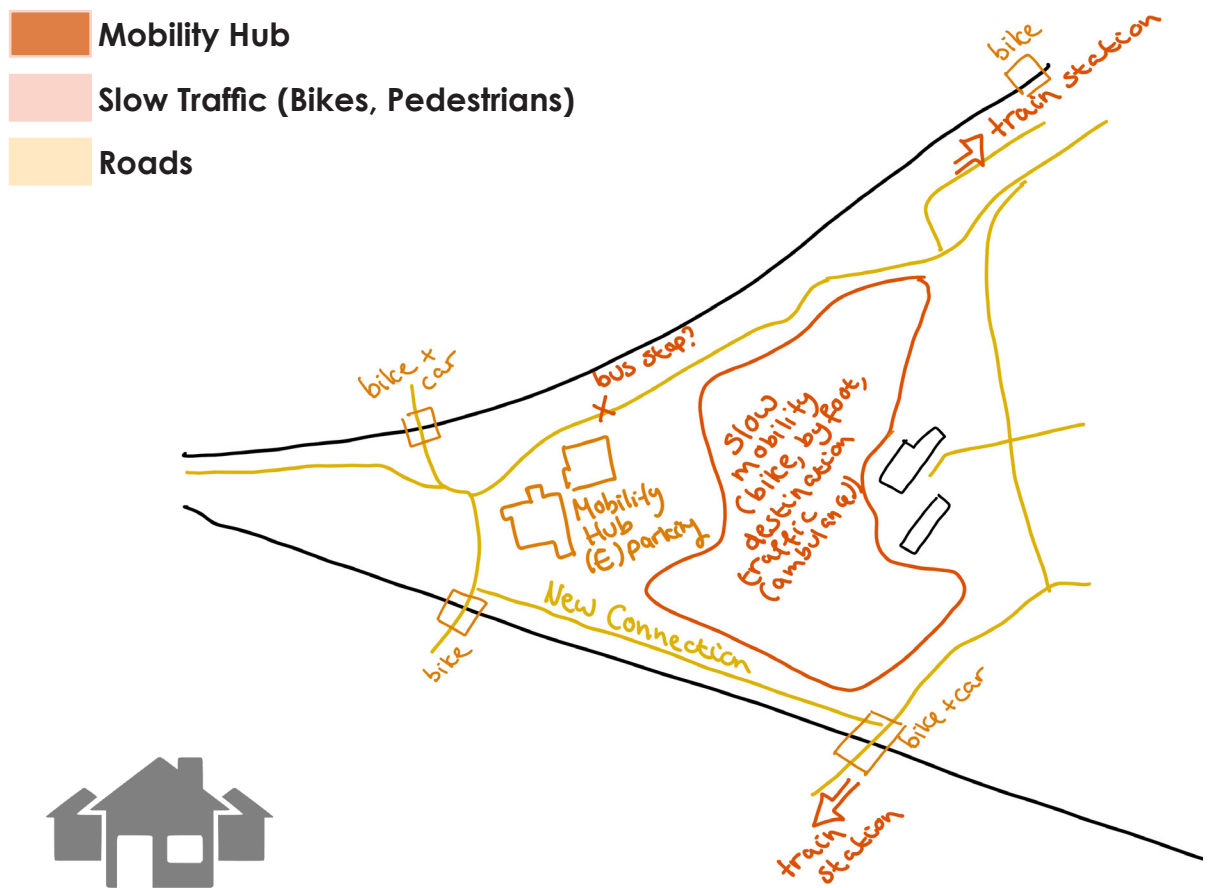


- Commercial Area
- Artists Workspace and Exhibitionspace
- Mobility Hub



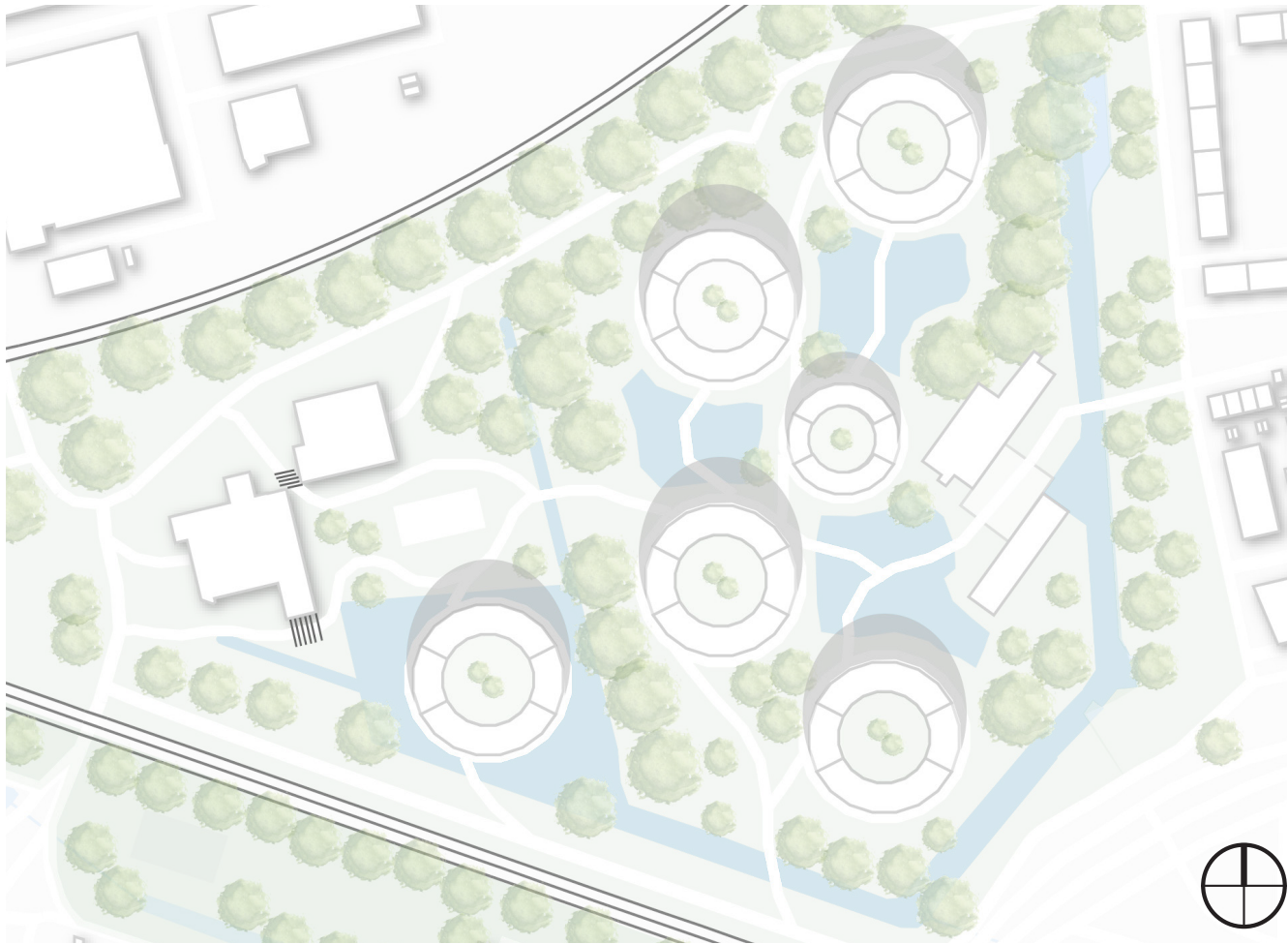


# Mobility

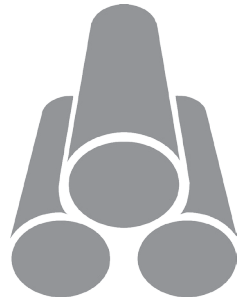




# Urban Ecology



Greening



Materialization



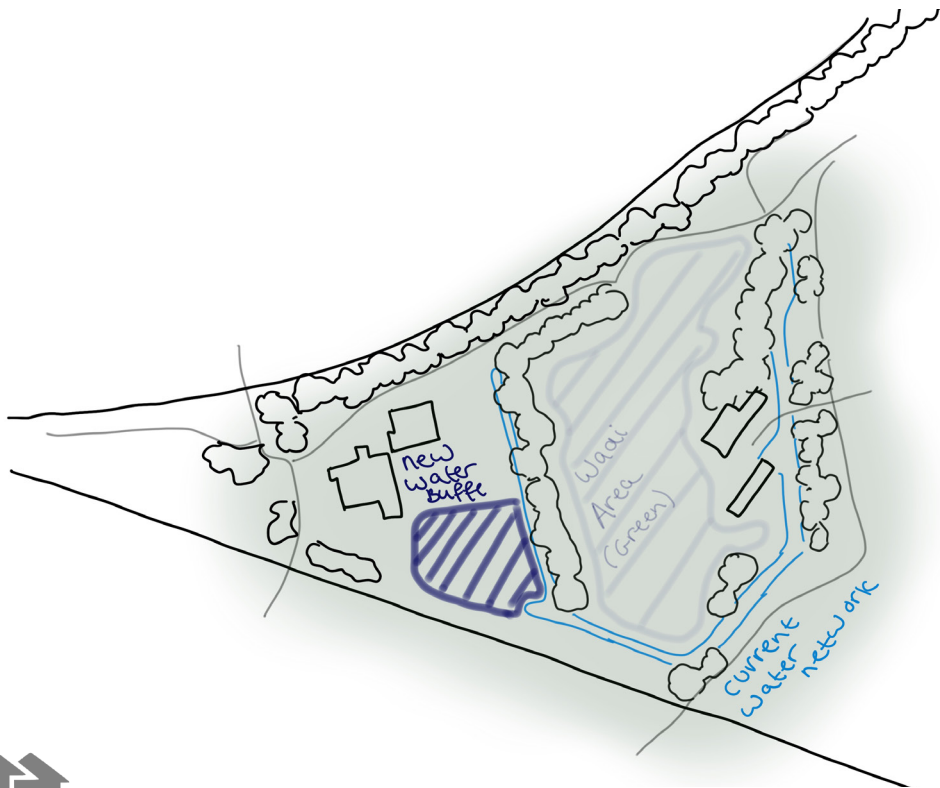
Shadow



Sloping area



Water storage





# Urban Plan

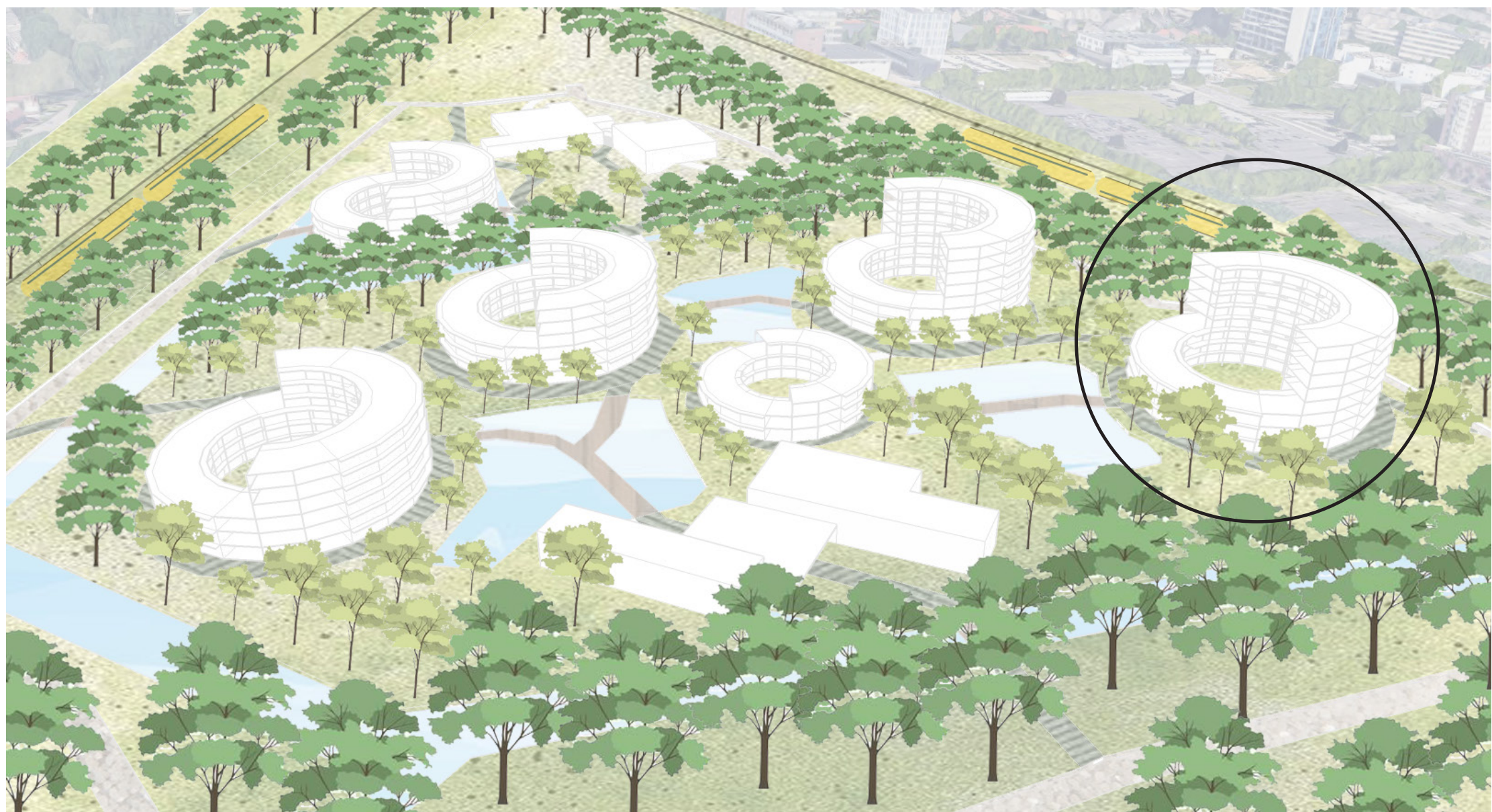


	Number of Modules	m <sup>2</sup>
Commercial	28	30 - 60 m <sup>2</sup>
Ground Bound 2 Stories House	42	120 m <sup>2</sup>
Studio	28	30 m <sup>2</sup>
Apartments (1-2 modules)	203	60 m <sup>2</sup>
Green and Water Network	-	80.000 m <sup>2</sup>
PVT Panels	-	5.500 m <sup>2</sup>





# Urban Plan



	Number of Modules	m <sup>2</sup>
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Green and Water Network	-	80.000 m <sup>2</sup>
PVT Panels	-	5.500 m <sup>2</sup>





# Architectural Plan

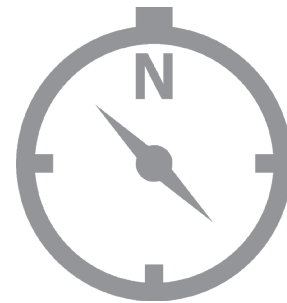




# Integrated Passive Climate Design



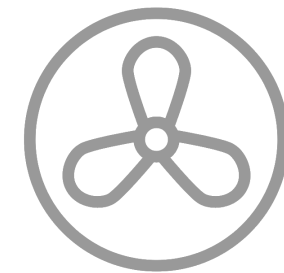
Shape



Orientation



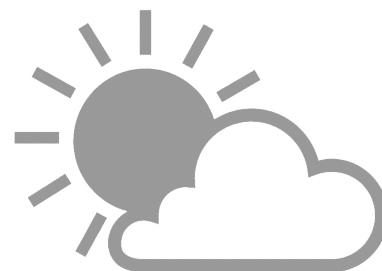
Zoning



Ventilation



Urban Ecology



Sun shading



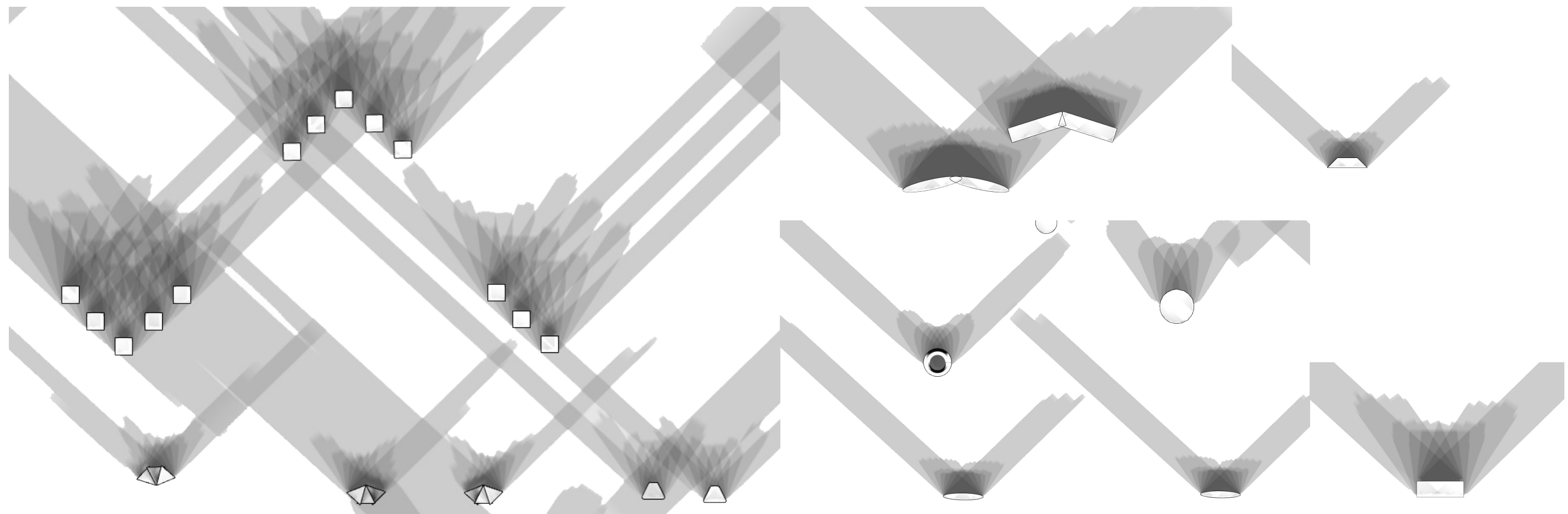
Window to  
wall ratio



Insulation



# Passive Climate | Shape

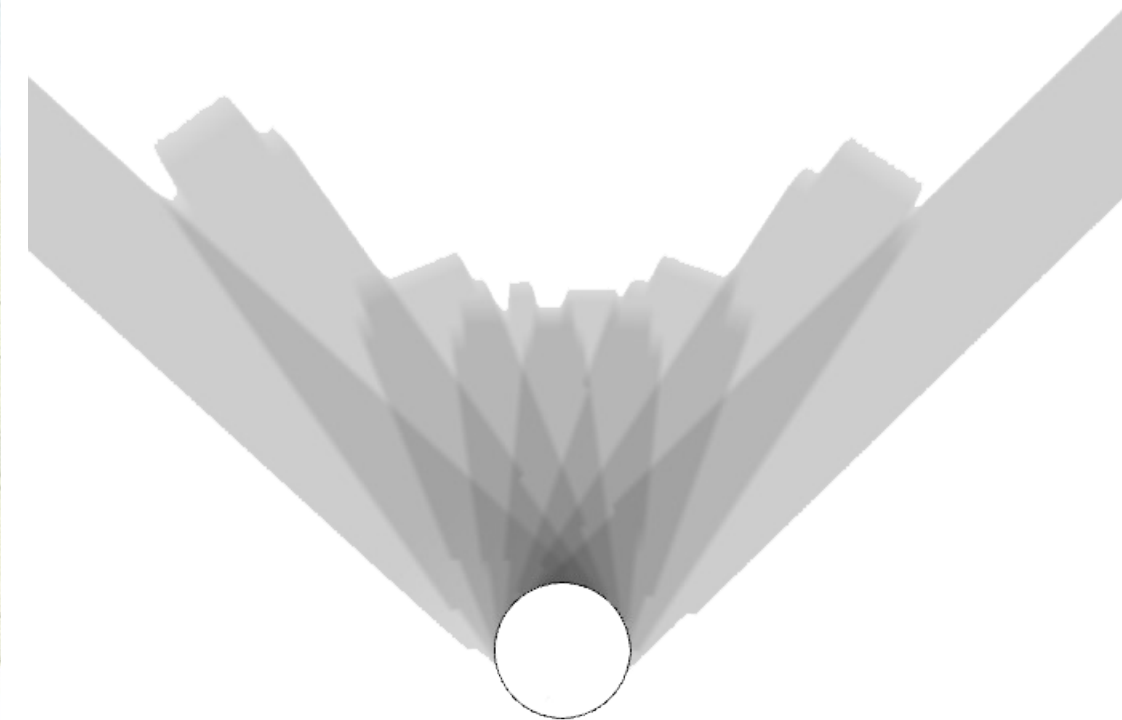
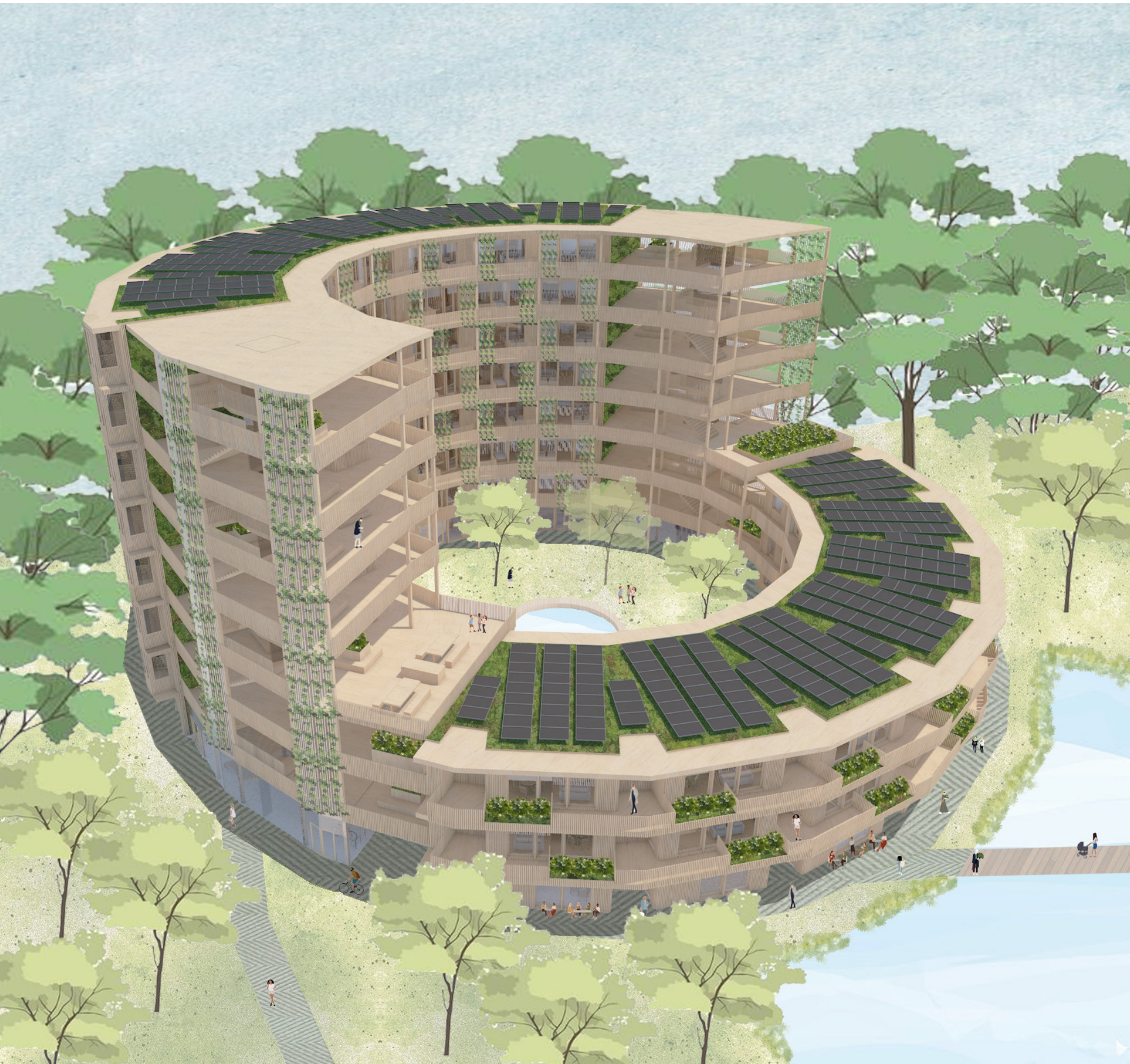


Shadow Study ⊕





# Passive Climate | Shape

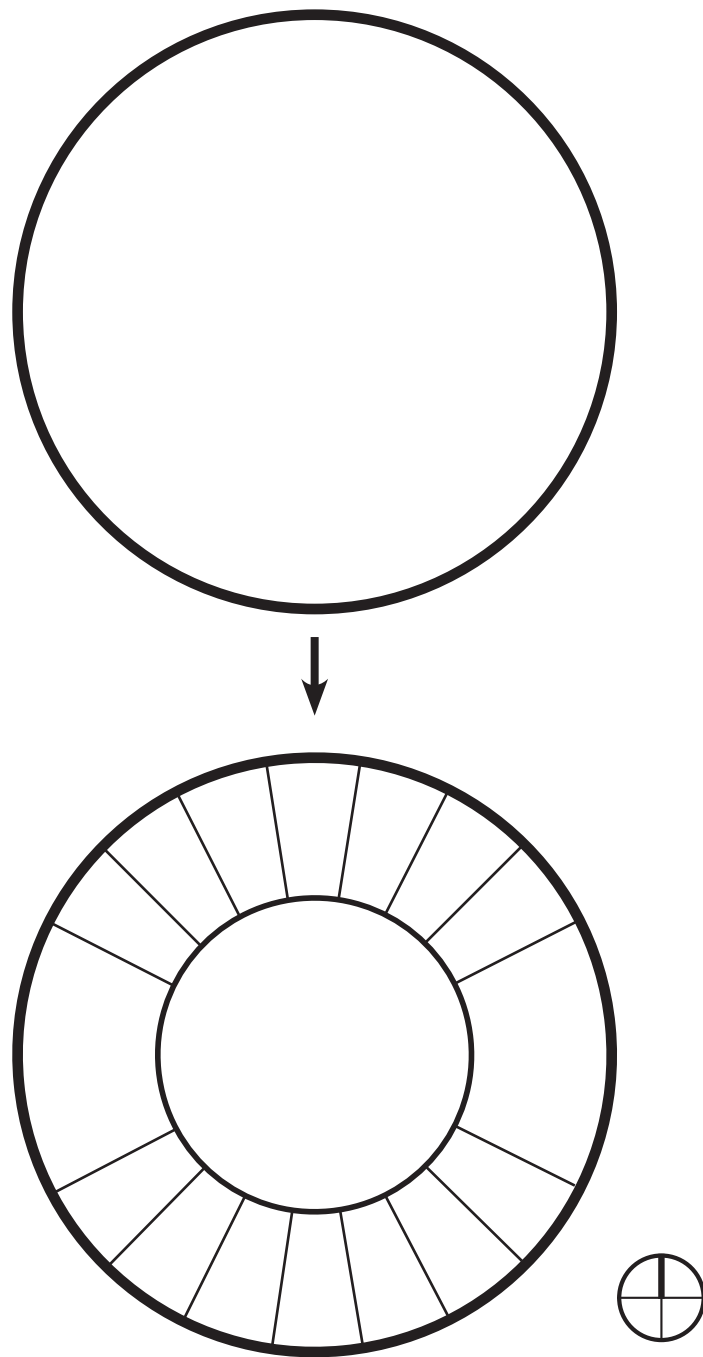
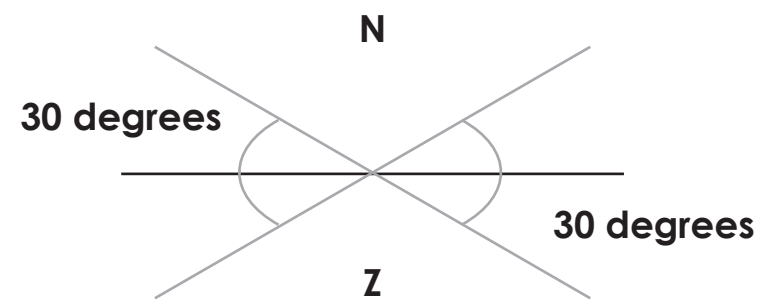


**Solar Gain Round Building**

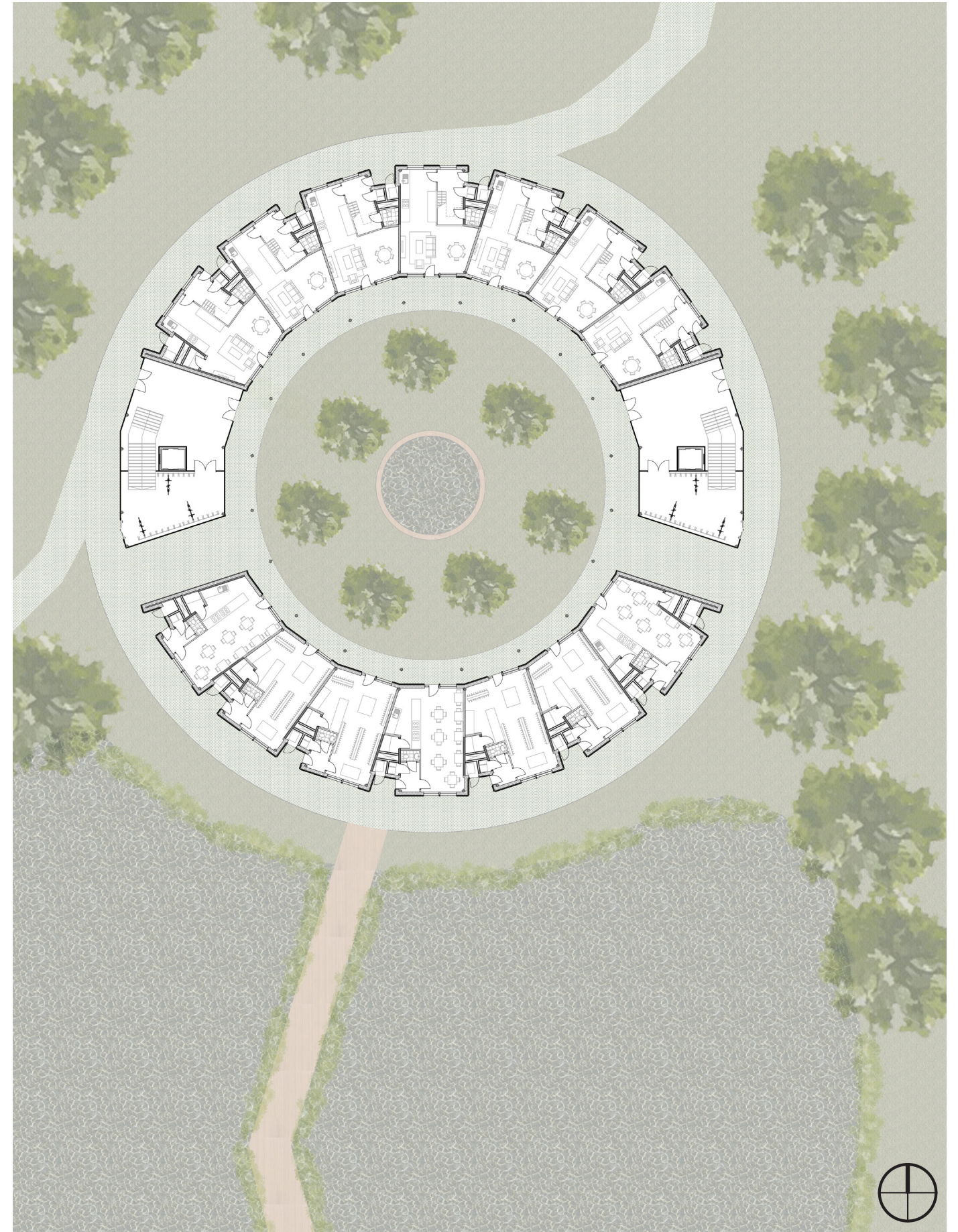




# Passive Climate | Orientation



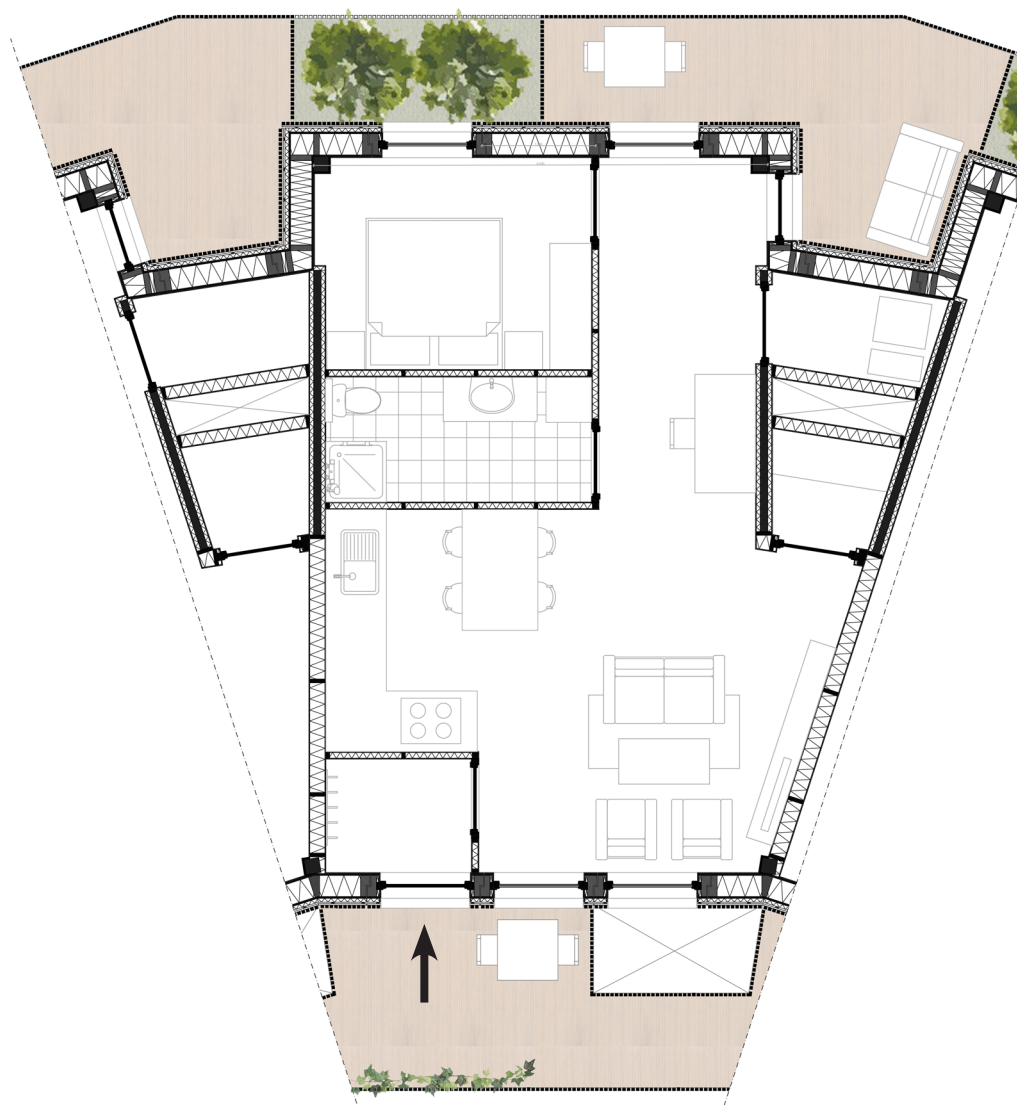
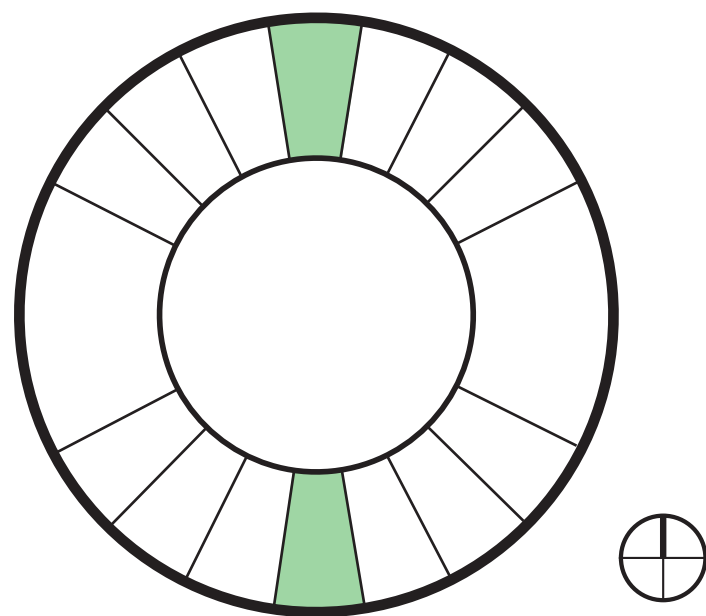
 Subdivision Round Building



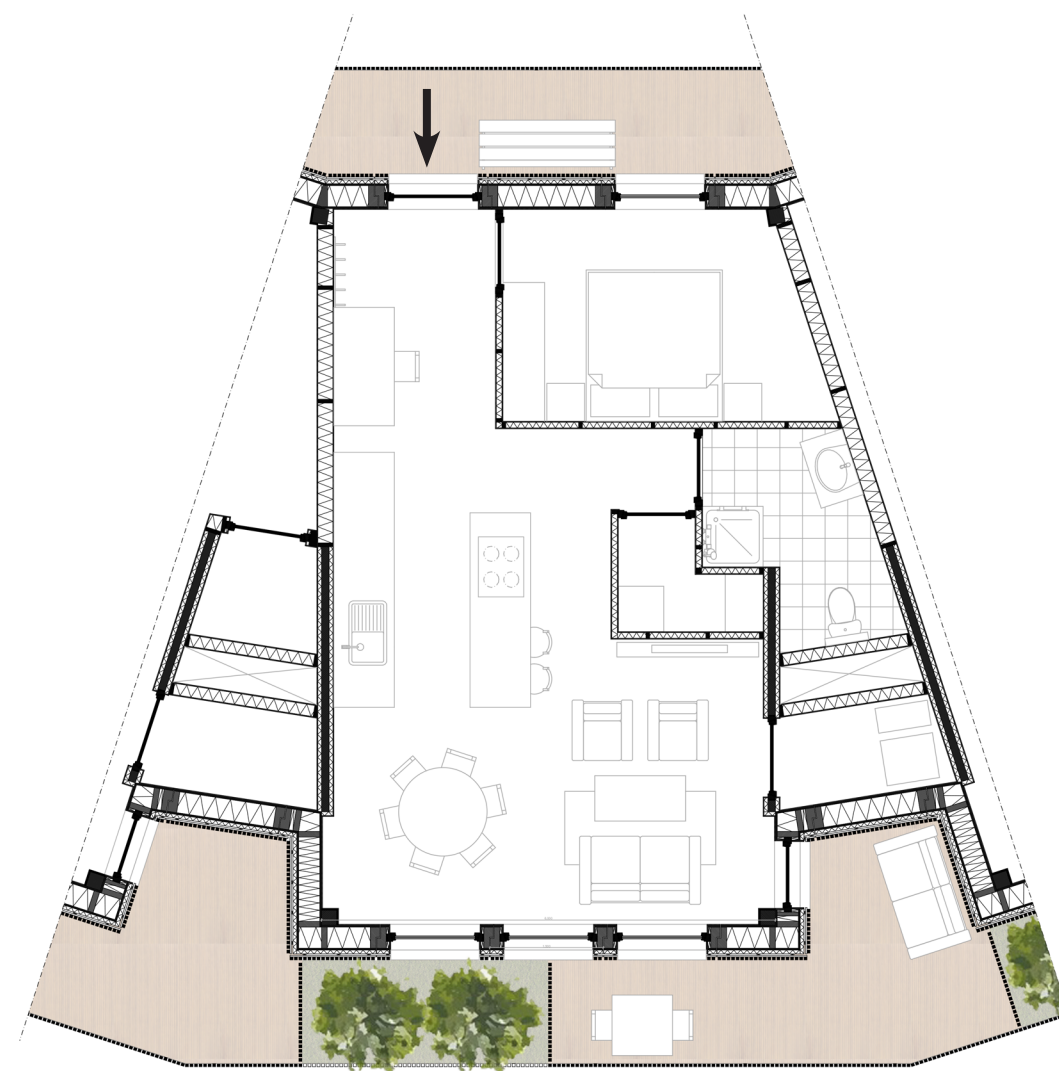
Ground Level in Situation 1:500



# Passive Climate | Zoning



**Floorplan 1 Module Apartment 1:50**  
**South Entrance**

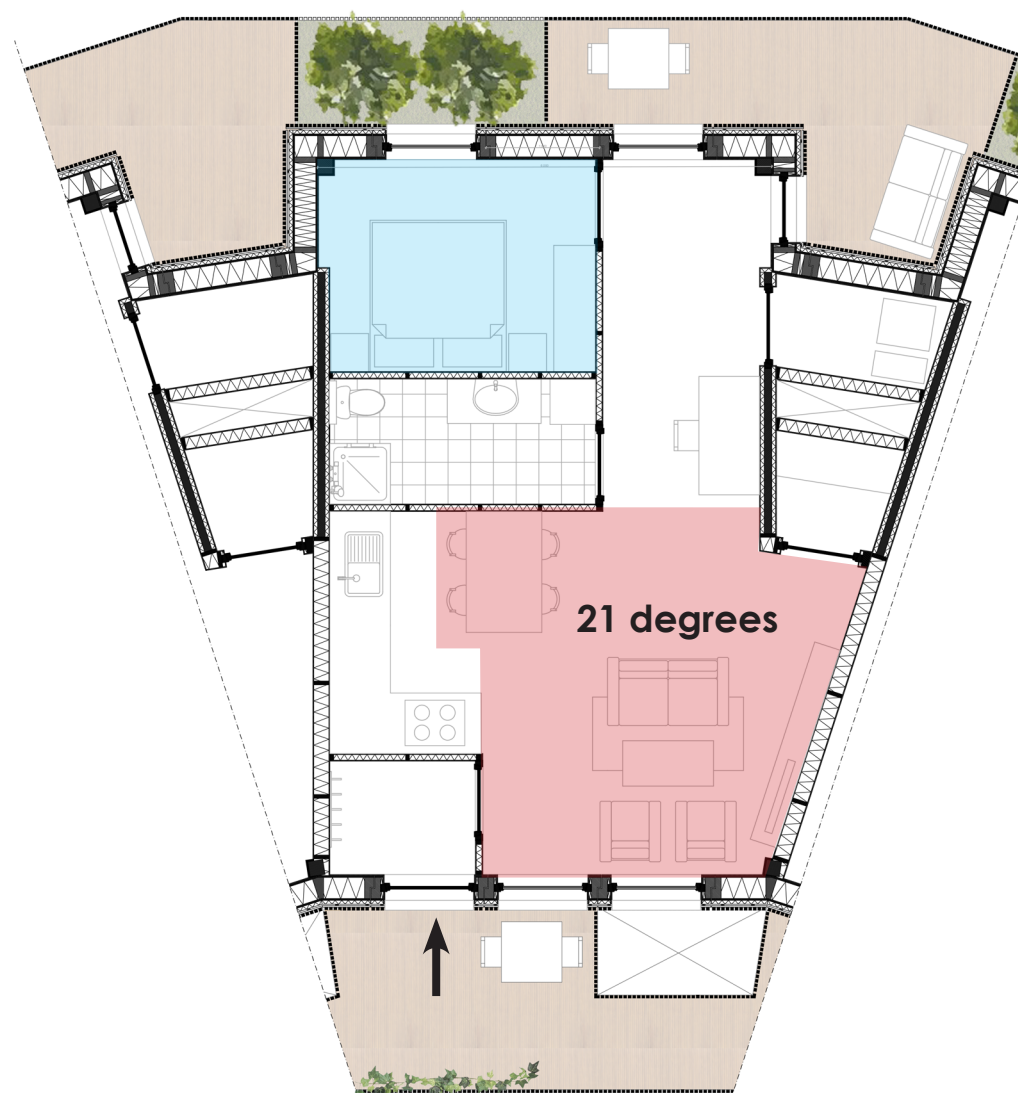
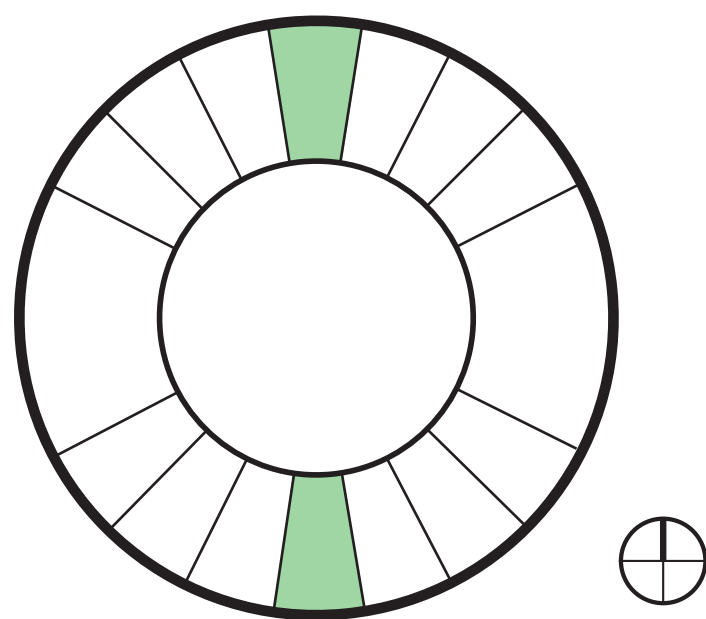


**Floorplan 1 Module Apartment 1:50**  
**North Entrance**

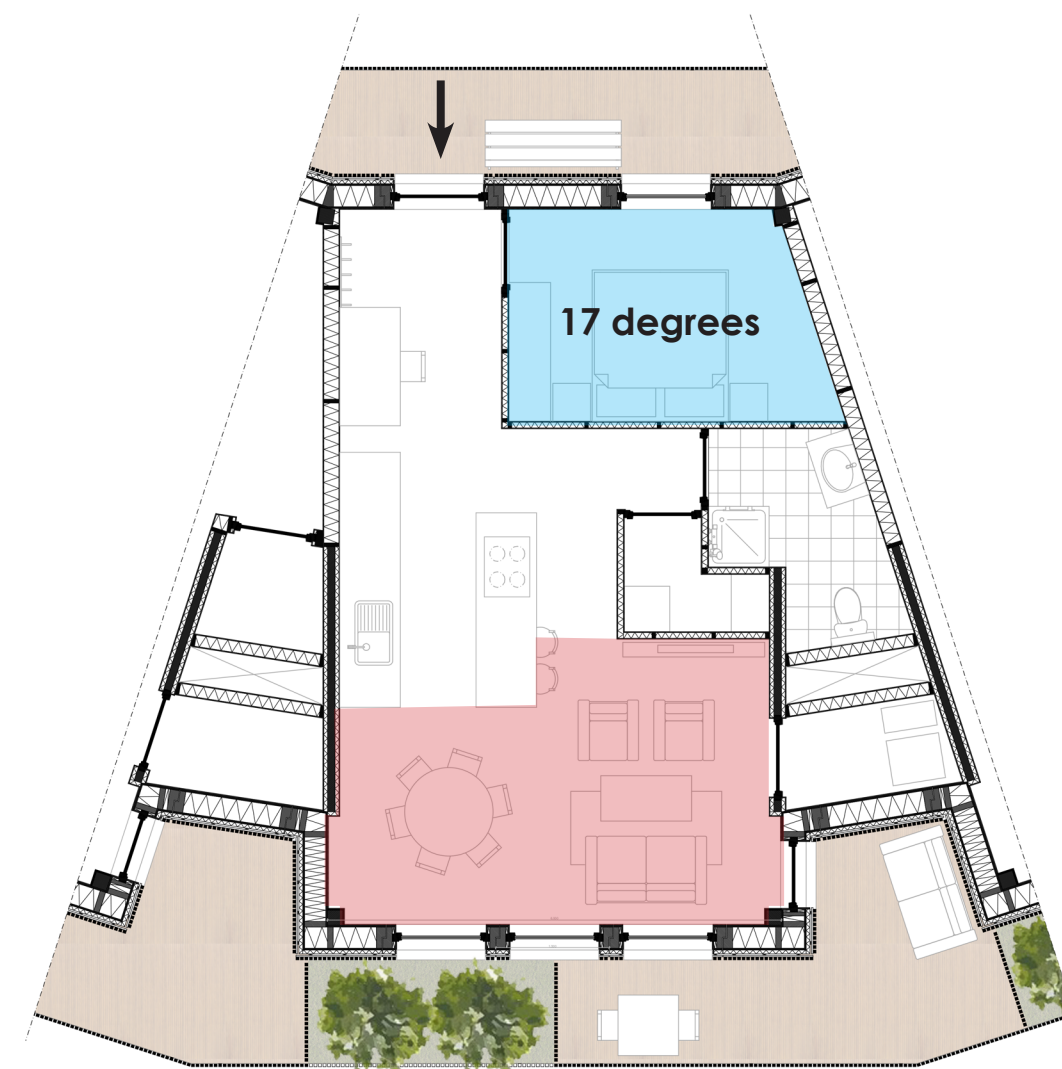




# Passive Climate | Zoning



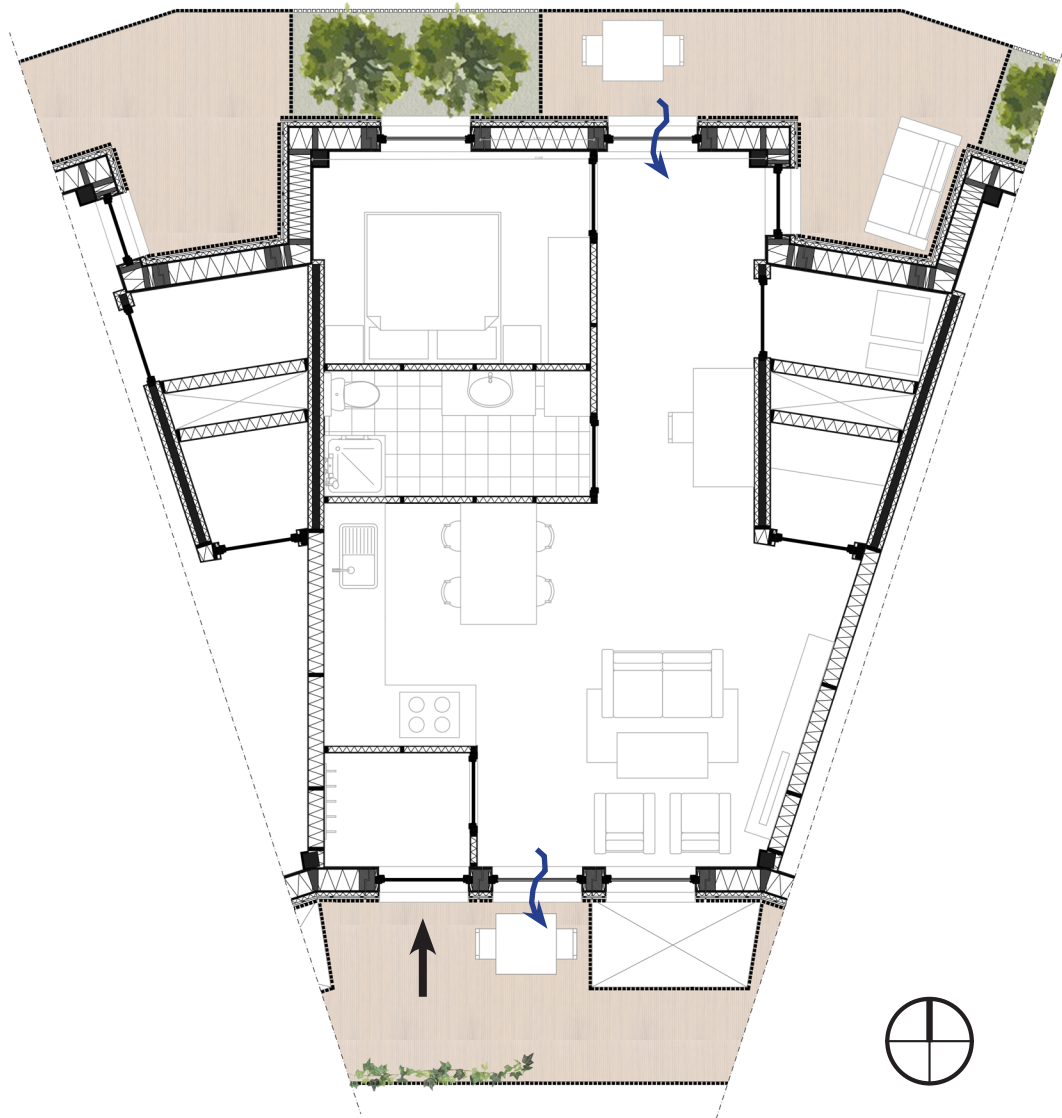
**Floorplan 1 Module Apartment 1:50**  
**South Entrance**



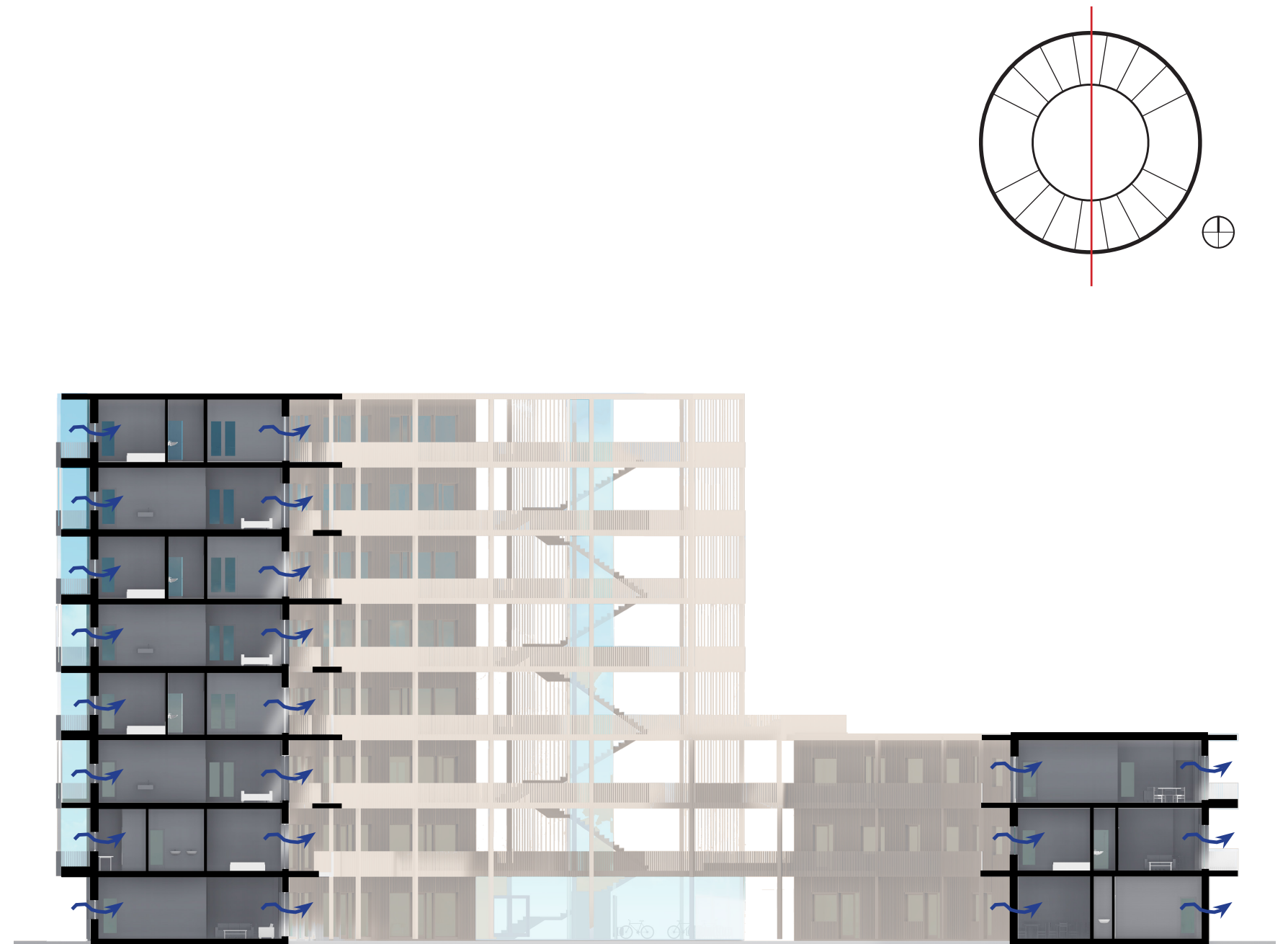
**Floorplan 1 Module Apartment 1:50**  
**North Entrance**



# Passive Climate | Ventilation



Cross Ventilation Apartment

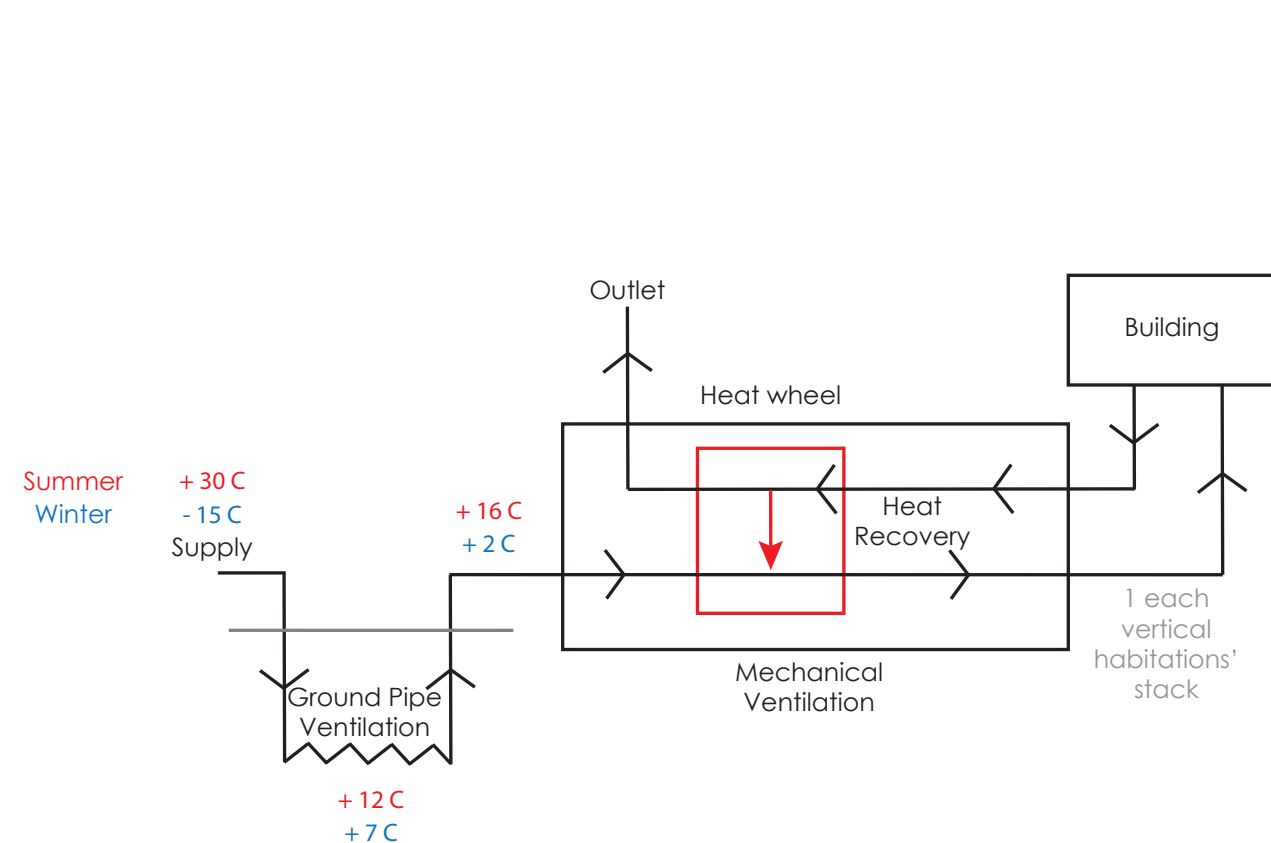


Cross Ventilation North-South Section 1:200

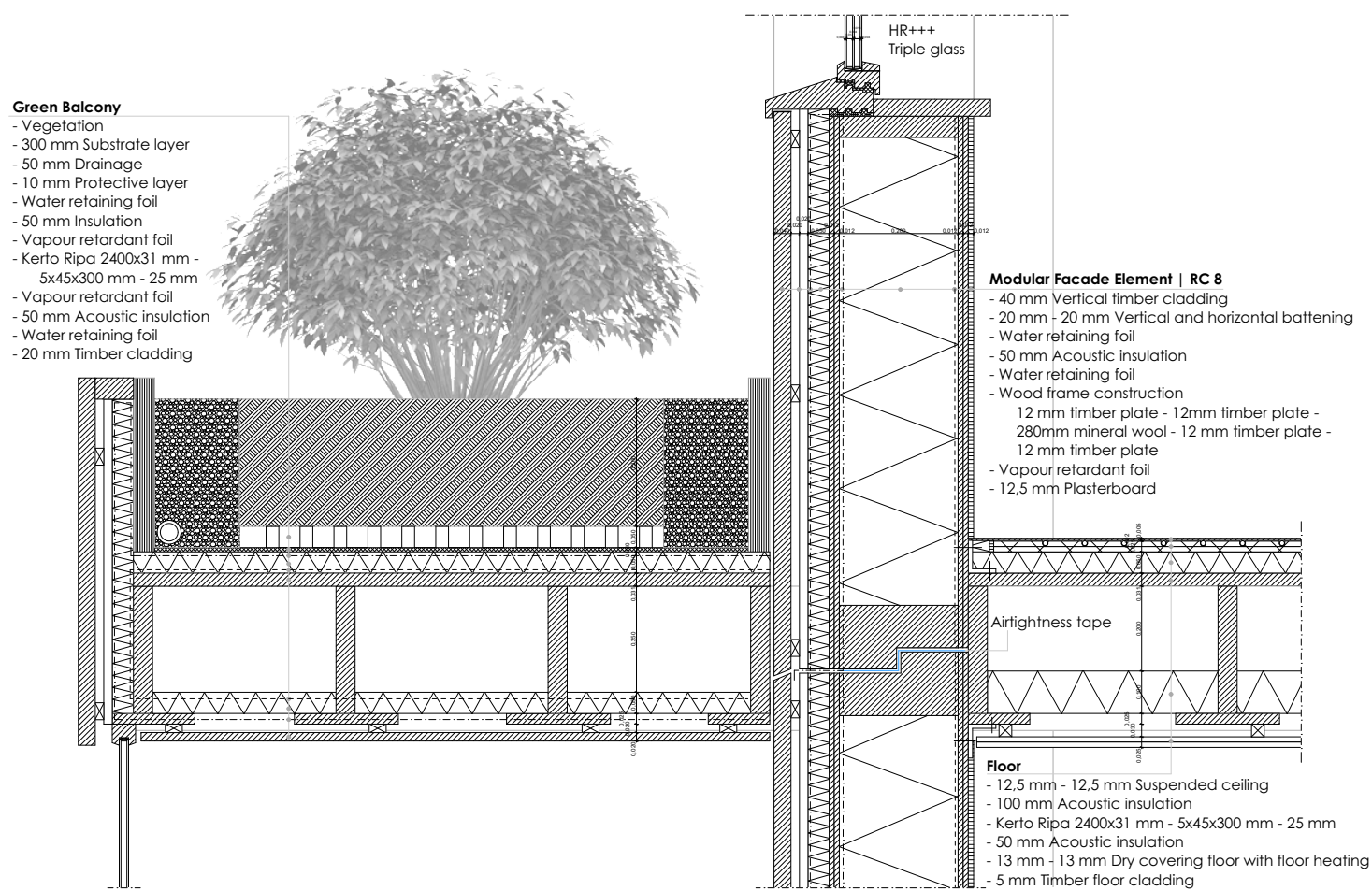




# Passive Climate | Ventilation



Mechanical Ventilation for Air Supply

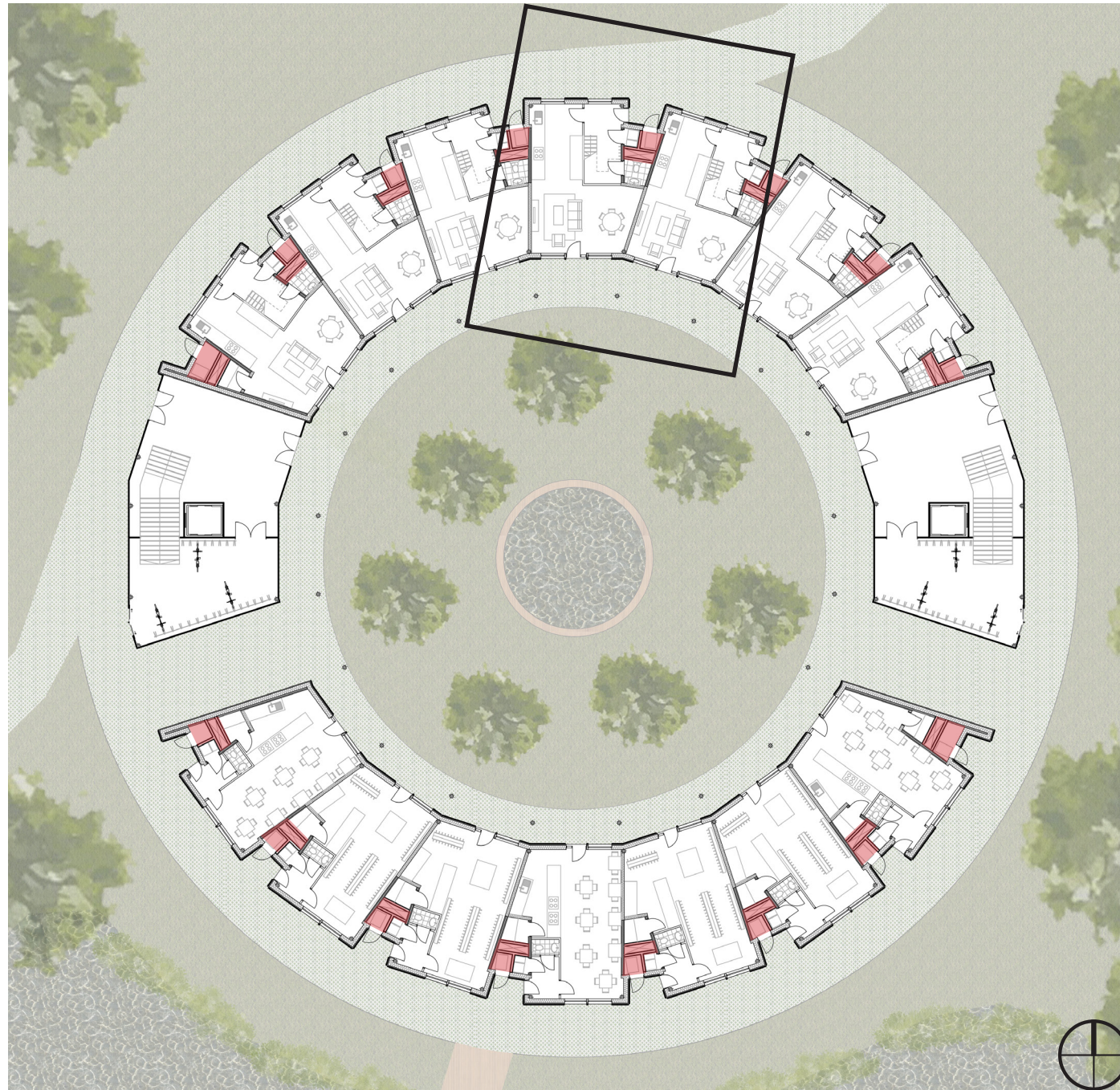


Detail Facade 1:5  
Airtightness





# Passive Climate | Ventilation



Floorplan Ground Floor 1:200

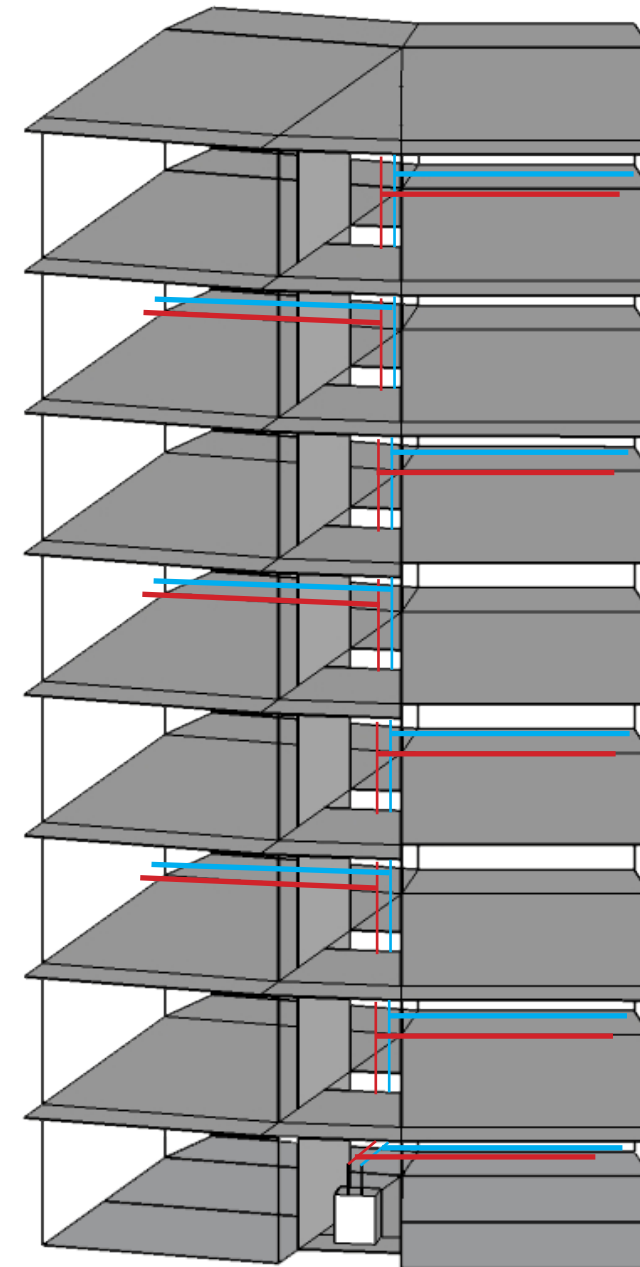
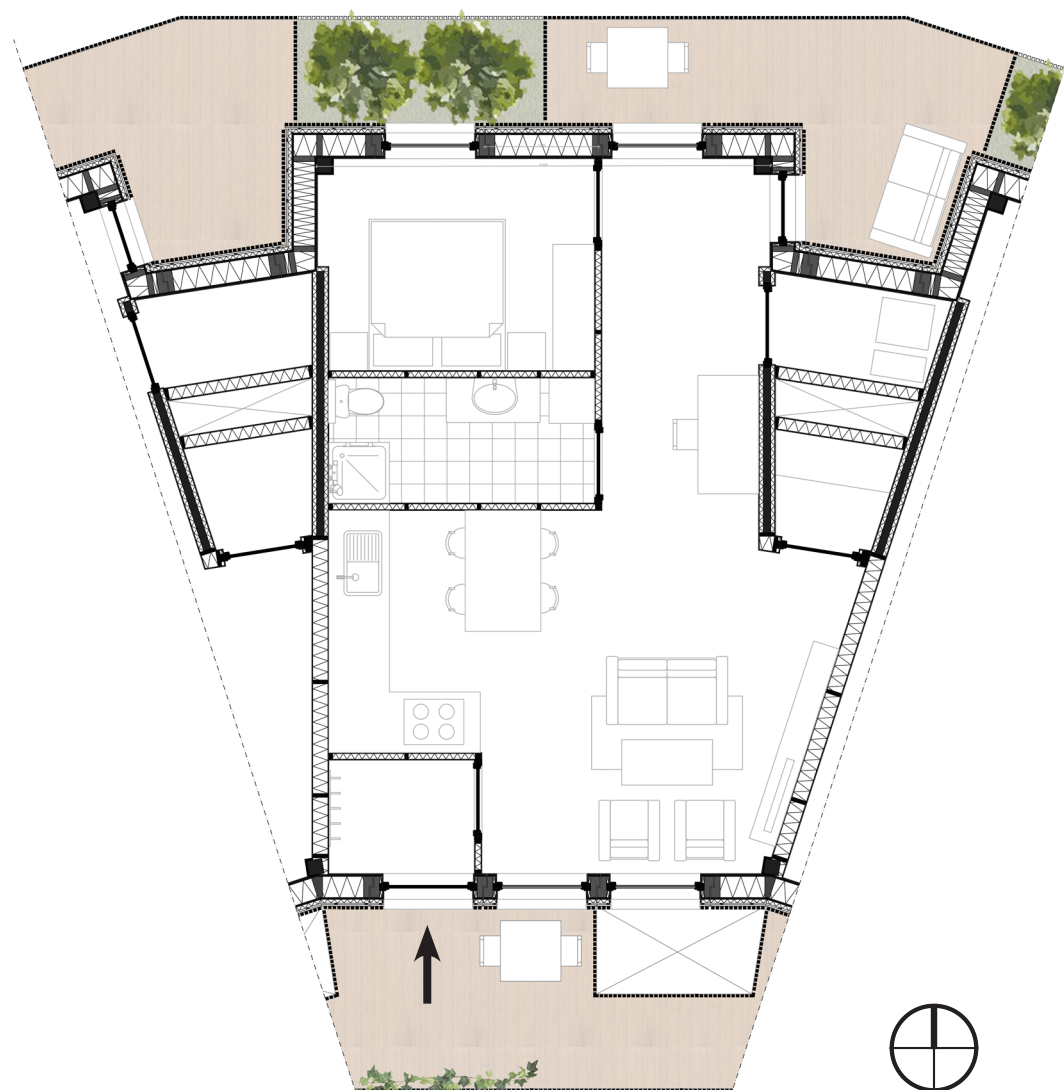


Diagram Mechanical Ventilation





# Module



**Floorplan 1 Module Apartment 1:50**  
**South Entrance**

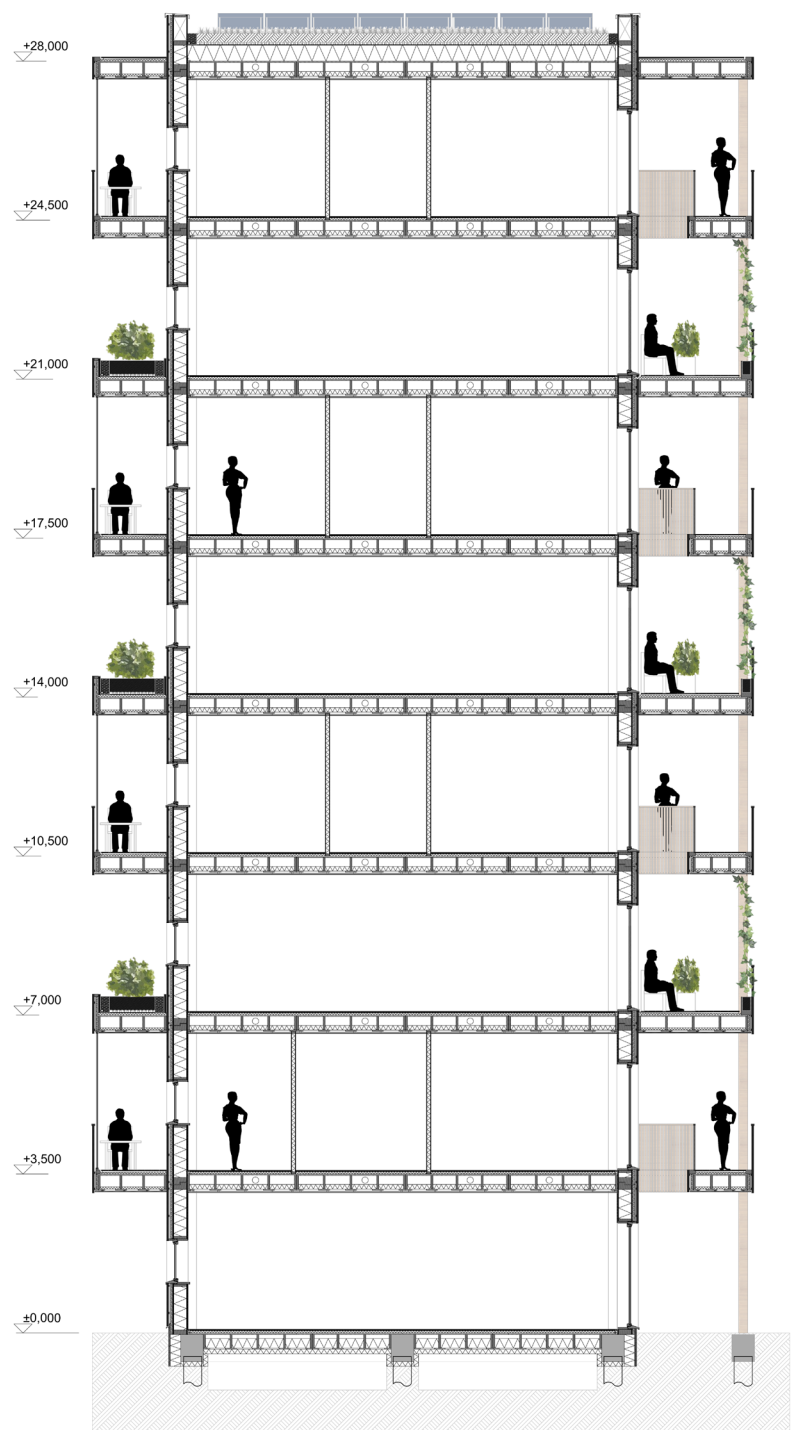


**Facade Fragment Model 1:50**

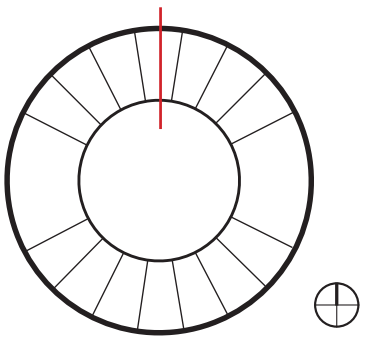




# Passive Climate | Urban Ecology

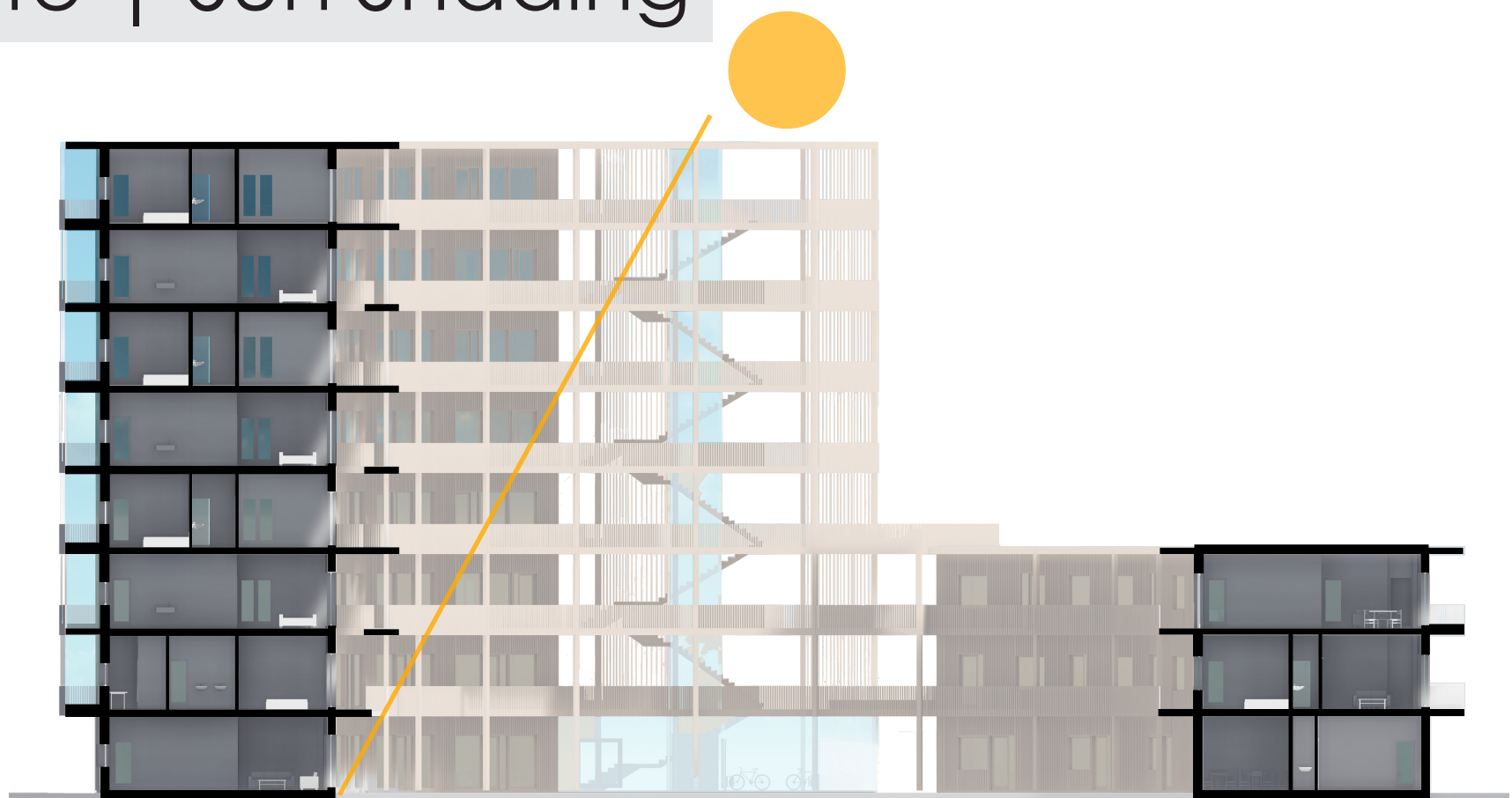


Facade Fragment 1:50  
Materiality

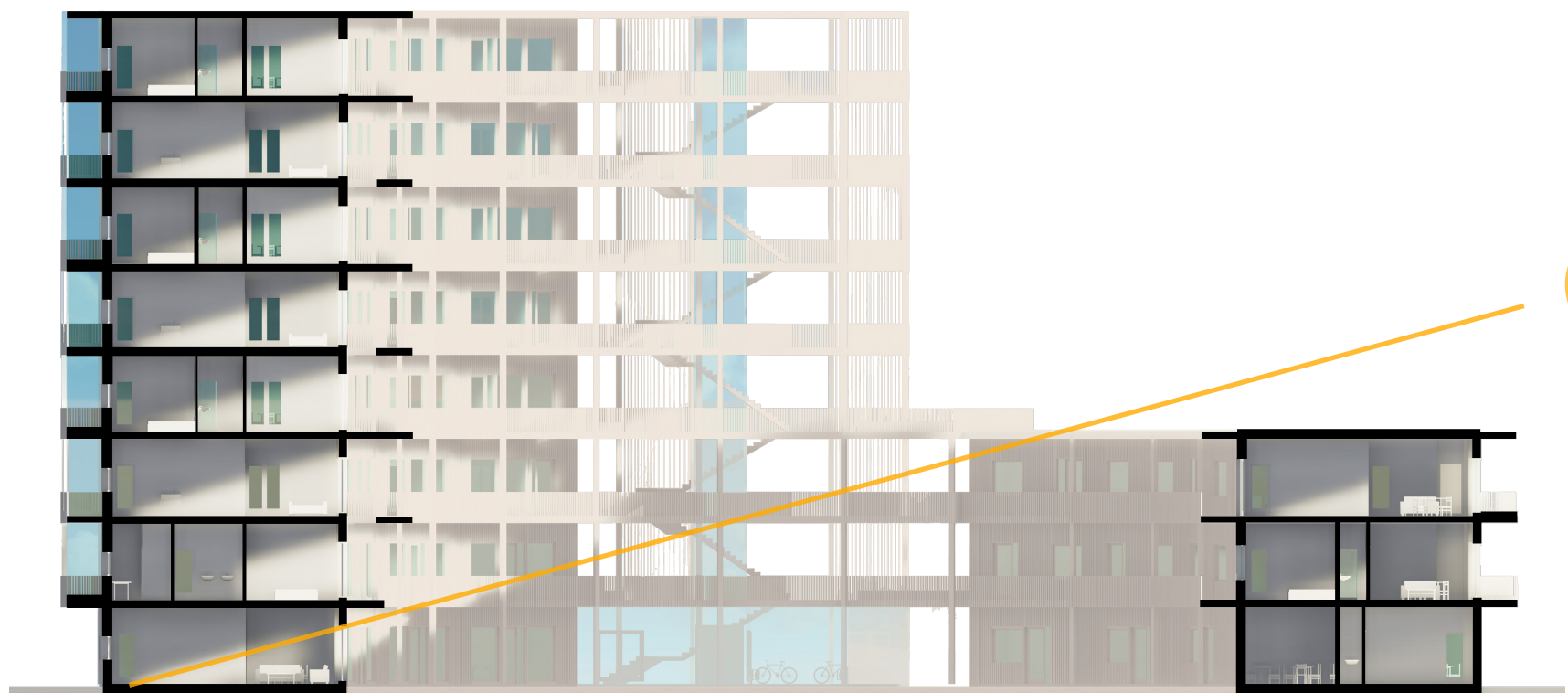




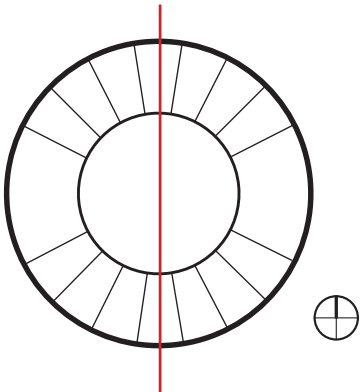
# Passive Climate | Sun Shading



North-South Section 1:200  
Summer

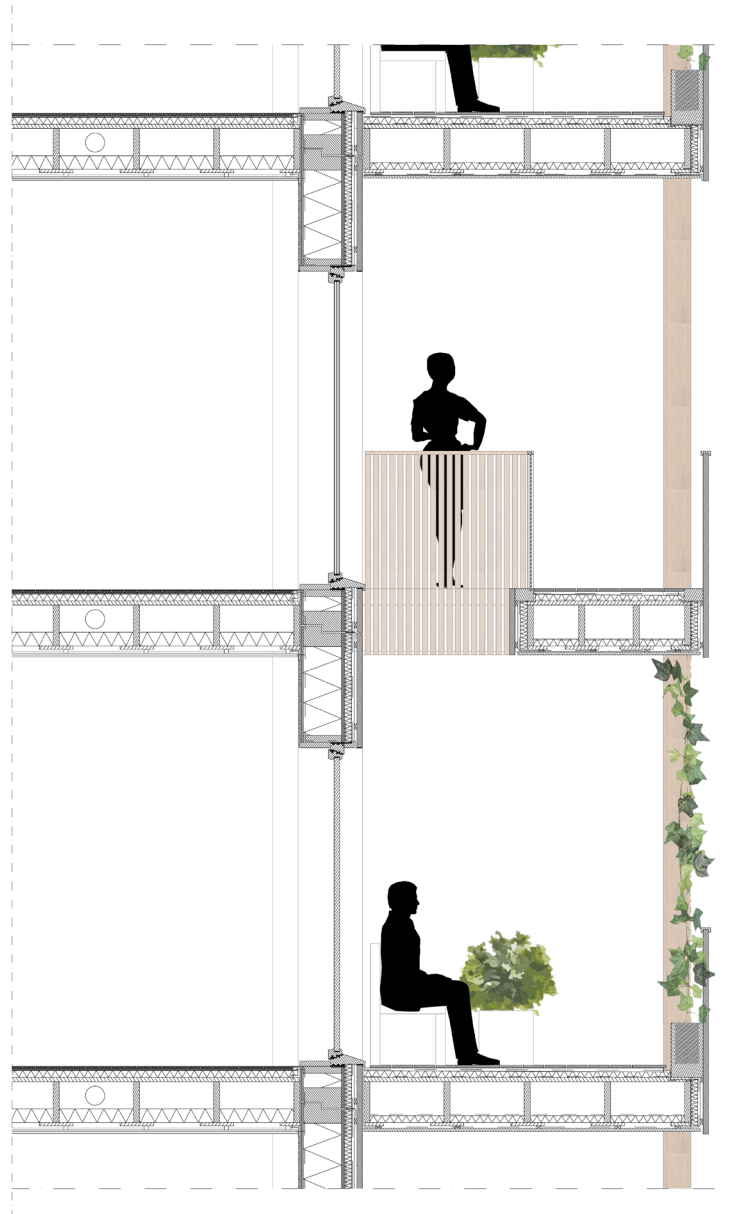


North-South Section 1:200  
Winter

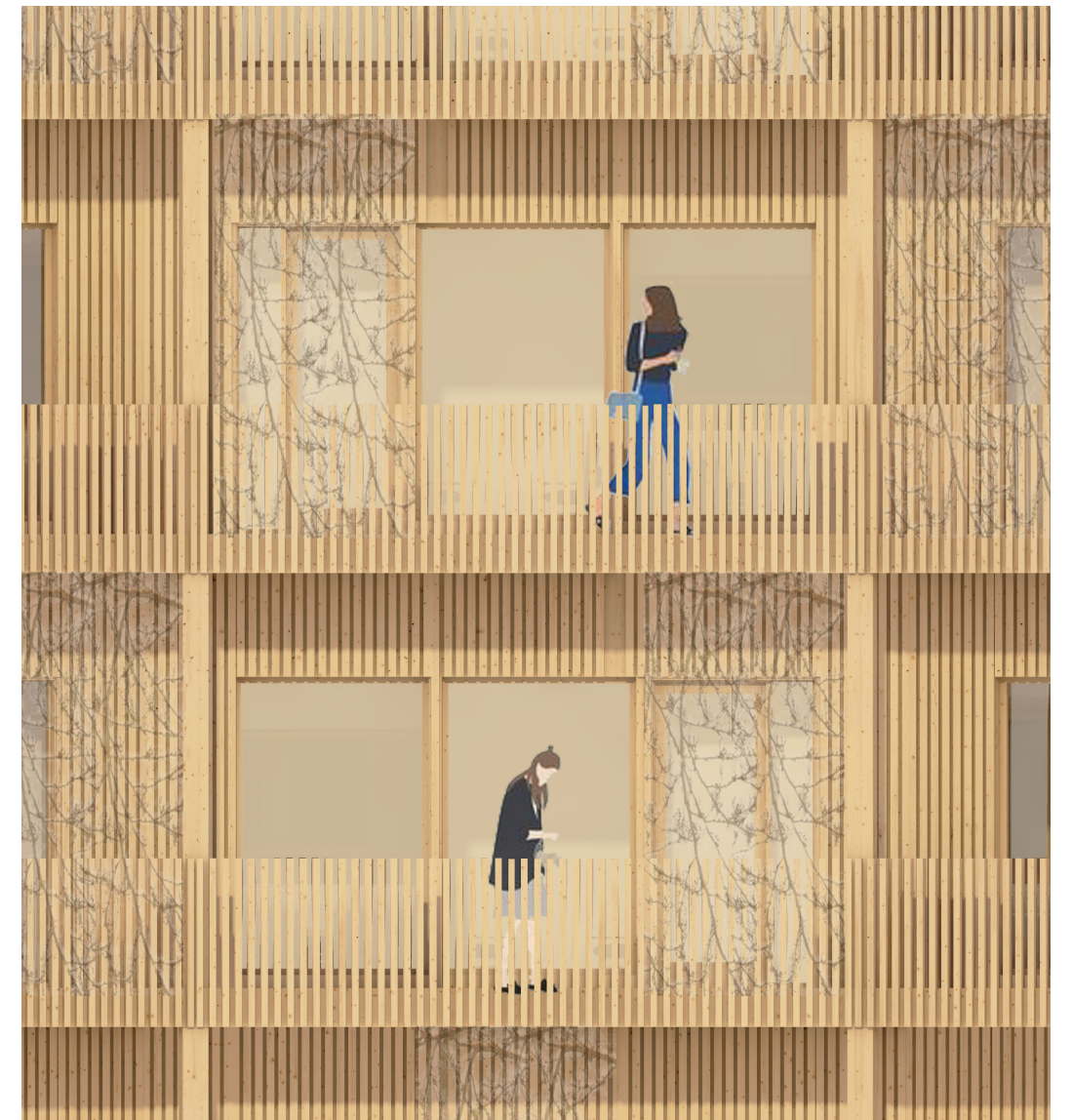




# Passive Climate | Sun Shading



Summer



Winter

**South Facade Fragment 1:20**





# Passive Climate | Window to Wall Ratio

WWR N	10-15%
WWR O-E	20-30%
WWR Z	30-50%



North Elevation 1:200



South Elevation 1:200





# Passive Climate | Window to Wall Ratio



**South Facade Elevation 1:20**

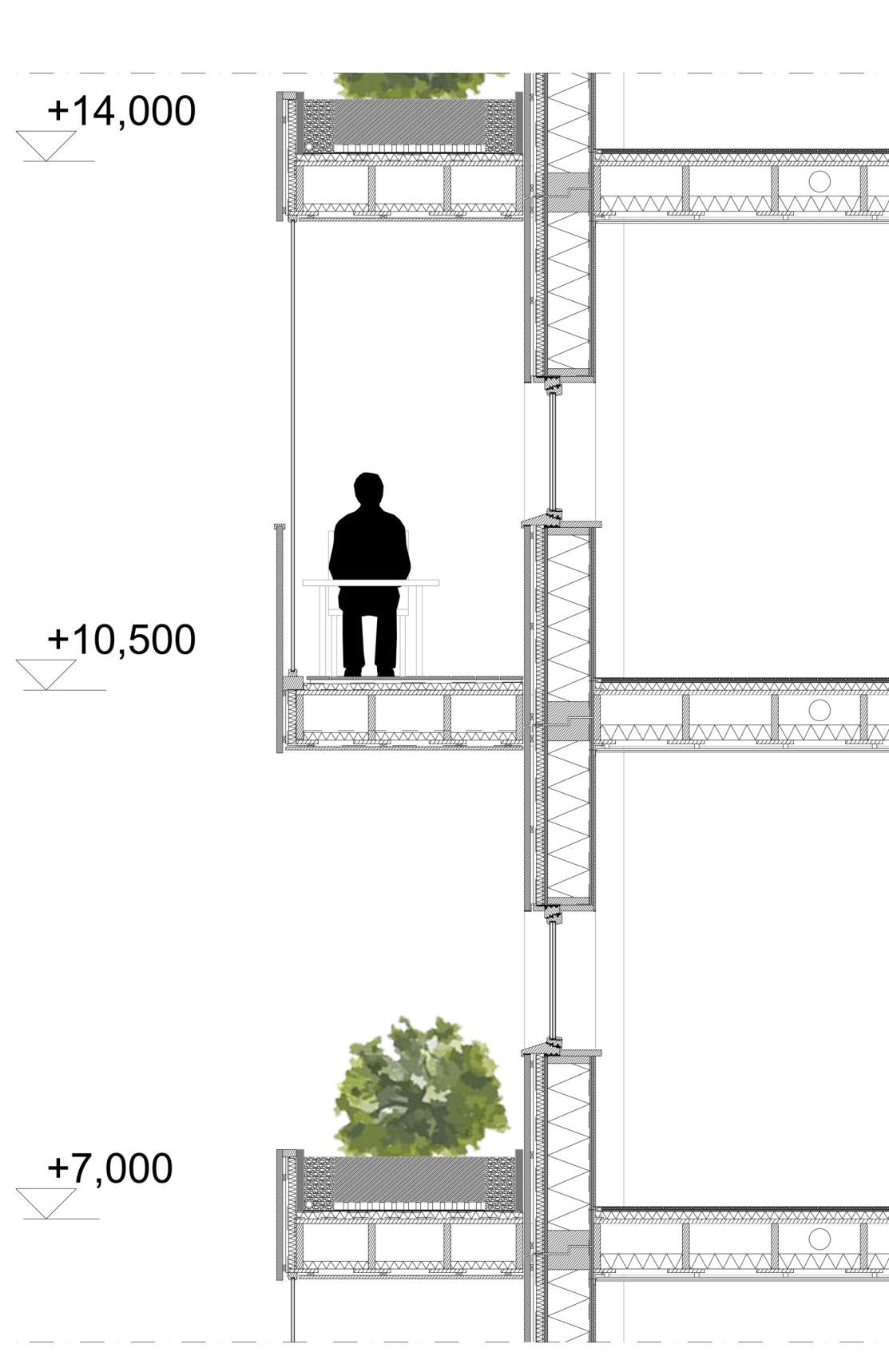


**North Facade Elevation 1:20**

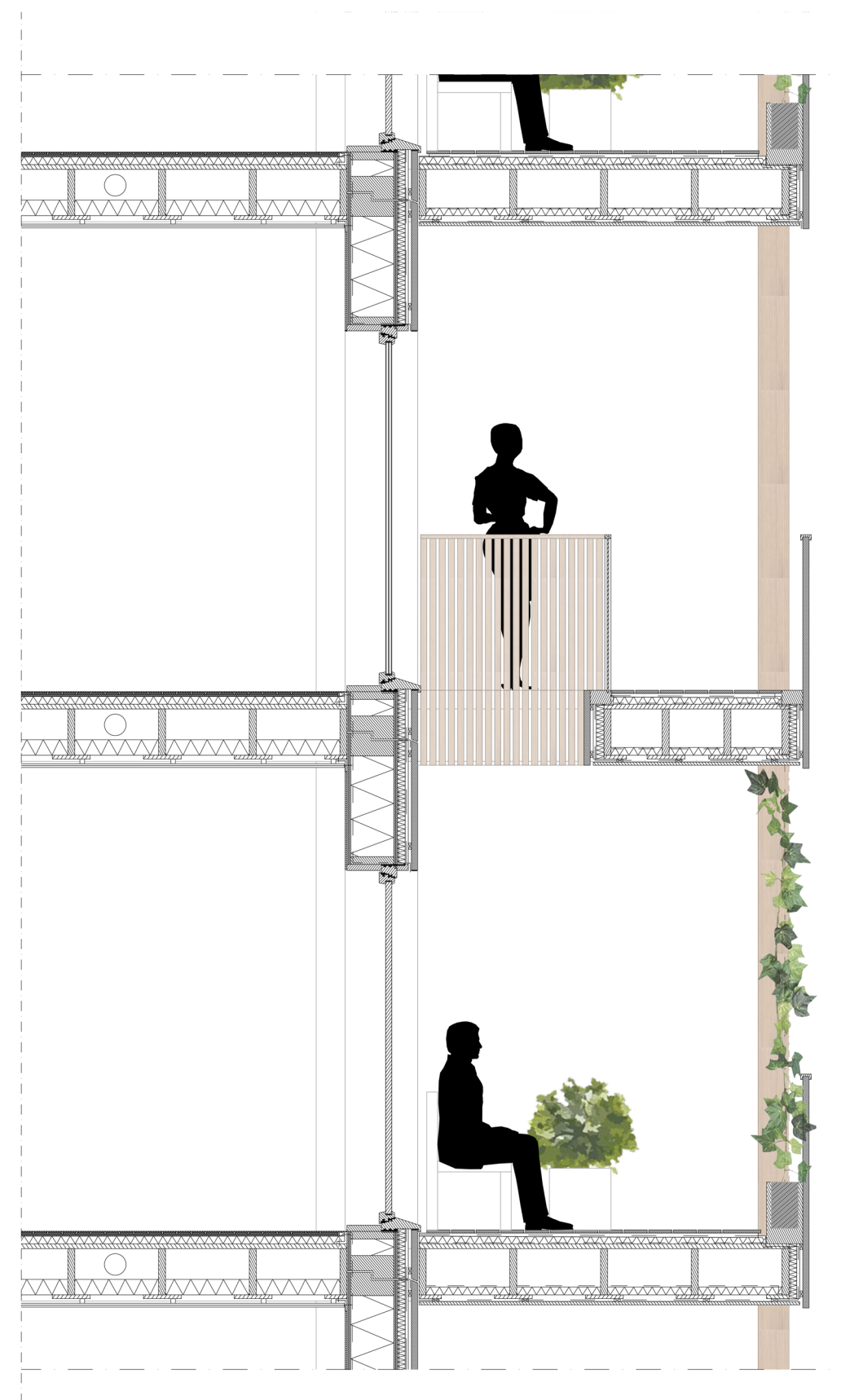




# Passive Climate | Window to Wall Ratio

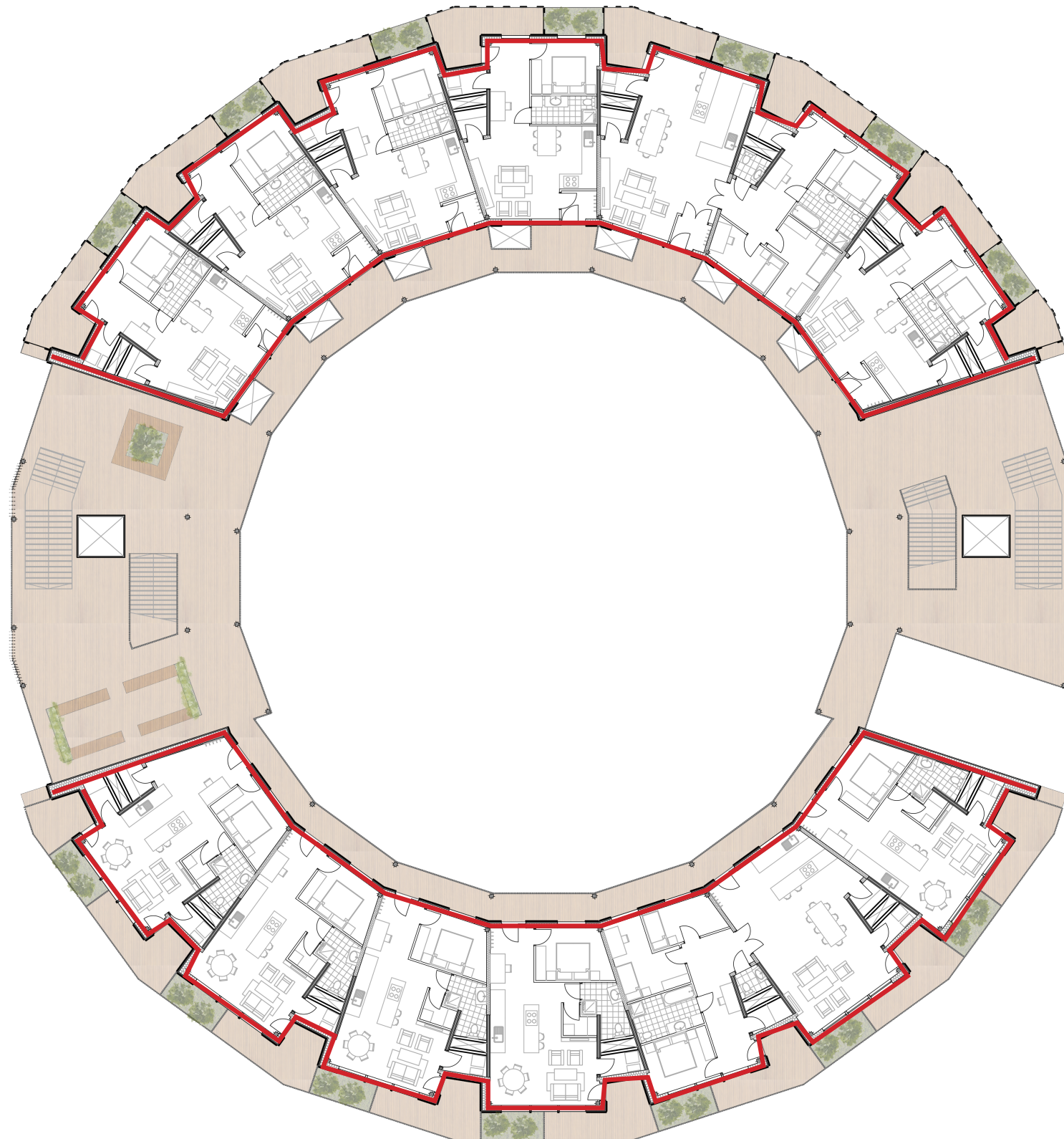


North Facade Section 1:20





# Passive Climate | Insulation

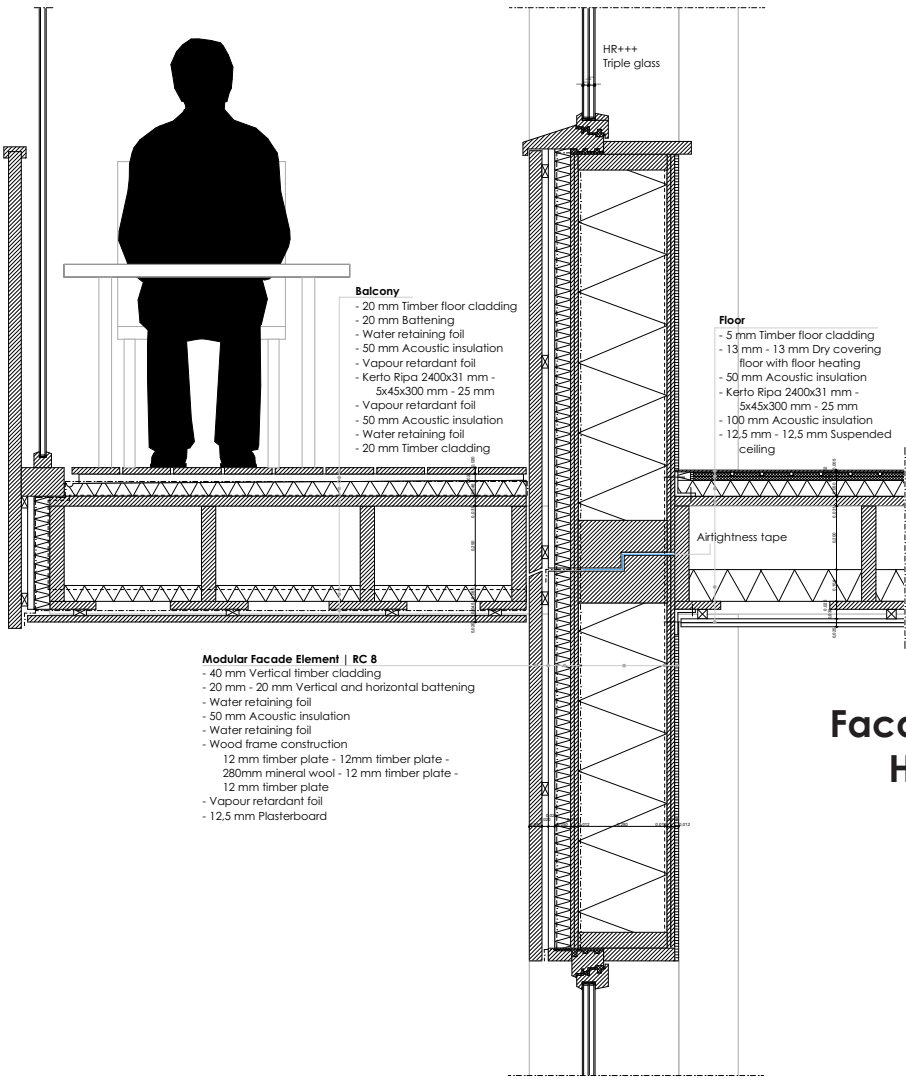


**Thermal Envelope 1:500**

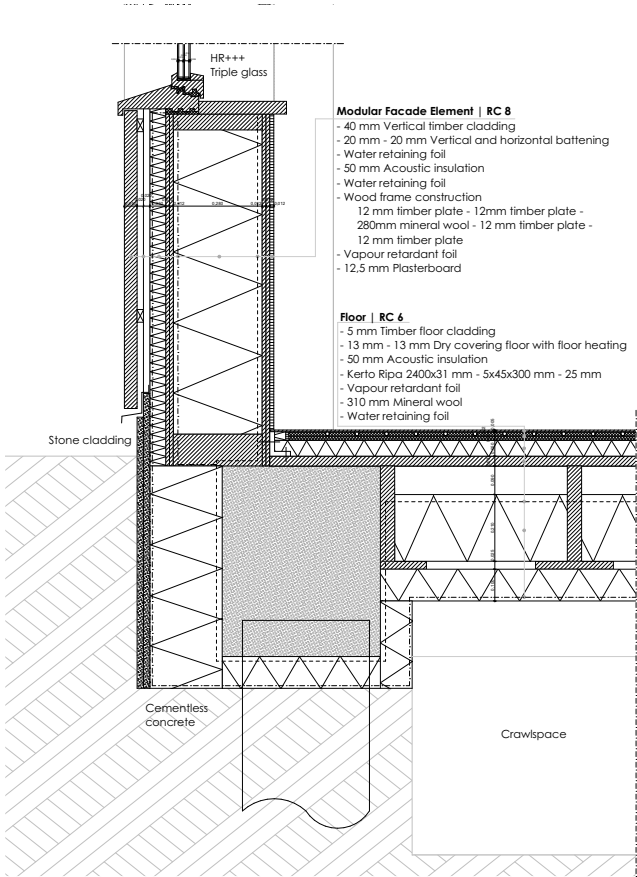




# Passive Climate | Insulation

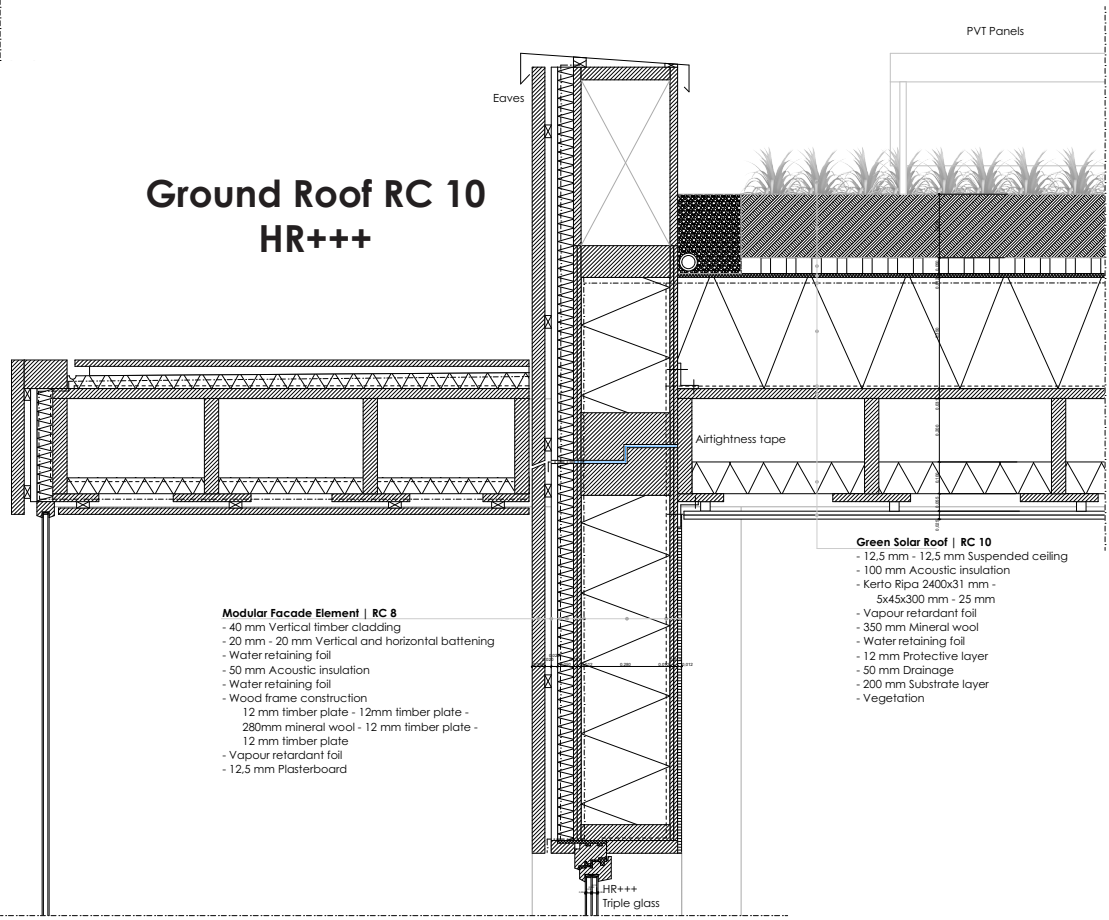


Detail Facade 1:5



Detail Ground Floor 1:5

Ground Floor RC 6  
HR+++

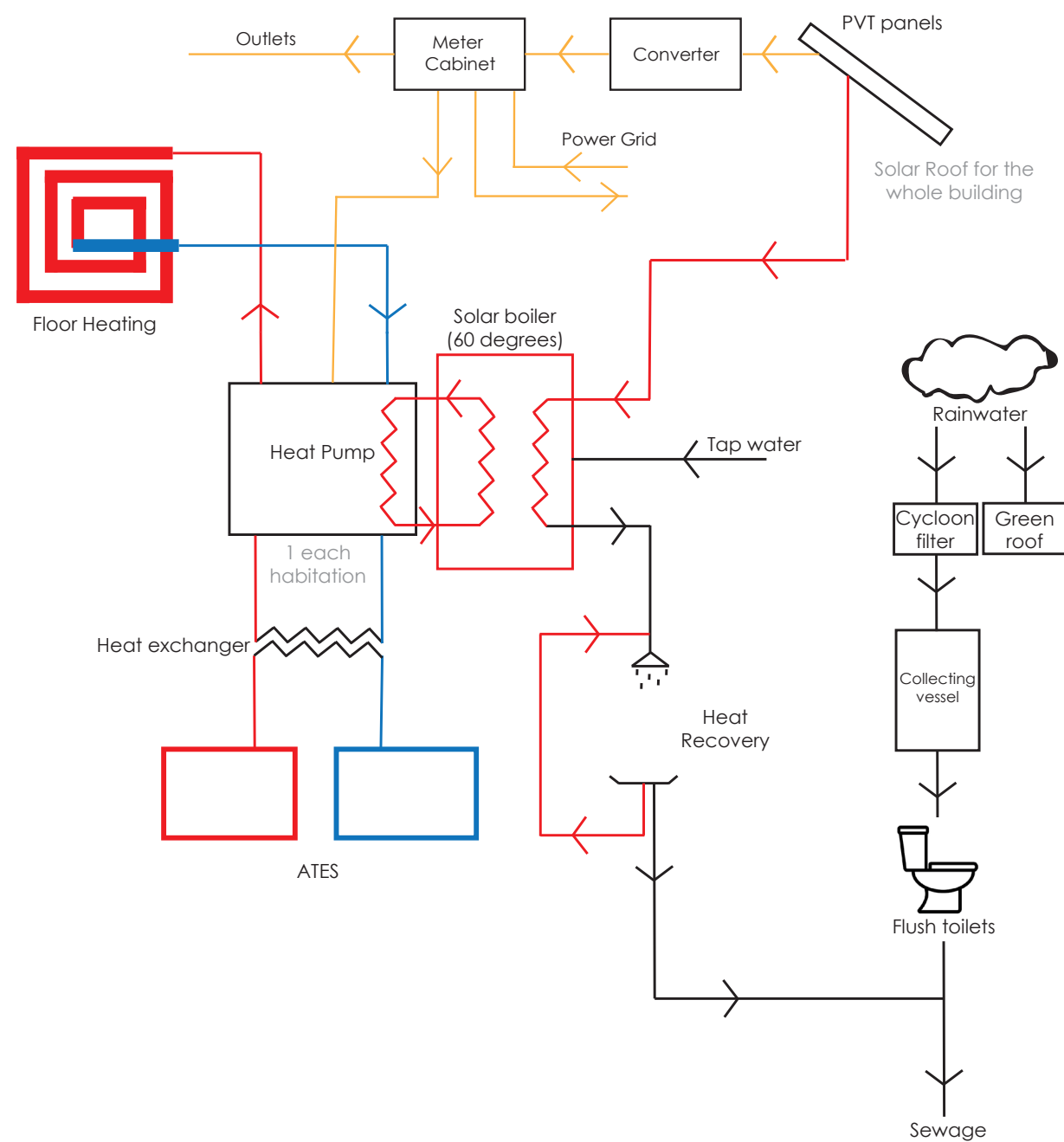


Detail Roof 1:5

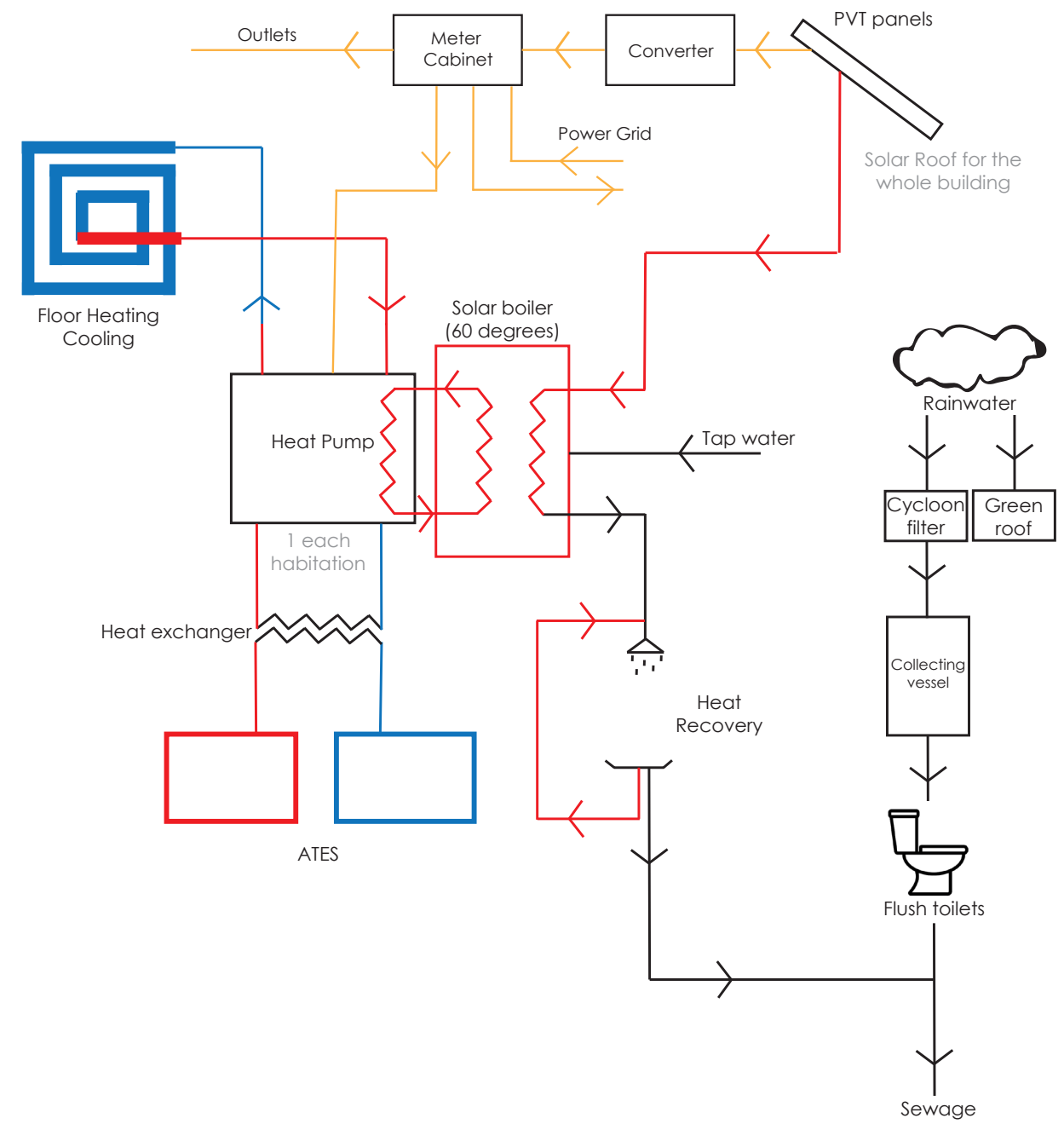




# Active Climate



Winter

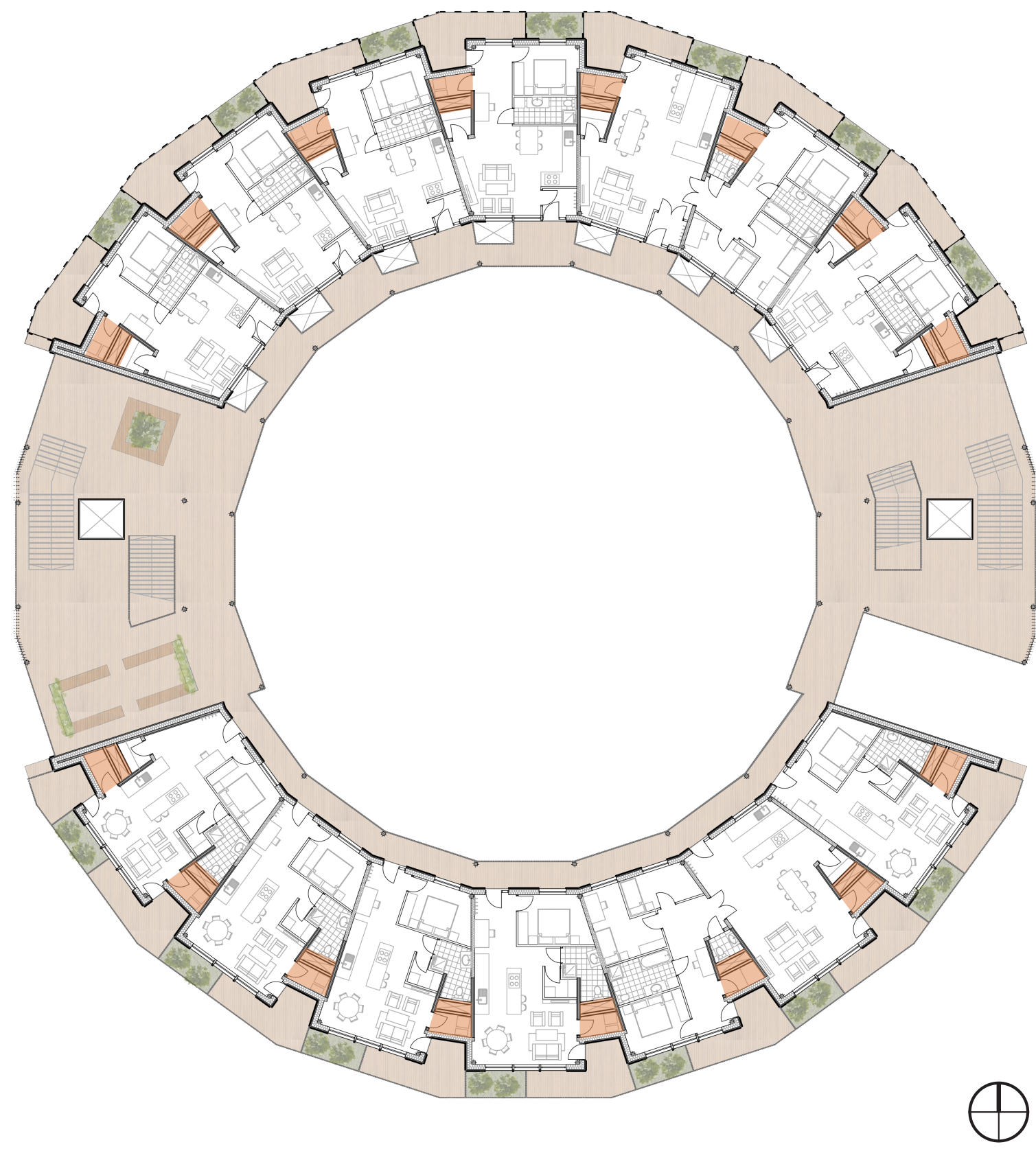


Summer

Active System Climate Diagram





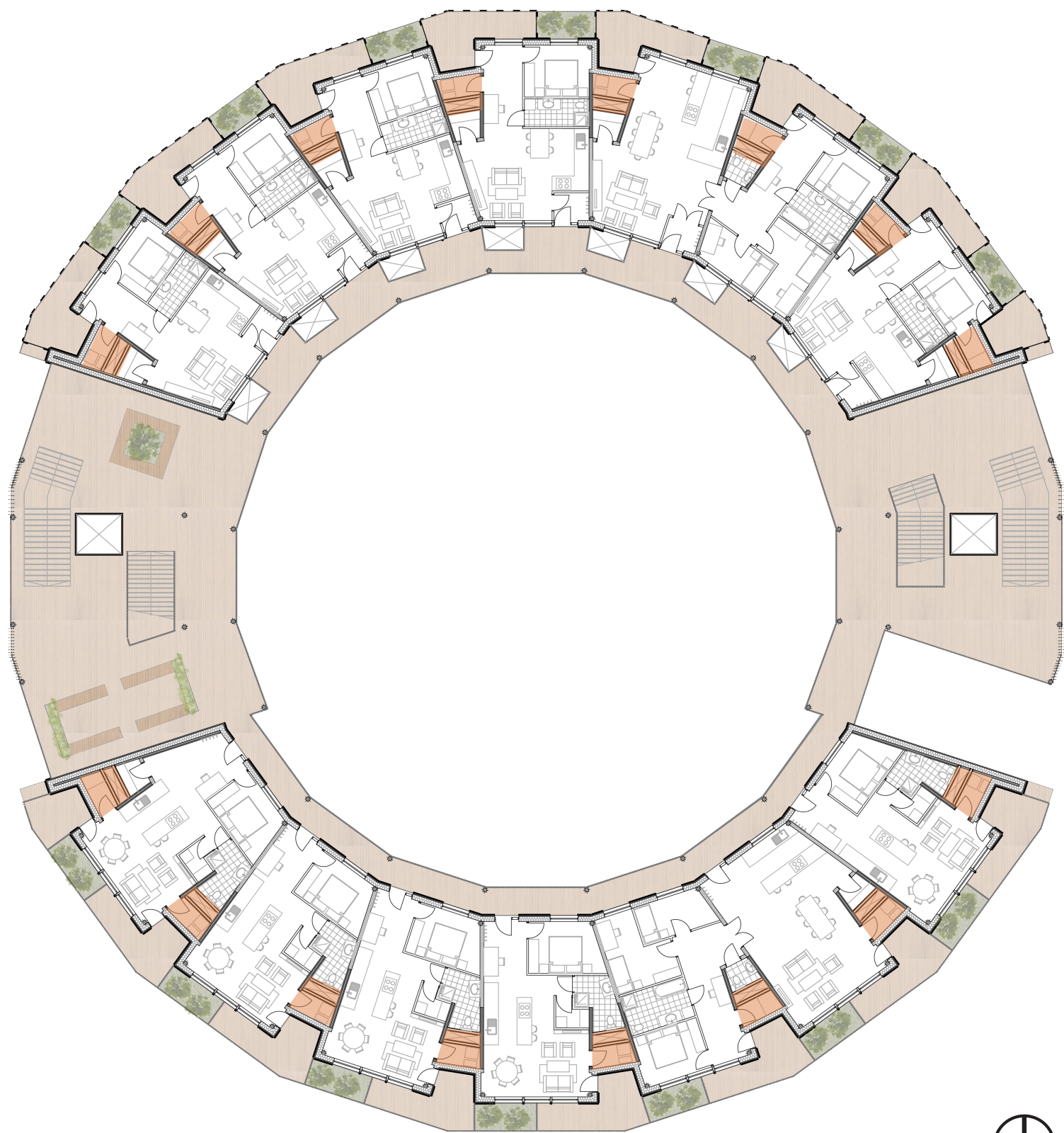


Floorplan Second Floor Technical Area 1:200

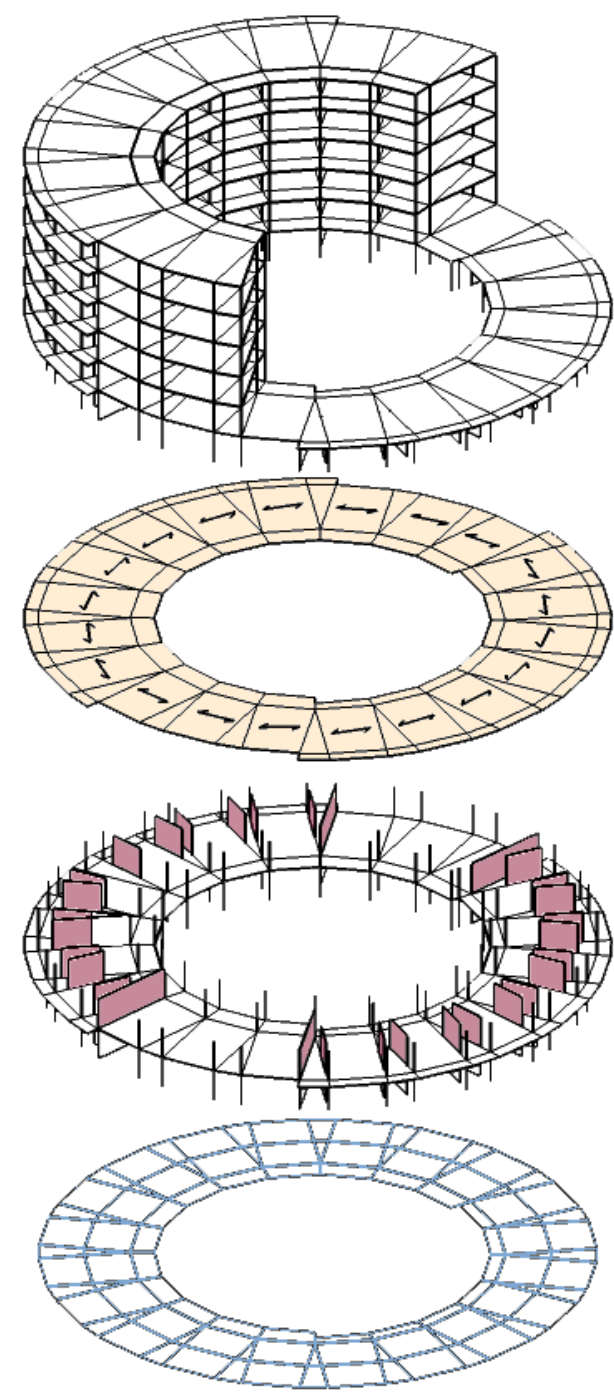




# Modular Strategy | Flexibility Structure



Floorplan Second Floor Technical Area 1:200



Wooden Hollow-Core Slabs

CLT Stability Walls  
Glulam columns and beams

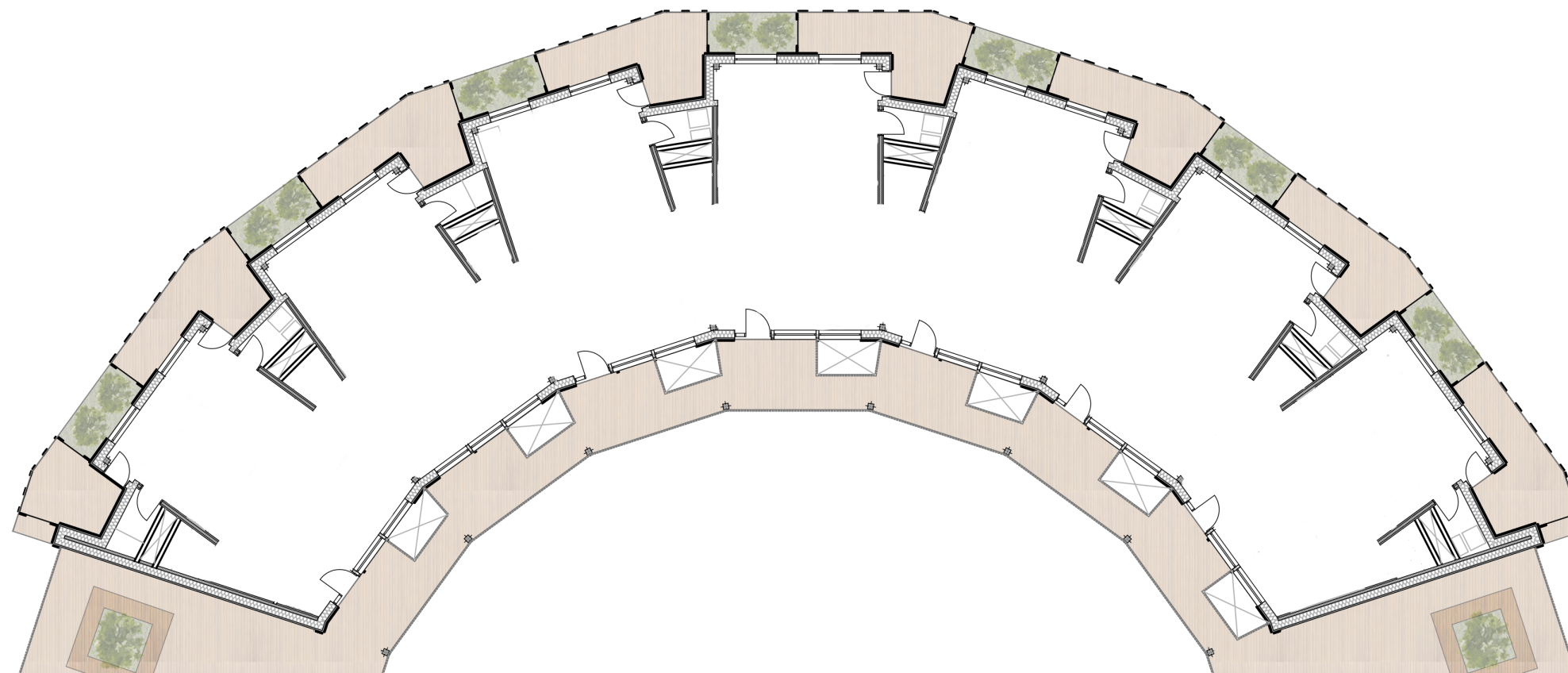
Cementless Concrete Foundation

Construction Axo





# Modular Strategy | Flexibility Structure

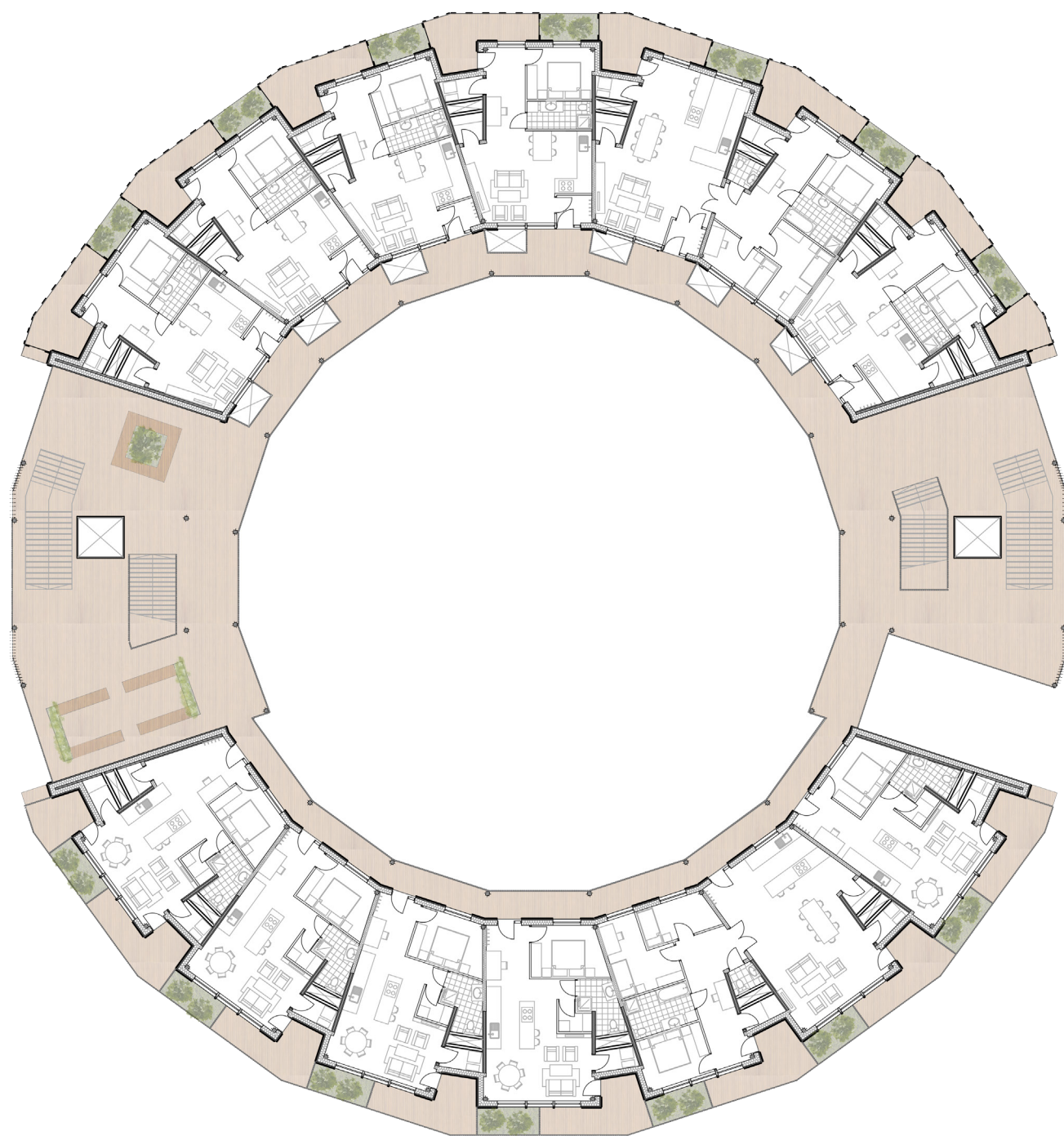


Empty Floorplan 1:200

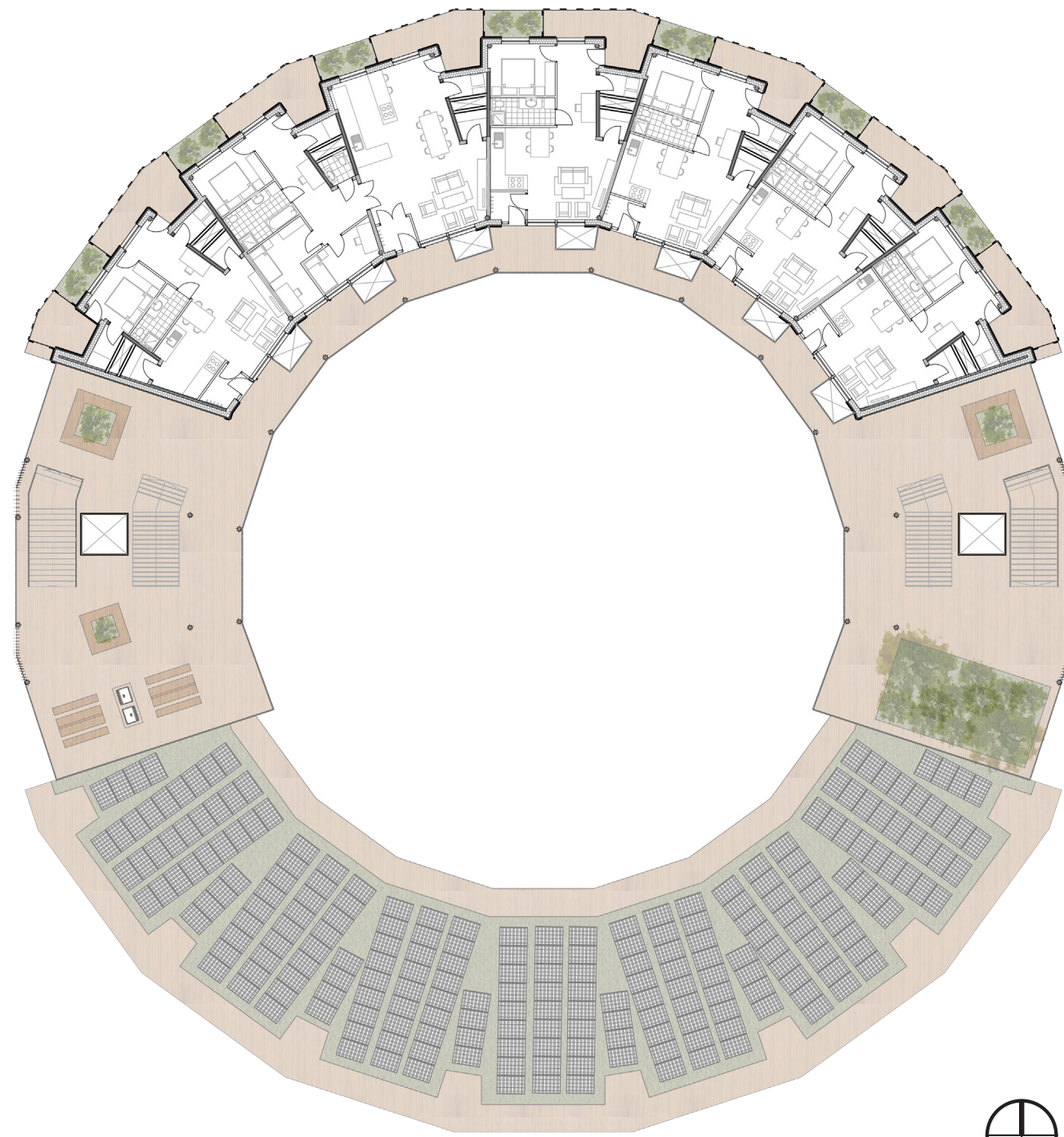




# Modular Strategy | Flexibility Structure



Floorplan Second Floor 1:200

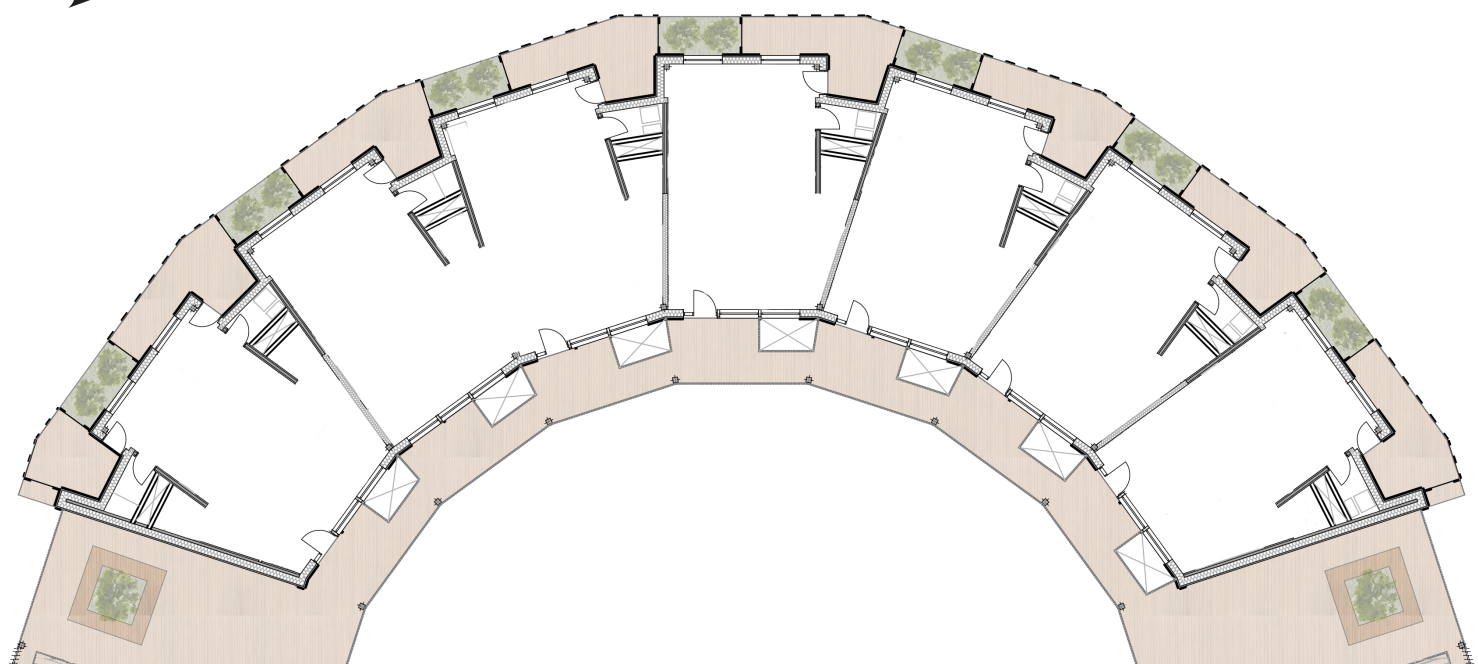
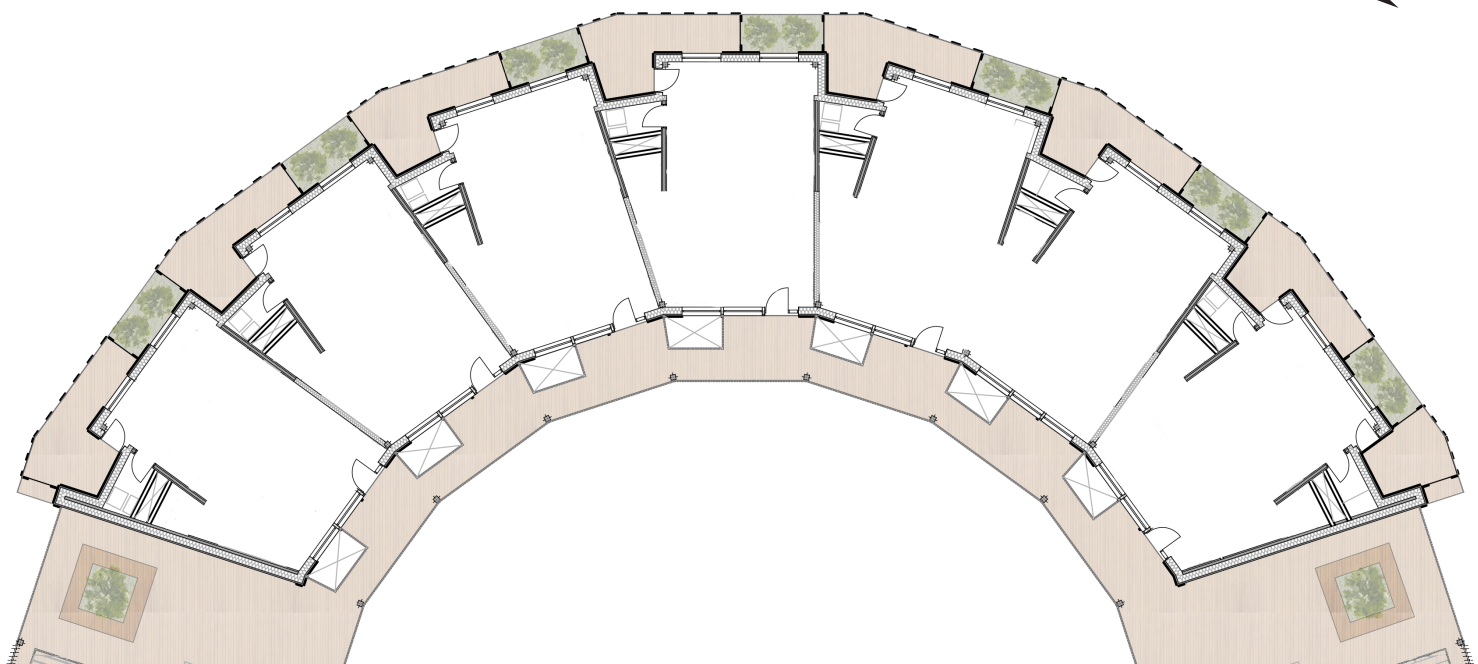
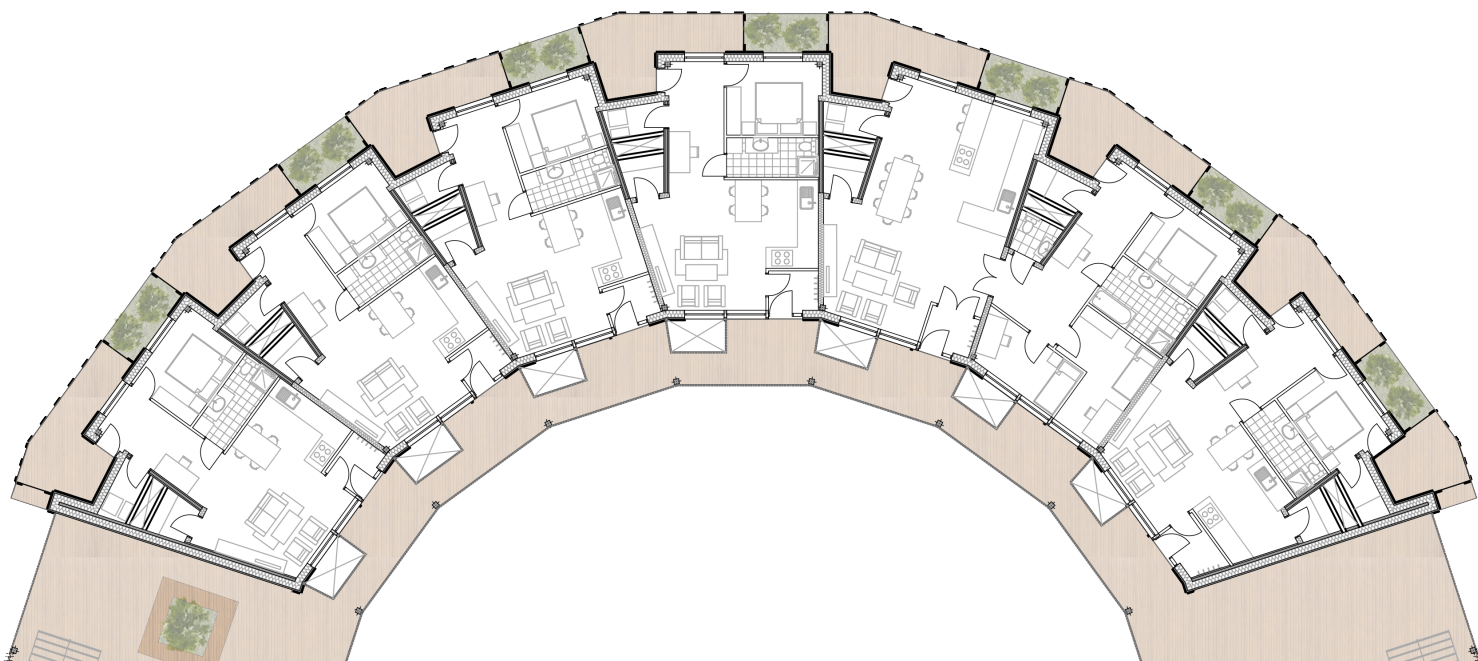


Floorplan Third Floor 1:200





# Modular Strategy | Mirrored Modules



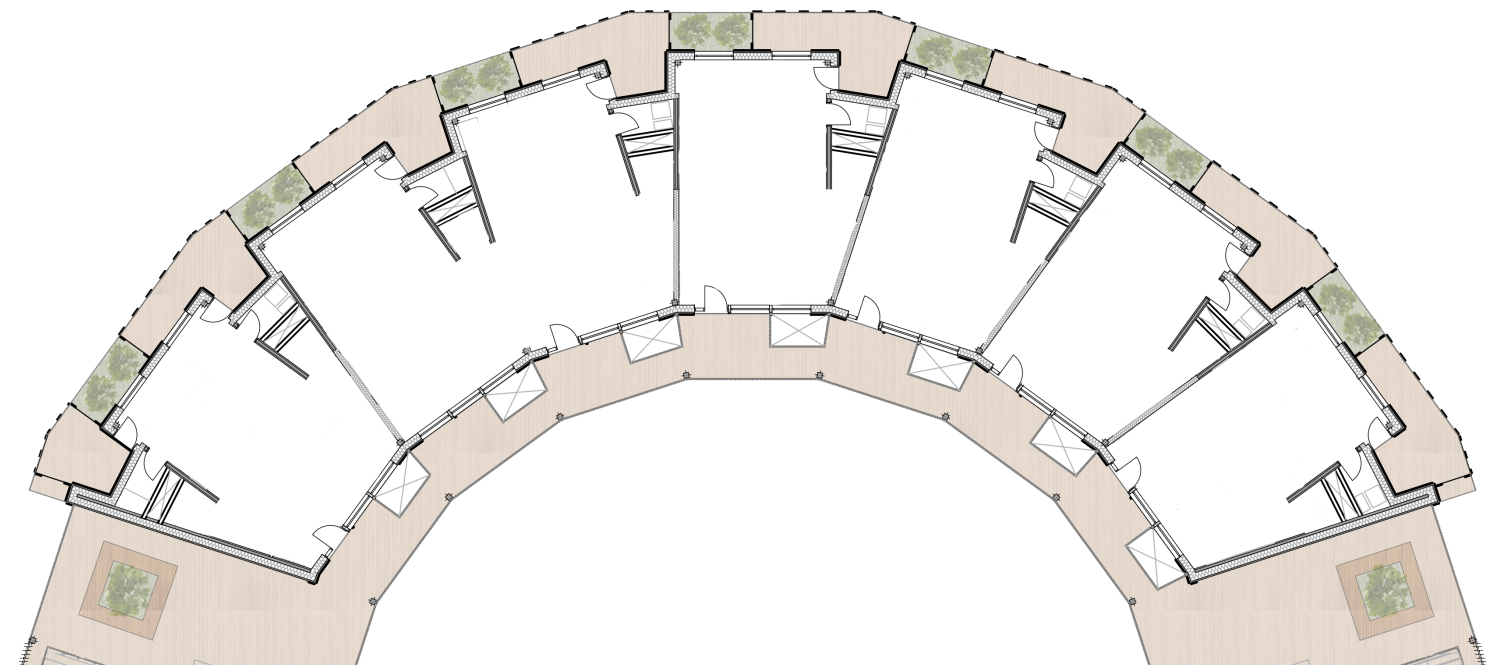
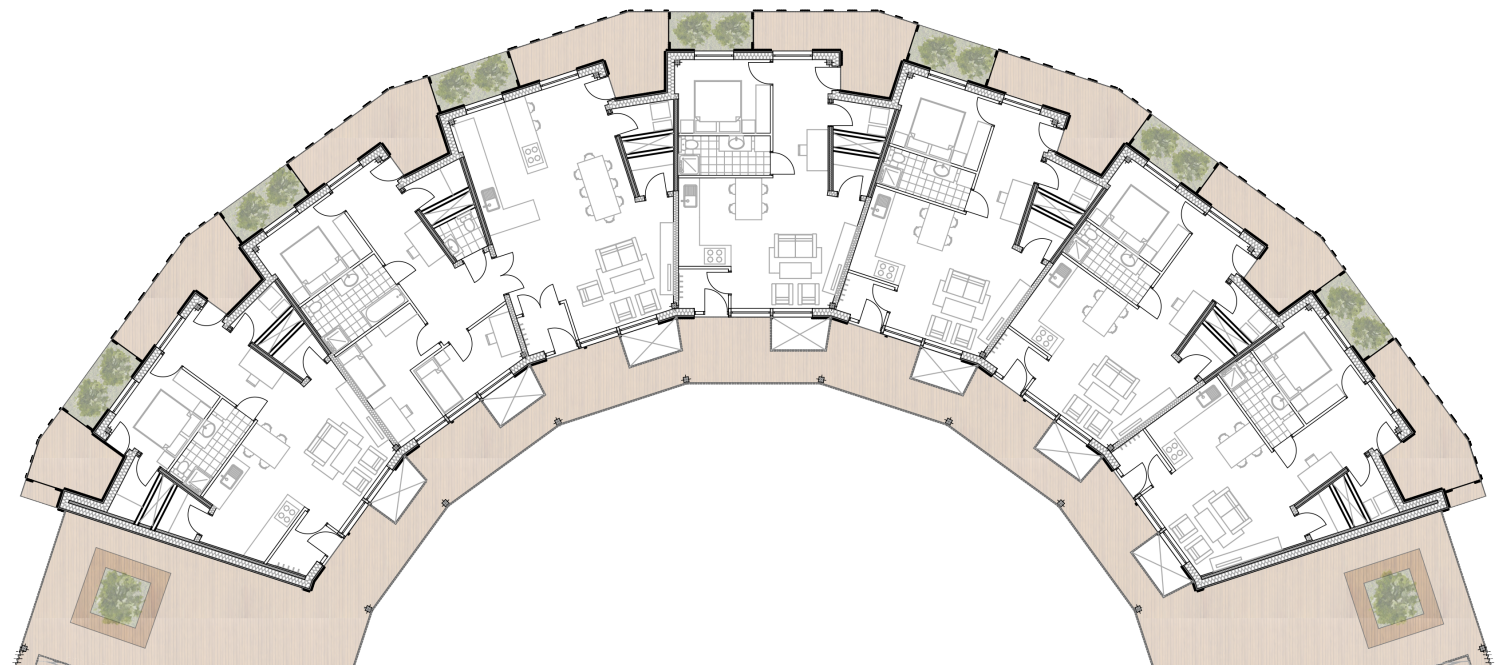
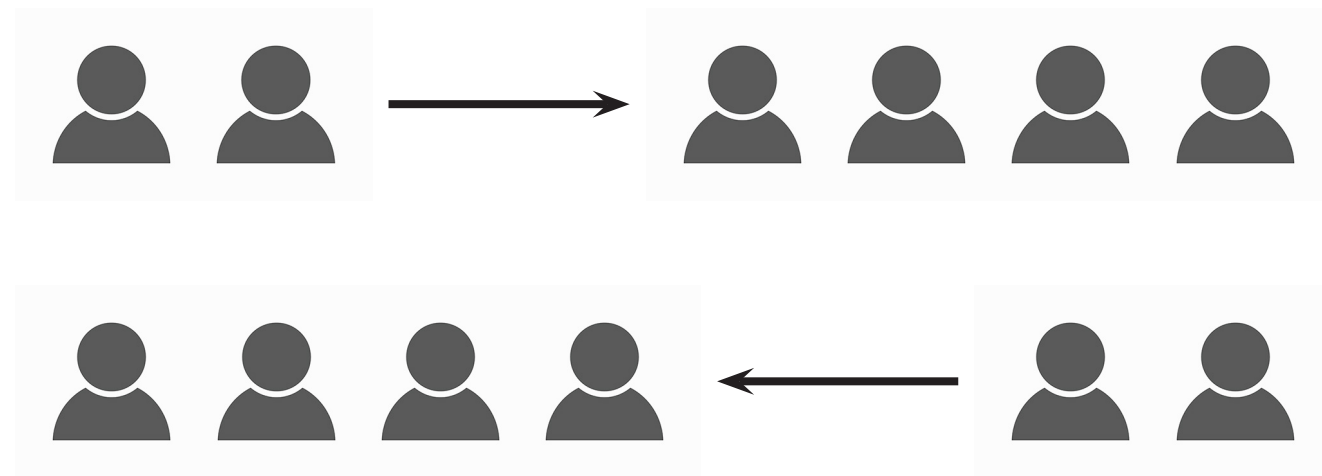
Floorplan Second Floor 1:200

Floorplan Third Floor 1:200





# Modular Strategy | 1-2 Modules



Floorplan Third Floor 1:200





# Modular Strategy | Facade Modules

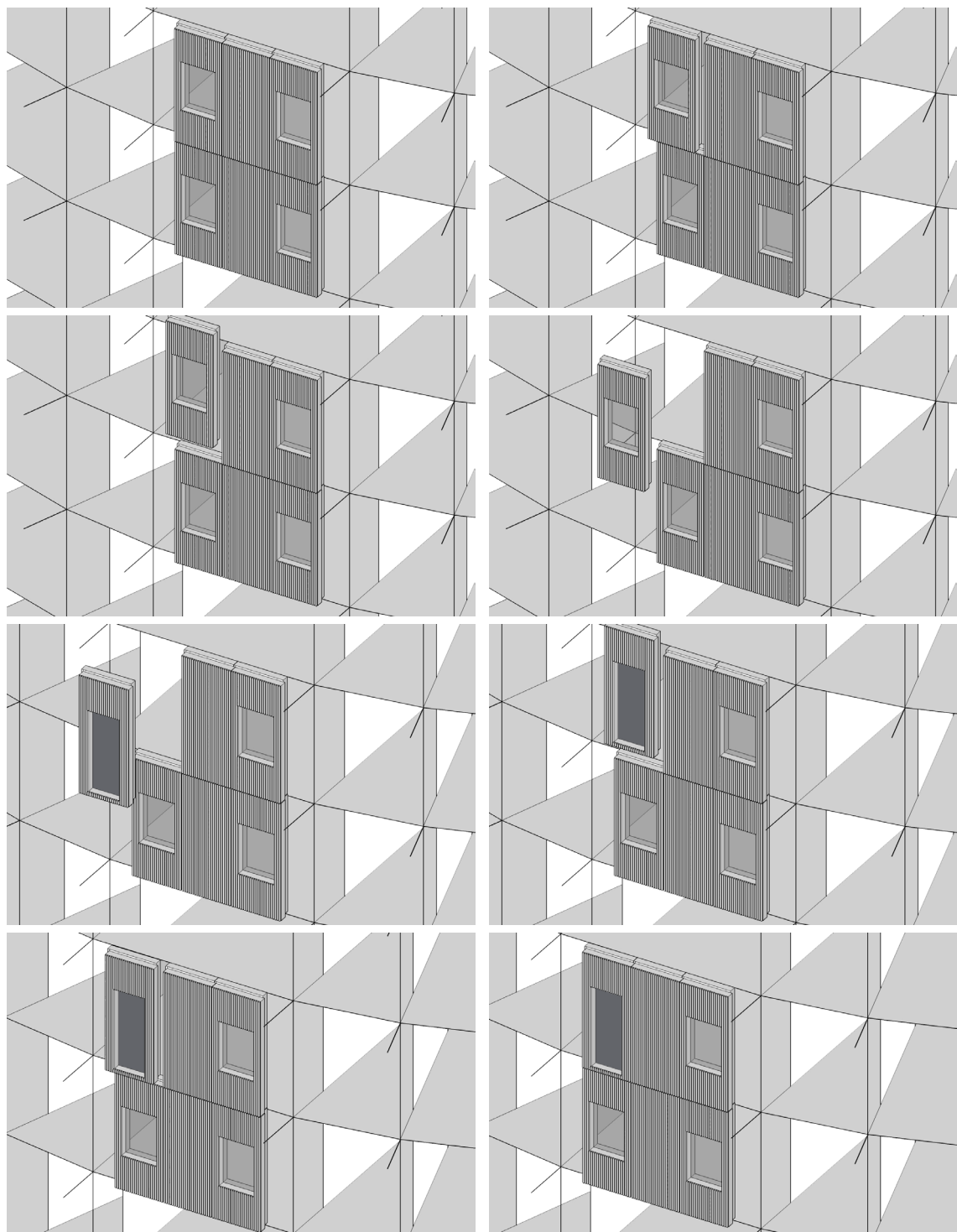
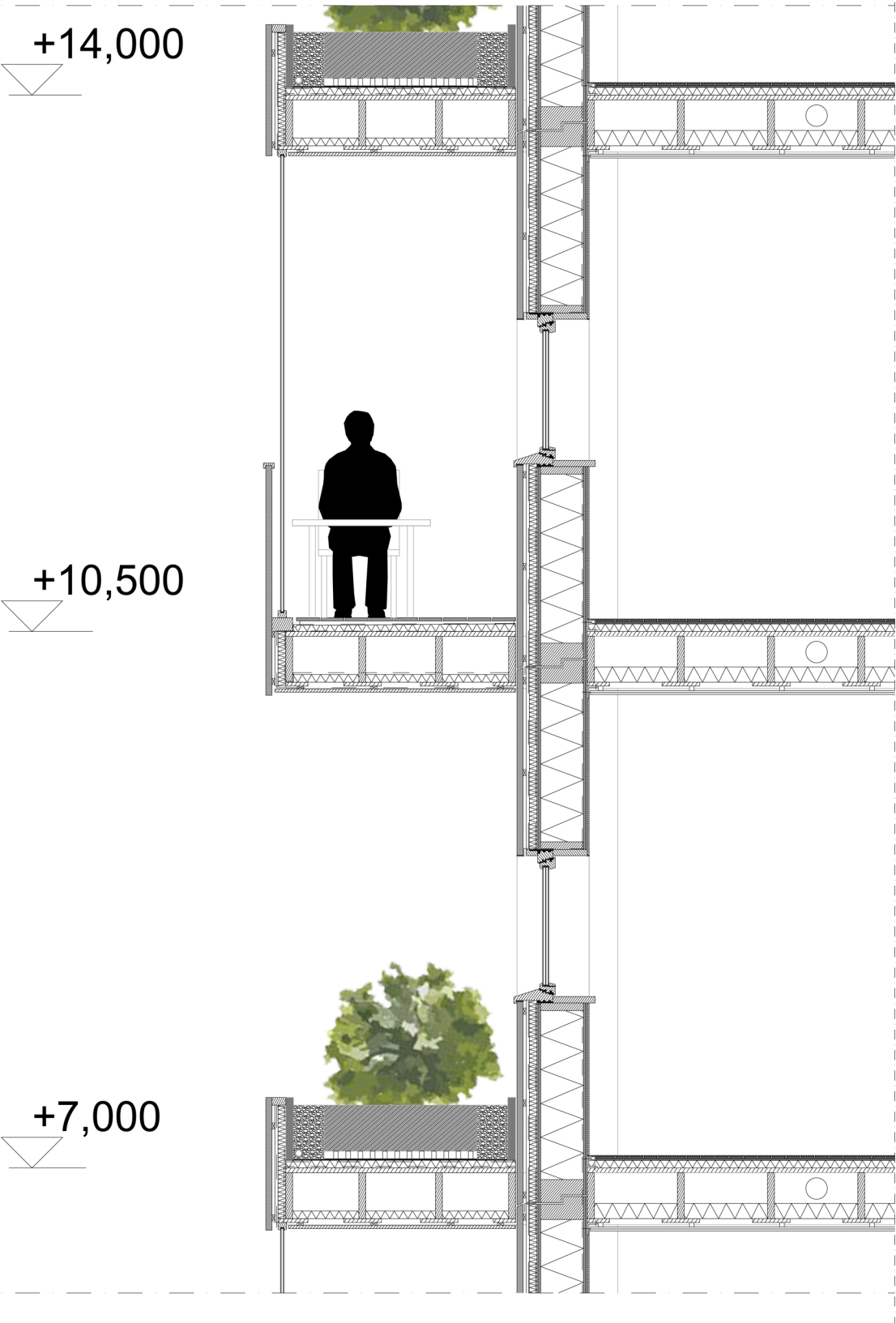


Diagram Modules (1,5 m x 3,5 m)



North Facade Section 1:20

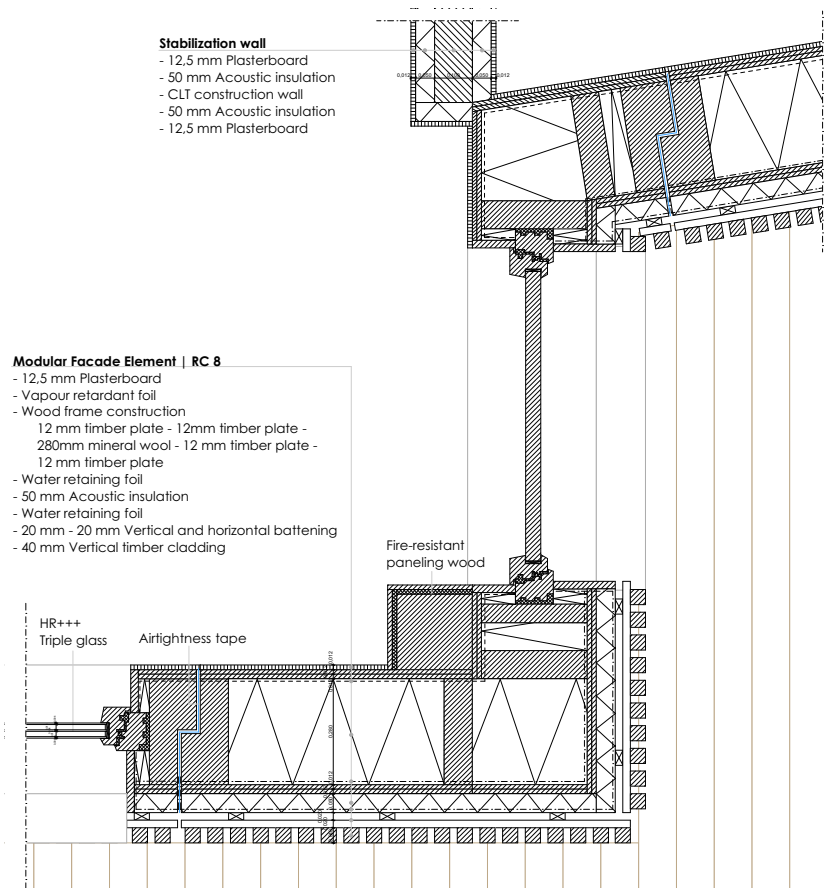




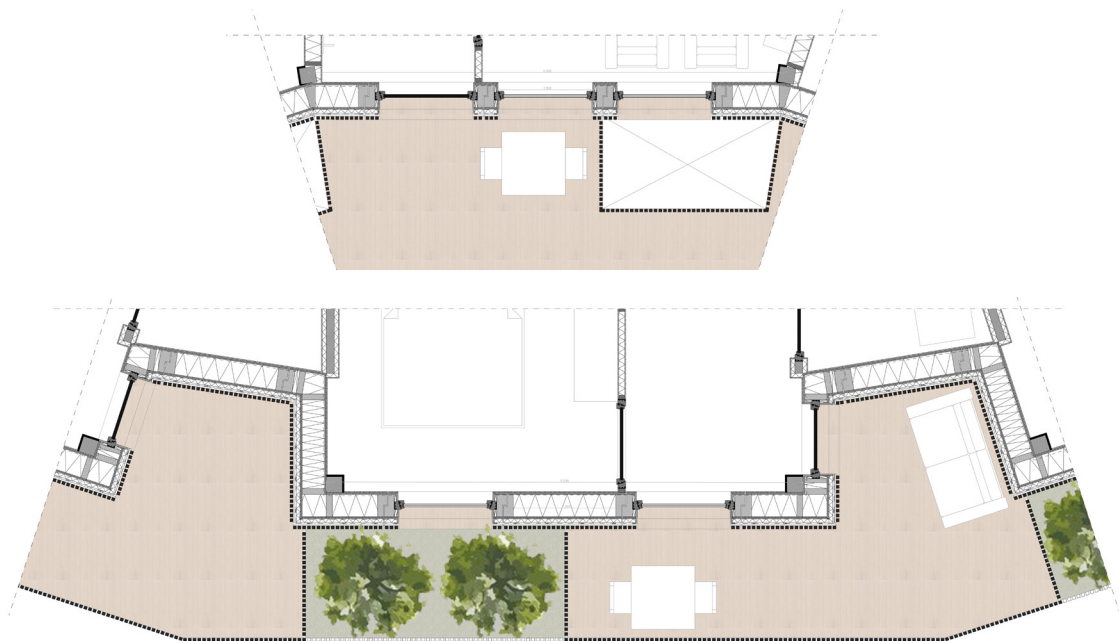
# Modular Strategy | Facade Modules



North Facade Elevation 1:50



Horizontal Detail Facade 1:5



Horizontal Section 1:20



South Facade Elevation 1:50



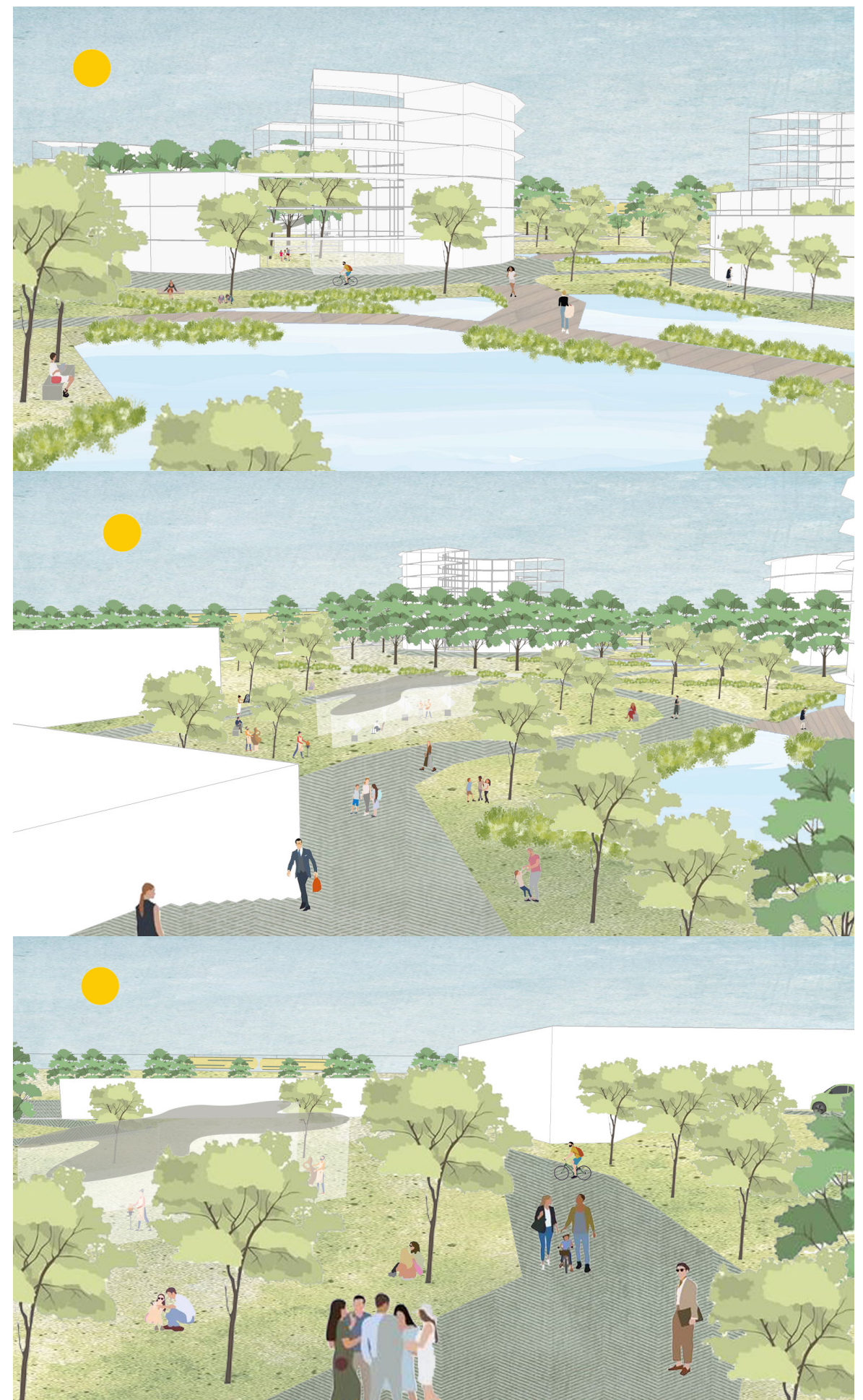


# Architectural Design



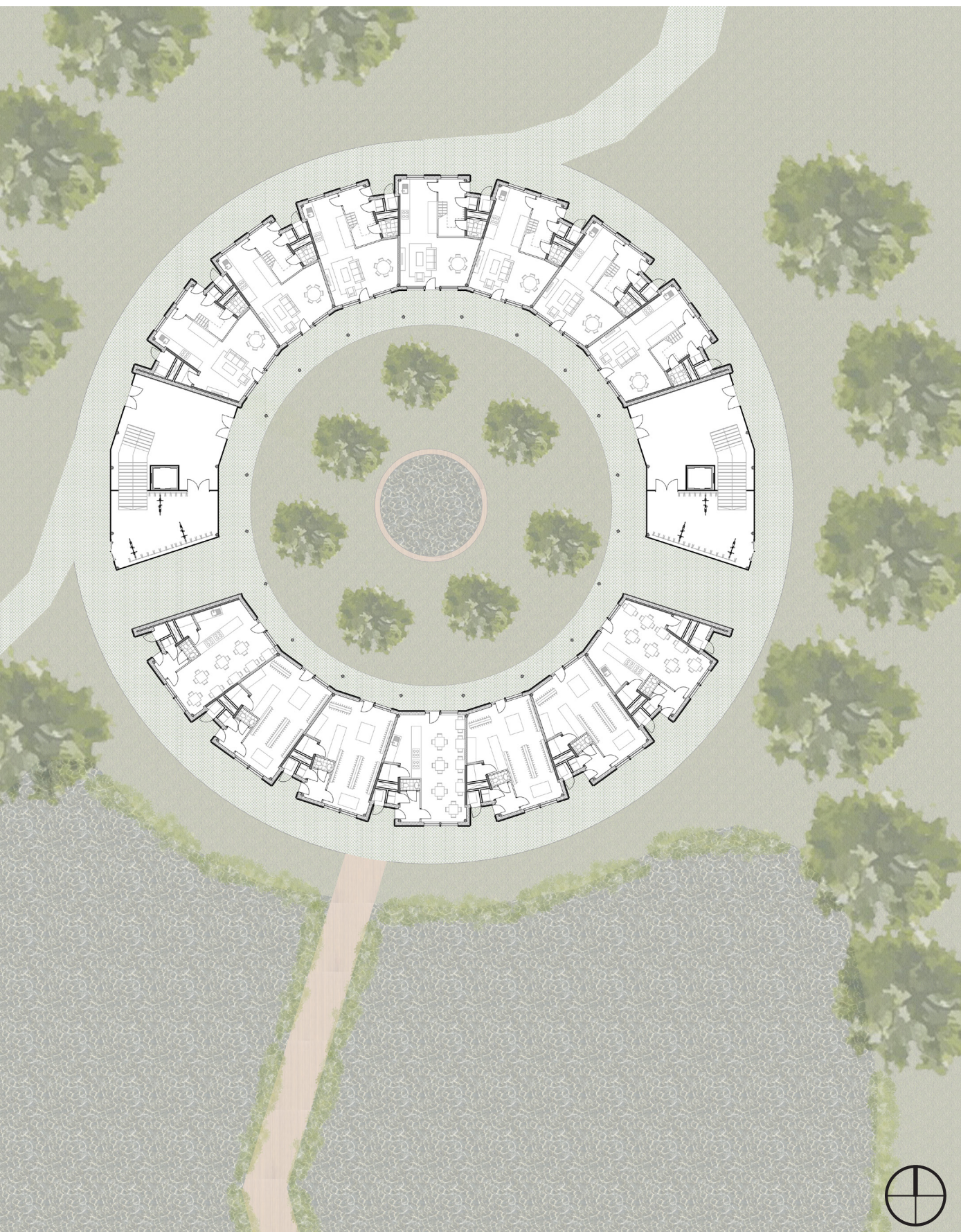


# Social Cohesion Neighbourhood





# Social Cohesion | Streets



Ground Level in Situation 1:500



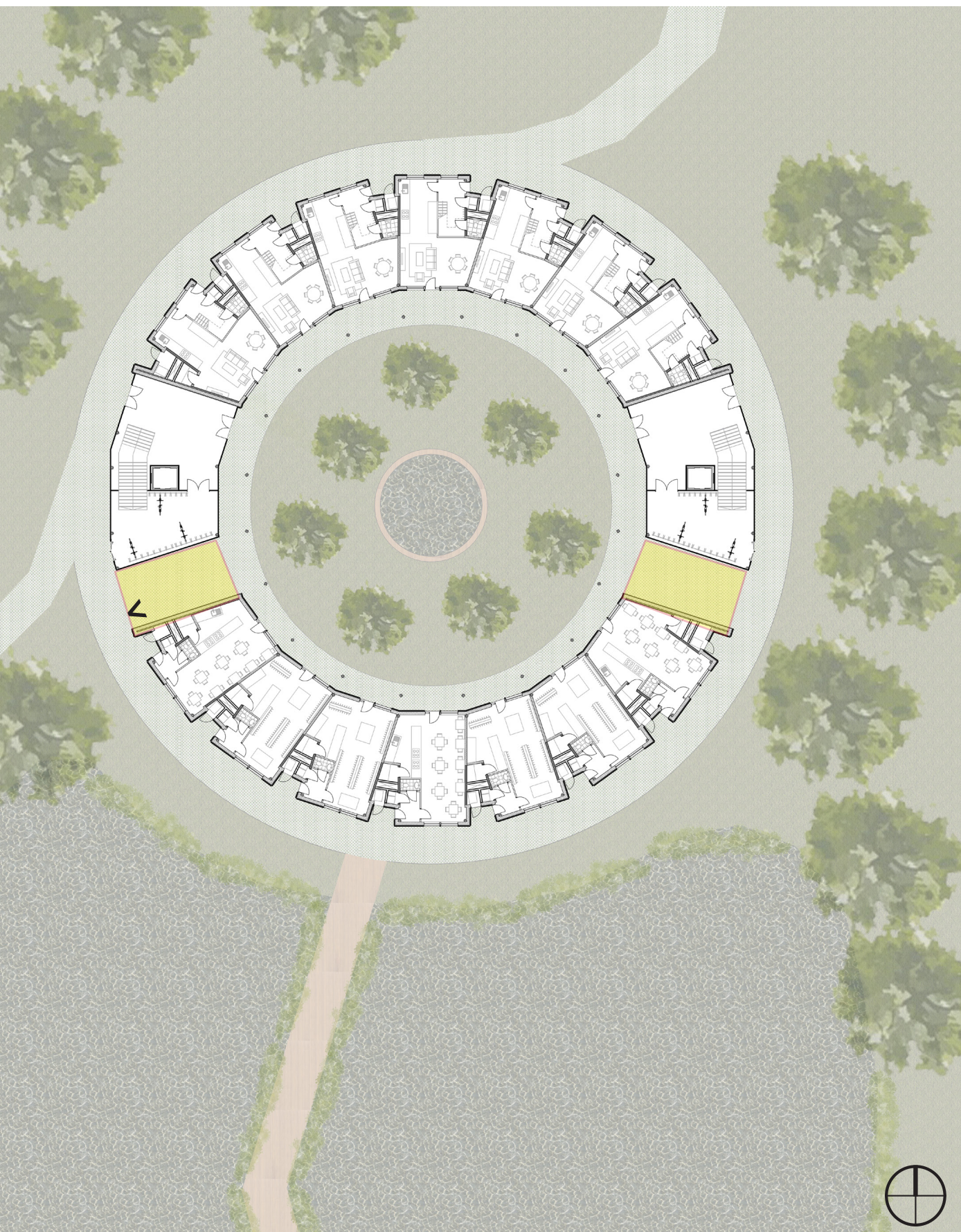


# Social Cohesion | Streets





# Social Cohesion | Streets

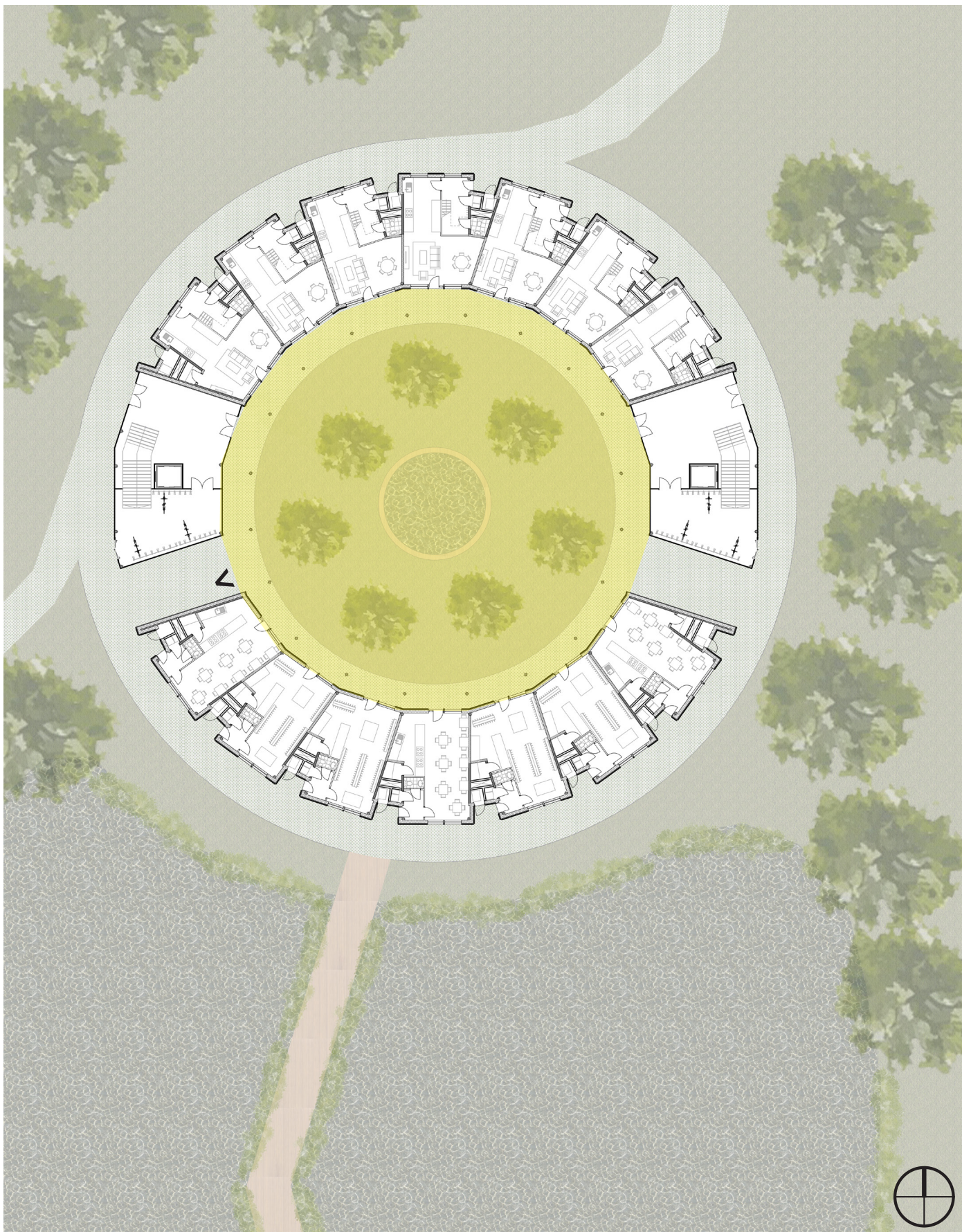


Ground Level in Situation 1:500





# Social Cohesion | Courtyard



Ground Level in Situation 1:500



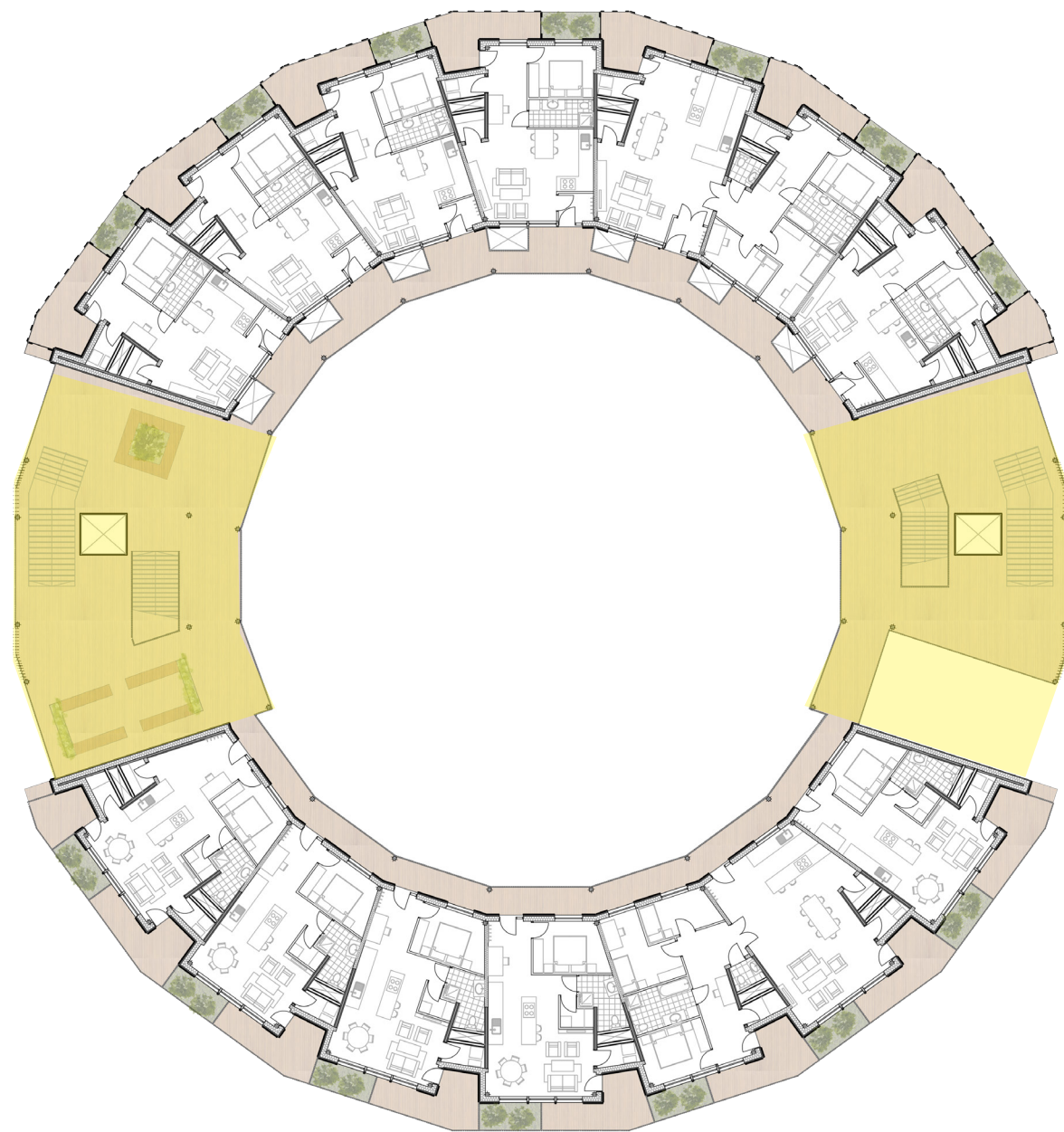


# Social Cohesion | Courtyard





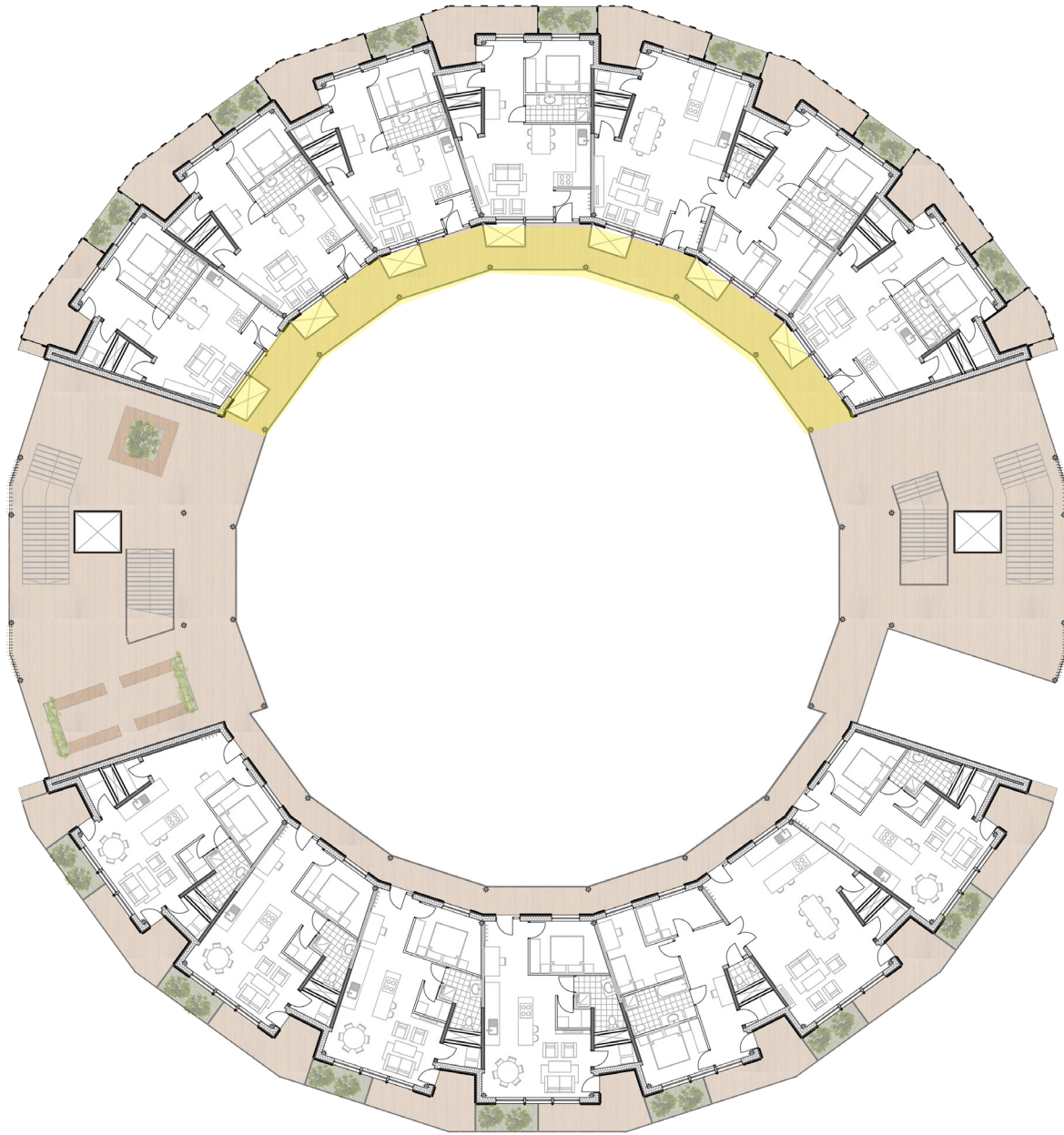
# Social Cohesion | Vertical Street



Floorplan Second Floor 1:200







Floorplan Second Floor 1:200



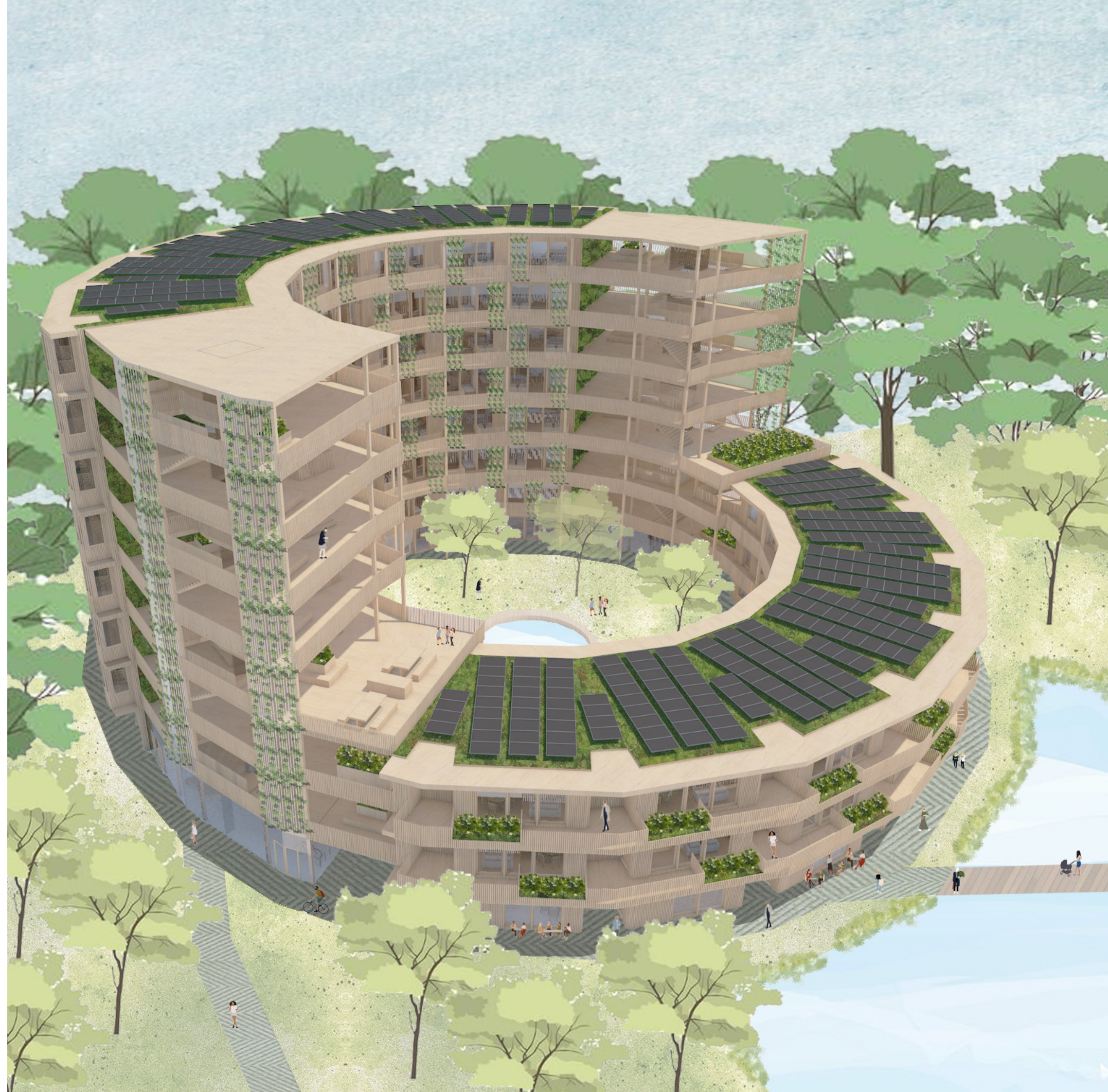


# Social Cohesion | Gallery





# Social Cohesion





# Solarpolis

Climate adaptive living

