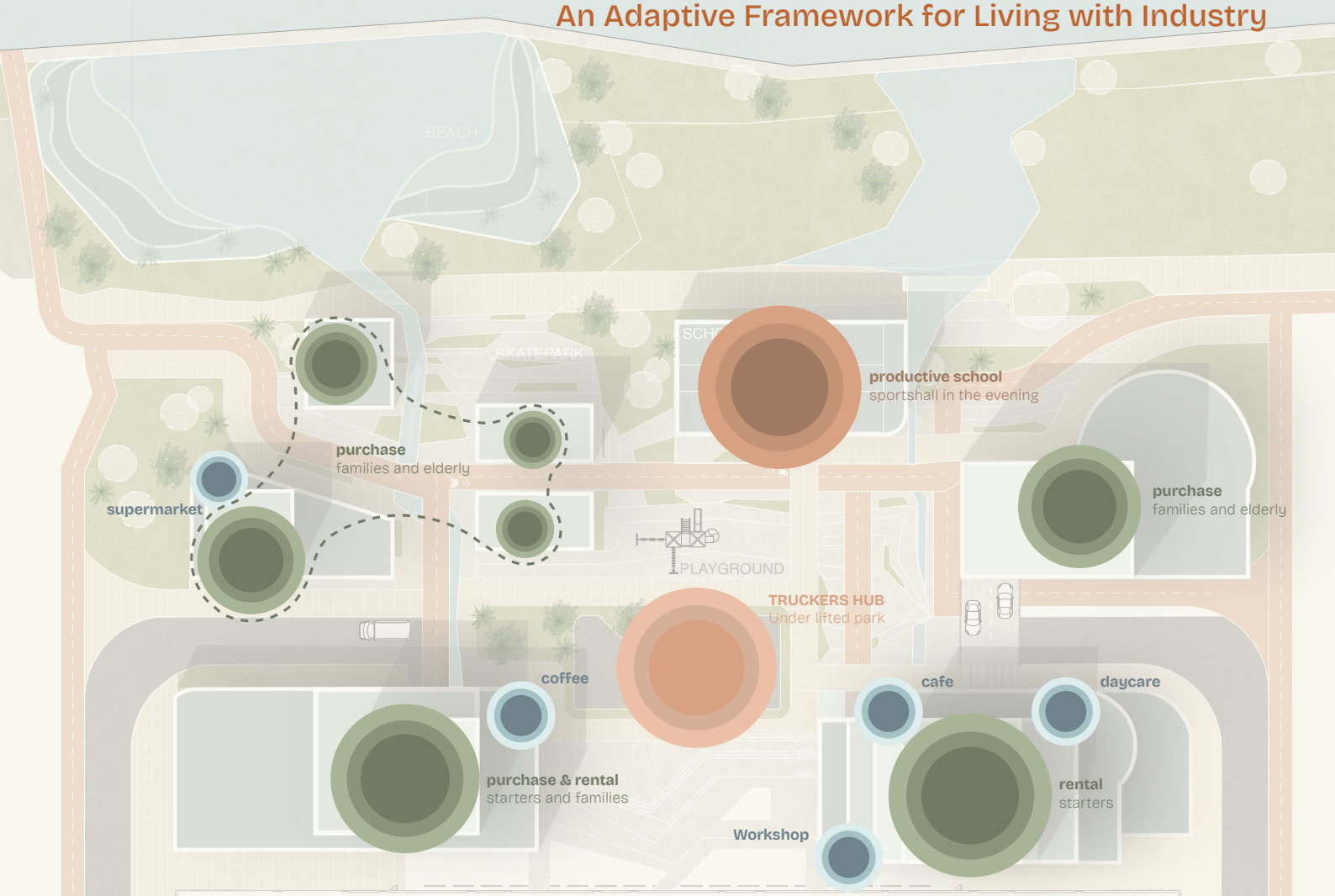
Between Shed and Polder

An Adaptive Framework for Living with Industry



SOLAR ROOF

Research done by Denise Heidema
Student number: 5664802

Technical Universit Delft
Msc3 'Advanced Housing Design
Ecologies of Inclusion'

Tutor Design: Olv Klijn
Tutor Group research: Olv klijn + Robbert Guis
Concsulted Expert Affordability & ownership: Darinka Czischke

ABSTRACT

The Netherlands is short approximately 400 000 homes, and nearly one million more are required by 2030. Greenfield expansion would consume the remaining open landscapes, including protected areas such as Midden-Delfland. The alternative is to densify the monofunctional industrial estates that line the urban edge, but most existing approaches displace the industry rather than integrate it. This project asks how an adaptive spatial framework, based on Habraken's Open Building principles, can enable the densification of a logistics site in Berkel en Rodenrijs (around 250 dwellings on the JoyLogistics plot) while integrating living, working and landscape into a system that evolves over time.

Following a research-through-design method, the project develops three interlinked design principles, supported by literature on Open Building, the productive city and place-attachment theory, and grounded in four case studies: Kalkbreite, Next21, The City Dune and Superlofts. A catalyst (free shared energy from PV on the 18,000 m² shed roof and aquathermal heat from an adjacent water buffer) attracts pioneers to a low-image industrial edge. An adaptive 8.4 by 8.4 metre support, carrying modular dwellings, façade panels and four lifespan layers, lets residents stay through every life phase via a modular tenure system. Symbiosis between residents and industry workers is built over time through shared infrastructure, a gradient public deck, a productive school, a workshop, and cross-financed governance.

The three principles operate as a closed loop in which architectural decisions, the tenure model and the governance structure reinforce one another: free energy attracts pioneers; modules let them stay; staying produces attachment; attachment produces symbiosis; symbiosis produces resilience; protected returns keep stakeholders investing. Each of the four precedents demonstrates one segment of this loop; this project demonstrates its closure. The result is a replicable method for densifying industrial edges without displacing industry, consuming protected landscape, or sacrificing affordability.

TABLE OF CONTENTS

1. Introduction 04
1.1 Problem statement 05
1.2 relevance 06
1.3 research/design questions 07
1.4 objective and motivation 08
1.5 scope 09

2. Approach 10
2.1 methods 11
2.2 theoretical framework 12

3. Results 14
3.1 Introduction of the project 16
3.2 Attract 20
3.3 Bond 28
3.4 Stay 34

4. Conclusion & discussion 48
4.1 Conclusion 49
4.2 Implications and recommendations 51
4.3 Reflection 53

References 54

Appendices 57
1. location analysis 58
2. social cohesion 66
3. energysystem 72
4. gridandconstruction 79
5. Formstudy 88
6. Casestudy 89
7. Functionanalysis 108
8. Governance, stakeholder analysis and affordability 109
9. Architecturaldrawings 120
10. Datamanegementchecklist 146

1 INTRODUCTION

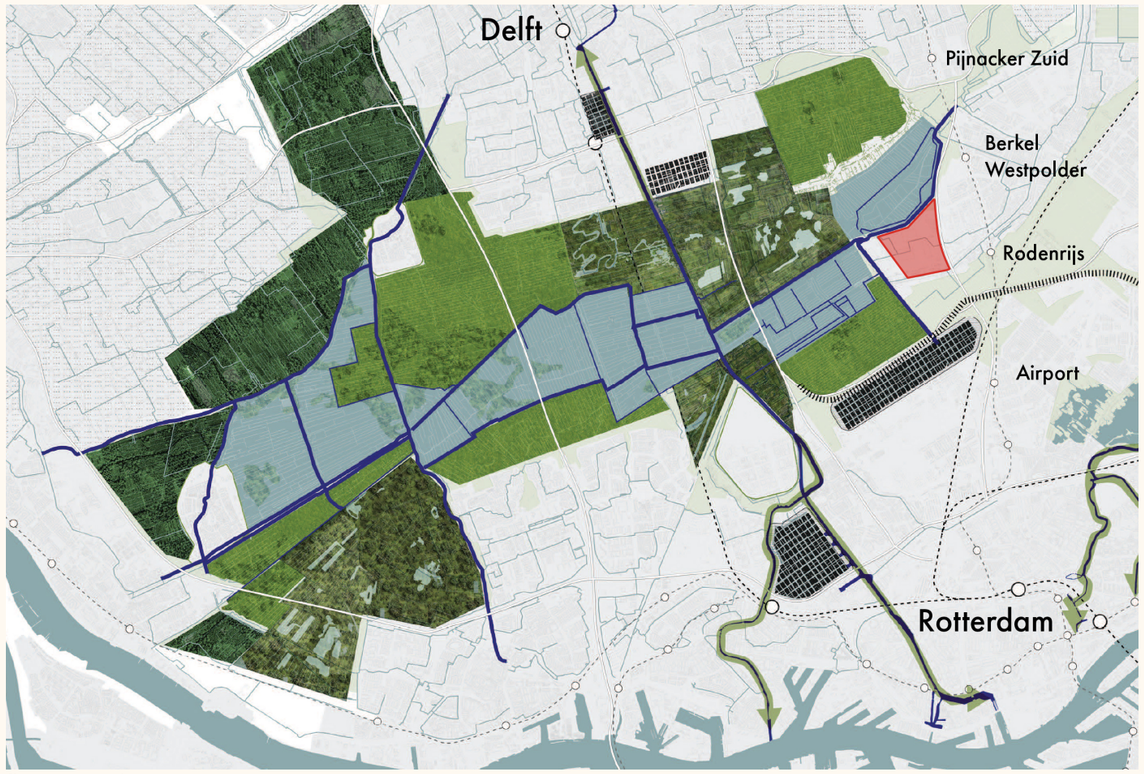


figure 1 zus plan

1. 1 PROBLEM STATEMENT

The Netherlands is facing a deficit of approximately 400,000 homes (a figure that has increased for three consecutive years), while nearly one million homes need to be added to the national housing stock by 2030 (ABF Research, 2024).

The Netherlands faces a deficit of approximately 400,000 homes (a figure that has risen for three consecutive years) while nearly one million homes must be added by 2030 (ABF Research, 2024). The crisis is most acute in the Randstad, where housing is becoming unaffordable for first-time buyers, low- and middle-income groups, and single-person households (DNB, 2025). Competing claims for agriculture, recreation, water management and ecological corridors (ZUS plan) limit the available land, so South Holland faces a hard dilemma: expand into the remaining open landscapes, or densify within the already urbanised area.

The dilemma is sharpest at the edges of Midden-Delfland, designated in 2017 as a Special Provincial Landscape for its cultural-historical value (TU Delft Repository, 2024). The polder absorbs water, supports biodiversity and stores carbon for approximately 2.3 million urban residents around it; further expansion threatens to turn the southern Randstad into one continuous urban fabric. The alternative is the industrial edge. Logistics and manufacturing estates along the polder occupy large amounts of land while delivering little urban quality: monofunctional, fenced and poorly connected. The problem is therefore not only a lack of housing but the absence of spatial strategies that can add housing without consuming open landscape and without displacing the productive functions on which the urban economy depends.

The challenge has a social dimension too. Modernist separation between industry and housing has widened the gap between knowledge workers and manual labourers, between those who think and those who make. Industrial areas are largely invisible to urban residents. On top of that, conventional area development typically delivers fixed masterplans with predetermined programmes, leaving little room to accommodate the demographic, technological and economic uncertainty that defines a 50–100-year horizon.



figure 2 pressure on Midden Delfland

1.2 RELEVANCE

Societally, the project responds to South Holland's housing need without encroaching on Midden-Delfland, by densifying industrial land. Reusing such sites avoids the 20–40 % of housing cost that typically goes into land preparation and new infrastructure. Stacking housing, parking and public functions above logistics raises land value per square metre without displacing productive activity, and shared infrastructure (energy, productive school, communal space) creates functional interdependence between groups the city has separated.

Disciplinarily, the project contributes to three areas where current practice falls short.

- First, most Dutch examples of housing on industrial estates follow a transformation logic in which industry is displaced rather than integrated; projects that design real structural interdependence are rare (Korthals Altes, 2008).
- Second, the Open Building tradition initiated by Habraken (1961) applied to this project to achieve resilience of a uncertain building location, is well established but has largely remained at the building scale; this project investigates what happens when support–infill is extended to the neighbourhood scale.
- Third, the project demonstrates that affordability can emerge from the spatial logic of the design itself (stacked land use, reused infrastructure, integrated cross-financing) rather than only from subsidies or cheaper construction without destroying unique identity and innovation.

1.3 RESEARCH/DESIGN QUESTIONS

Main question
How can an adaptive spatial framework, based on Open Building principles, enable the densification of a logistics site in Berkel and Rodenrijs, while integrating living, production, and landscape into a system that can evolve over time?

Sub-questions organised under three design and research principles

Adaptivity (important to reduce risks on this new building location)

1. What spatial grid and structural system can accommodate the dimensions of truck logistics, car parking, commercial functions, and housing within a single adaptive framework?
2. How does the Open Building principle of support and infill make these functions changeable over time, and how does that change reduce risk for residents, investors and the municipality?

Symbiosis (important to increase connection between workers and residents, and between people and the location)

1. How can the spatial relationship between the logistics hall, the polder and the residential environment be designed as a mediator between industrial activity and living, creating identity, activity and connection without nuisance for any party?
2. In what ways can shared infrastructure stimulate mutual dependence between industrial workers and residents, and thereby strengthen social cohesion and place identity over time?

Catalyst (Attracting people and investors towards an 'unattractive' neighbourhood)

3. How can a model of cross-subsidization, in which land costs are shared through stacked land use, existing infrastructure is utilized, and solar energy acts as a catalyst for pioneer housing, make housing development on industrial land financially feasible for both investors and residents?

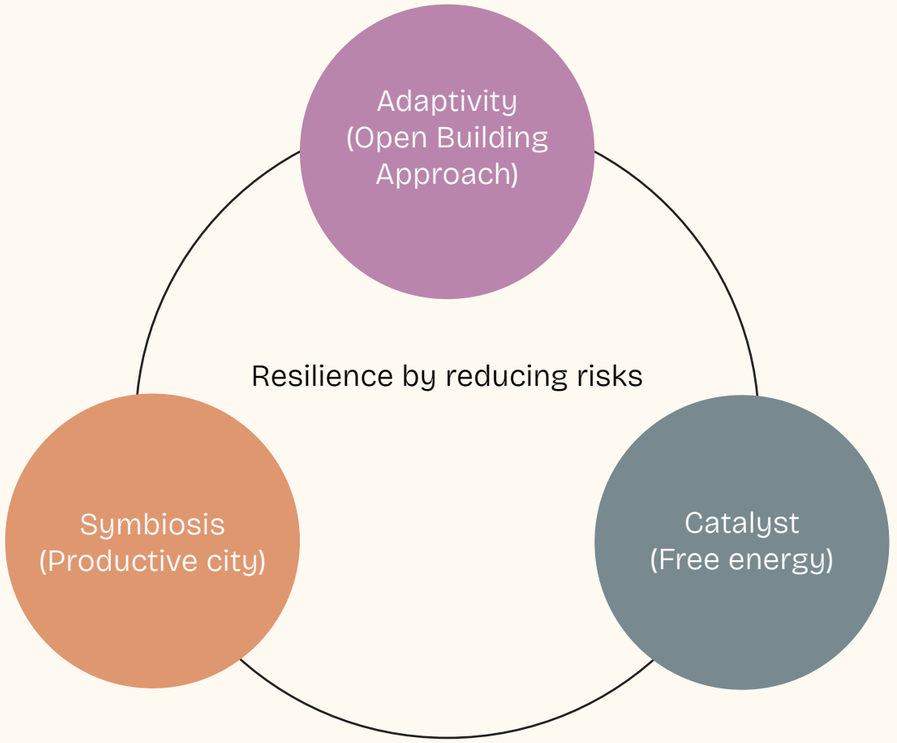


figure 3 the three principles

1.4 OBJECTIVE & MOTIVATION

The aim is to develop an adaptive design framework for the JoyLogistics site that demonstrates how living and production can coexist and evolve together over time. Instead of a fixed end state, the project designs architecture as infrastructure for change: dwellings grow and shrink with their residents, functions shift in response to unforeseen demand, and the relation between industry and housing deepens rather than diminishes.

My personal motivation comes from a strong interest in bringing together complex, interdependent systems into a single spatial whole in which components fit together like a Tetris puzzle. I am fascinated by adaptability: how architecture can be driven by changes in the behaviour of individuals and society, rather than directing people toward predetermined behaviours. Everyone is equal in the framework.

1.5 SCOPE

The research focuses on a single industrial site in Berkel en Rodenrijs adjacent to Midden-Delfland and the JoyLogistics shed. The design intervention concentrates on the spatial structure next to the shed (volumes, public landscape and their connections) rather than on the internal logistics operation. The project operates at three scales: an adaptive masterplan, a detailed residential tower demonstrating the modular grid and Open Building principles, and a system-scale strategy integrating shared infrastructure, energy, parking and public programme through a cross-financing model. Detailed financial feasibility, zoning procedures, internal logistics redesign and the specific engineering of the energy system fall outside the scope and are treated as design assumptions.

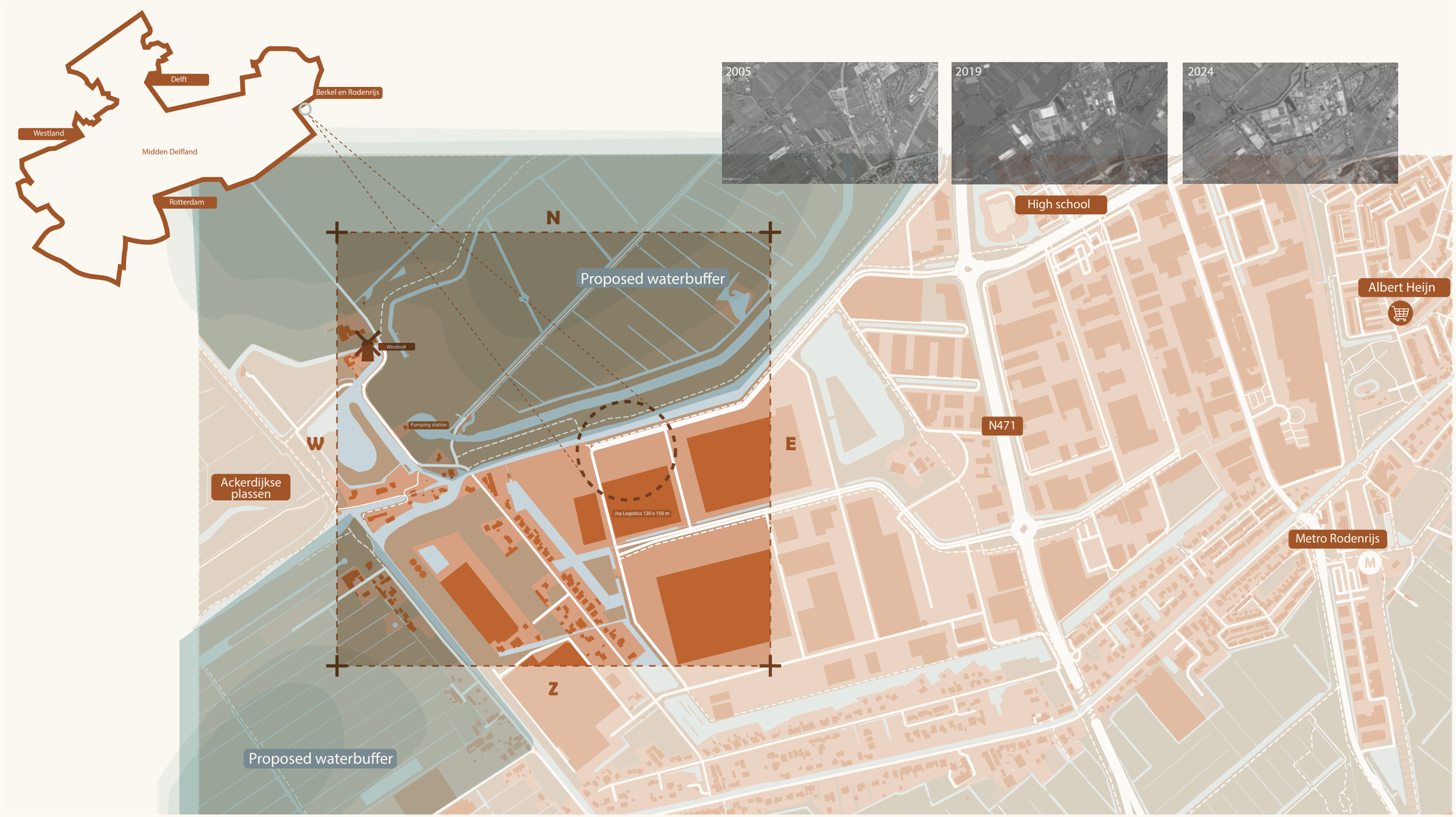


figure 4 location analysis

2 APPROACH

2.1 METHODS

This project follows a research-through-design approach in which research and design influence each other in an iterative loop rather than as separate phases. The design is both subject and instrument: ideas from literature and precedent are tested spatially, and the spatial findings raise new questions that feed back into theory, case studies and site analysis. This suits a challenge (designing an adaptive framework for an uncertain future) that cannot be answered through literature alone or through intuition without grounding.

<u>The methodology combines five activities:</u>
Group masterplan and tool catalogue (Q1). The project began as a group exercise. With a team of fellow students, I co-developed a masterplan for the wider industrial edge and produced a tool catalogue of densification typologies for industrial fabric (empty plot, top-up, wrap, remove-and-rebuild, repurpose, take bites, intensify, split up, multipurpose, lifted platform). Each option was tested against six criteria (relation to industry, type of roof, affordability, densification potential, use of exteriorless architecture, target group) and applied to the wider area to test scalability. The group's research focused on existing infrastructure, open-space conditions and the reach of nearby public transport (the site is within ten minutes by bicycle of Metro Rodenrijs). The six shared guidelines listed in appendix 1 emerged from this collective work and continue to structure my individual plot. The decision to build next to the shed on a lifted deck above shared parking (rather than transforming or replacing the shed) was the highest-scoring tool from the catalogue on the combination of affordability, density and respect for the existing operation.

<u>Literature study</u>
Conceptual foundations such as Open Building (Habraken, 1961; Kendall & Teicher, 2000), the productive city (Architecture Workroom Brussels, 2016; Ryckewaert, Zaman & De Boeck, 2021), affordability through compact-city strategies (Korthals Altes, 2008), and place-attachment theory (Lewicka, 2011; Brown, Perkins & Brown, 2003) are the bridge between adaptive architecture and durable community.

<u>Case studies</u>
Four projects were selected because each isolates one of the four pillars for this project:
1. Structural and programmatic adaptability (Next21)
2. Affordability through stacking on active infrastructure (Kalkbreite)
3. Mediation between a hard edge and a soft landscape creating a gateway into Midden Delfland (The City Dune)
4. Casco delivery as a driver of attachment (Superlofts).

A fifth precedent (Juliatoren) informed the expressive use of exterior staircases. The case studies are embedded in the relevant design decisions in Chapter 3 and can be found in the Appendices (appendix 6). None of the four precedents combines all pillars, defining that combination is the contribution.

<u>Site analysis</u>
A detailed analysis of the JoyLogistics site mapped no-go zones (truck docking, daylight access to the shed), sightlines from truck drivers toward Midden-Delfland, walking routes and entry points, points where housing–industry connection is strongest, and truck routes. Six thematic maps translated this into design constraints (Appendix 1).

<u>Stakeholder analysis</u>
Identified four principal parties (municipality, logistics company, housing corporation, pension-fund-backed cooperative) and the conditions under which each would engage. Not a stand-alone product; it directly shaped the cross-financing (Appendix 8).

These activities do not lead to the design sequentially. Each design iteration draws from all of them simultaneously and updates them: an early grid study sent the research back to Next21; a question about how residents would finance module expansion led back to Superlofts; a question about how the deck could be financially feasible led to the stakeholder analysis and Kalkbreite. The design is the integrator.

2.2 THEORETICAL FRAMEWORK

It is important to build resilience by reducing risks when developing housing in a new neighbourhood that is perceived as unattractive. Risks can be reduced by creating symbiosis between groups, adaptibility for changing needs and developing a catalyst to attract residents in the first place (Appendix 2).

The framework is built around Habraken's distinction between permanent structures that define the collective and durable dimension of a building and variable structures that enable change, individuality and evolving user needs (Habraken, 1961). This is the lens through which the three principles (Adaptivity, Symbiosis and Catalyst) read together as one system.

Adaptivity, the Open Building approach

Habraken's De Dragers en de Mensen (1961) distinguished the support (the permanent, collective part, lifespan > 100 years) from the infill (the individual, adaptable part, lifespan 15–20 years). Technically this turns renovation into a continuous process; economically it removes the need to speculate on what buyers want in five years; socially it restores a participatory role for the resident. The approach was developed at TU Delft (SAR, OBOM) and applied at Next21 (Utida et al., 1994), where thirteen architects designed individual dwellings within one structural framework and corridors were designed as three-dimensional streets (Kendall & Teicher, 2000). In this project the support–infill logic is extended from the dwelling to the neighbourhood: a 4.2 × 4.2 m grid (derived from an 8.4 × 8.4 m main grid) forms the permanent structure, dimensioned to combine trucks, cars, commercial functions and housing within one logic.

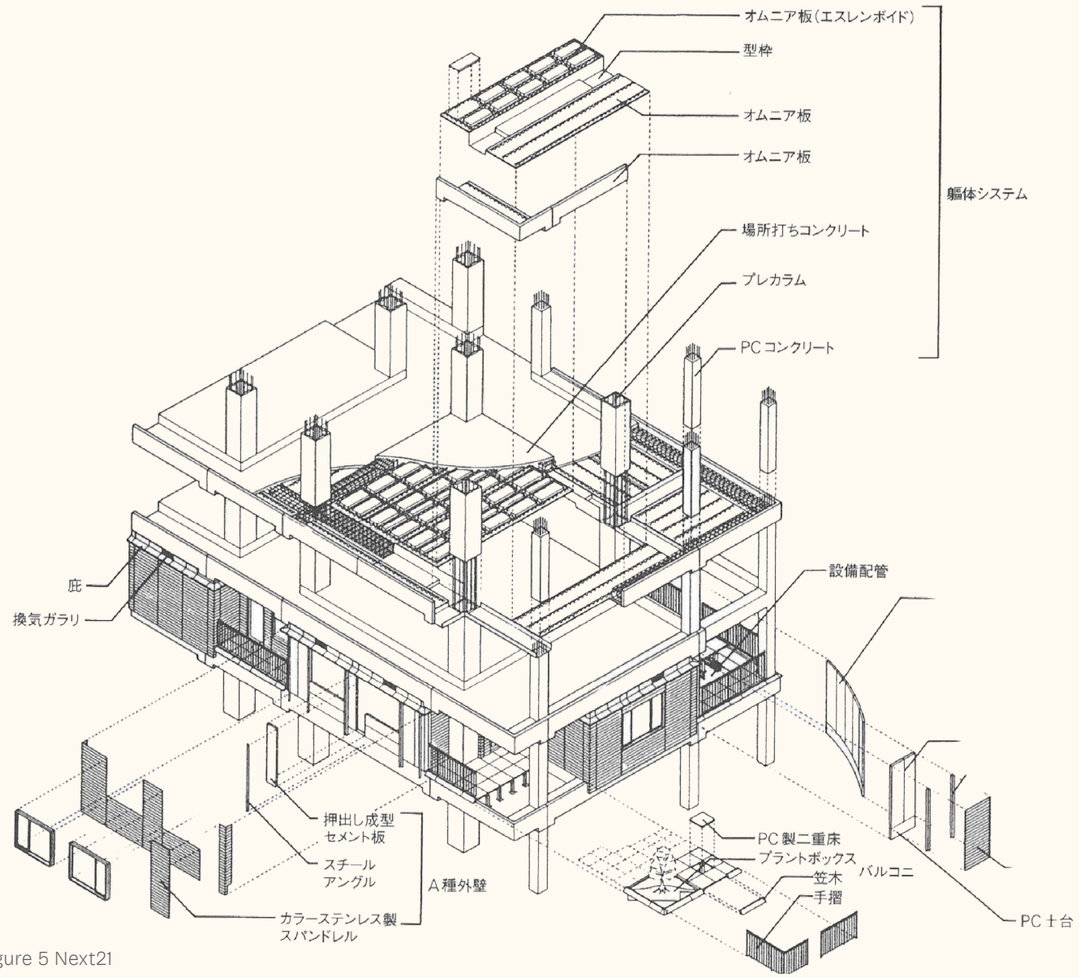


figure 5 Next21

Symbiosis, the productive city

Architecture Workroom Brussels (2016) and Ryckewaert et al. (2021) argue that European cities have become places of consumption without production, and that the displacement of industry has deepened the gap between "thinkers and doers." Reintegration is economic and social necessity. The discourse offers concrete instruments such as the productive school, the Maison de Quartier Productif, the Work Palace, in which "the scale of workspaces determines the housing development, not the other way around." Symbiosis is not automatic, however. Place-attachment research (Lewicka, 2011; Brown et al., 2003) identifies length of residence as the strongest predictor of emotional bonds with a neighbourhood. The length of residence depends on the architecture letting people stay through every life phase. Symbiosis therefore depends on adaptivity of the neighbourhood. By creating adaptivity through open Building approach on a neighbourhoodscale, this can be achieved.



figure 6 Thinkers vs. Makers

Catalyst, energy as a social and economic instrument

The 18 000 m² roof of the JoyLogistics shed, the adjacent watercourses and the planned ZUS water buffer make the site exceptionally suited to solar PV combined with aquathermal heat extraction and seasonal storage. Rather than a technical add-on, zero-energy living is positioned as the decisive argument for attracting pioneers to a low-image industrial edge. The near-zero bill is financial security and it carries the argument that residents depend on the industry for energy and industry gains a stable partner which is the urban industrial symbiosis described by Architecture Workroom Brussels (2016).

The loop

The contribution of this report is not any one principle but their causal interlocking. Free energy attracts pioneers (Catalyst); the modular grid lets them stay (Adaptivity); staying produces attachment, which over years produces symbiosis with the industry (Symbiosis); symbiosis produces social resilience; resilience protects the investment of every stakeholder; protected investment attracts further commitment; commitment improves the neighbourhood; the improved neighbourhood, with the still-free energy, attracts the next cohort. The four case studies each demonstrate one segment; none closes the loop.

3 RESULTS

This chapter answers the five sub-questions under the three principles: the catalyst (attract), symbiosis (bond) and adaptability (stay). The first section introduces the design. The calculations and detailed research sit in the appendices.

figure 7 3D render

3.1 DIVING INTO THE PLAN

The masterplan locates around 250 dwellings on the strip east of the shed. A dense neighbourhood with added functions brings life to a setting otherwise dominated by a closed-off shed, and the residents help to pay (indirectly, through the cross-financing model described in §3.3 and §3.4) for an added public deck above the shared parking and the loading and docking zones for trucks.

Several building volumes step down in height from the shed toward Midden-Delfland (rental towers, a purchase tower, a purchase low-rise, and a productive school at the polder edge), and the deck transitions materially from concrete to planting along the same axis. This is the gateway into Midden-Delfland. The rental tower highlighted in figure 10 is developed in detail to test resilience at the architectural scale.

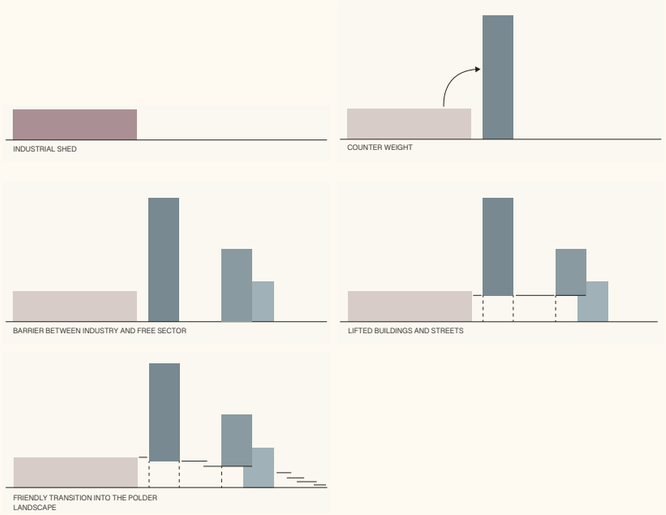


figure 8 formstudy

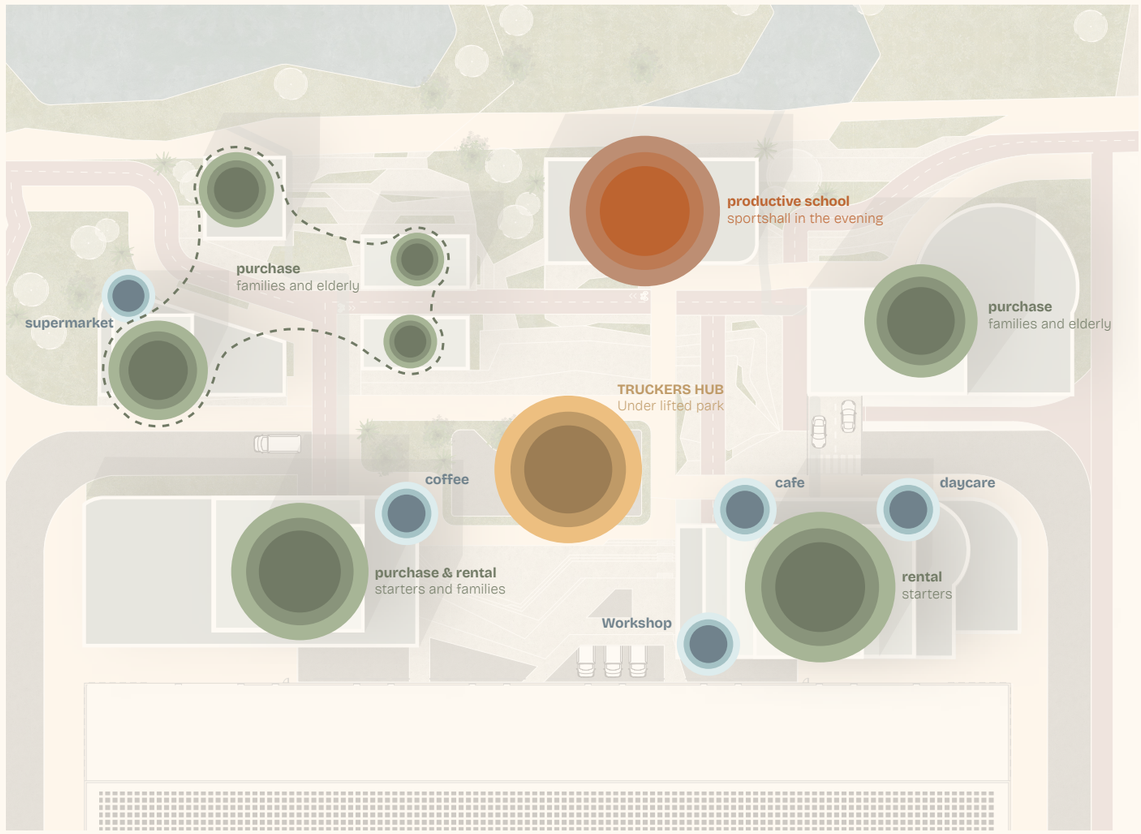


figure 9 functions

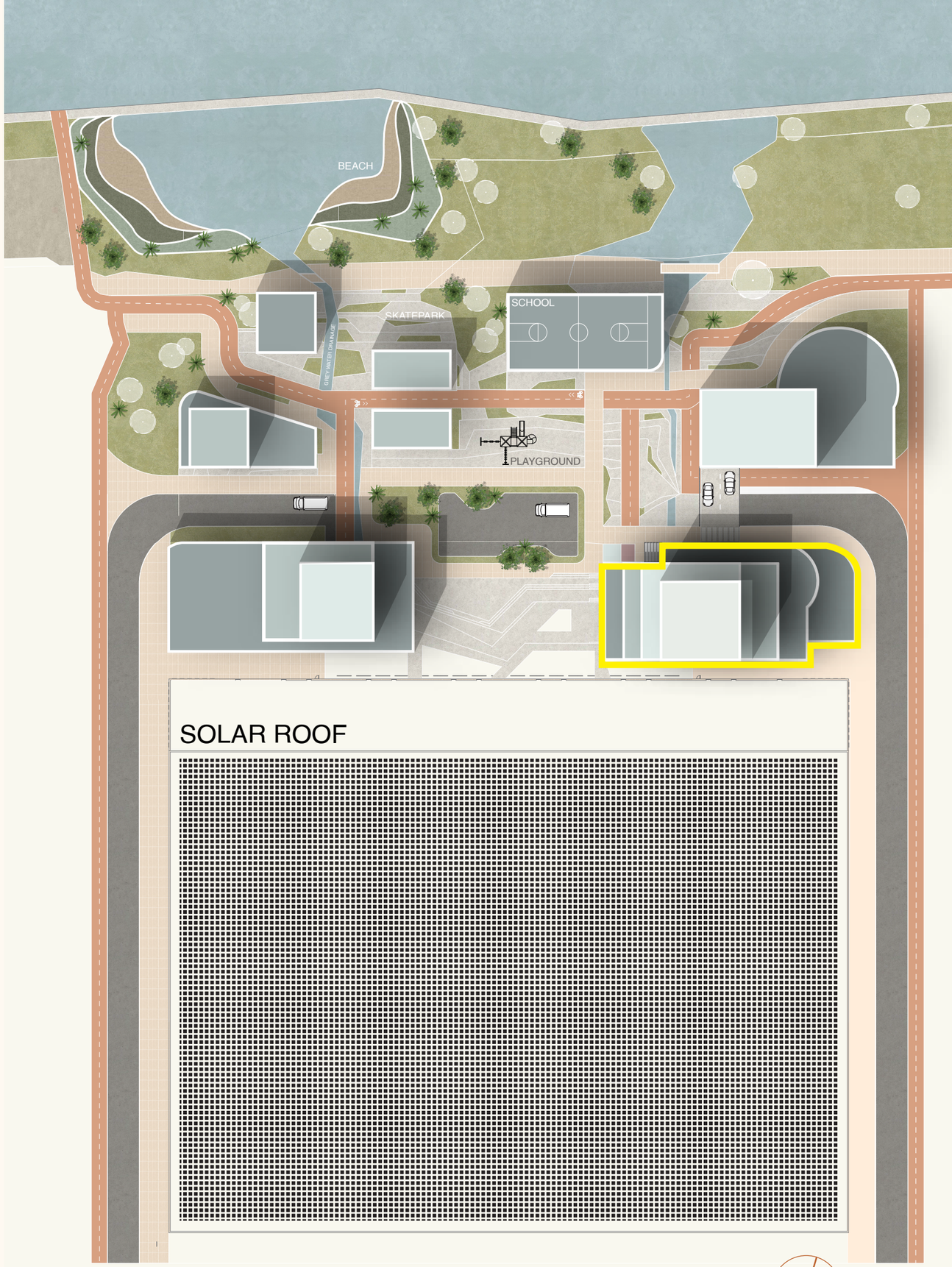


figure 10 site and chosen building to develop

The rental tower contains 80 dwellings in three volumes separated by an open level (with parks and storage), so the volumes read as different streets within one vertical neighbourhood. The goal is to reduce the risks of an “unattractive” location by attracting people with a catalyst, then building an ecosystem that adapts to people’s needs and grows with them through their life stages, so symbiosis can form over the long run. Investors need to be convinced that housing here works as an investment with durable value, not as something built only out of necessity.

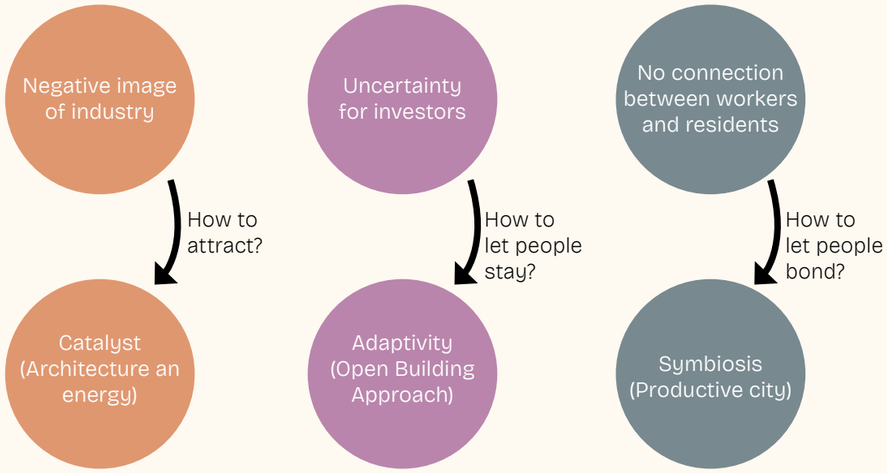


figure 11 risks + solutions

3.2 ATTRACT

Free energy and architecture as the catalyst
Sub-question 5, in part

Attraction — Architecture and benefit from shared resources
Bond — Shared facilites and stimulated encounters
Stay — Attachment needs time

The first move is to overcome the negative image of the site by giving residents something they cannot get elsewhere: a near-zero energy bill, attached to architecture that makes the benefit visible from the moment they walk in.

Energy
The 18 000 m² shed roof produces enough energy cover the demand of 250 dwelling and the logistic shed itself (Appendix 3), with capacity to spare for adjacent sheds. Aquathermal heat (TEO) from the ZUS water buffer, stored seasonally in a WKO and distributed through a low-temperature heat network, delivers space heating and hot water. The system as a whole delivers near-zero energy bills and acts as the financial certainty that draws people to the neighbourhood.

The energy infrastructure is owned by an energy cooperative under the SCE subsidy regulation. Residents become members on moving in and receive their share of the yield. Each tower pays its proportional share of the PV and heat network from its construction budget, so the system is paid up front rather than billed monthly (Appendix 8).

Topic	Competent authority	Points of attention
Rooftop PV	Municipality (environmental permit)	Fire safety; structural integrity; grid connection (congestion)
TEO (heat extraction)	Hoogheemraadschap van Delfland	Ecological assessment; Assessment Framework for Cold Discharges (STOWA); return temperature
WKO sources	Province of South Holland	Subsurface energy master plan; interference with other WKO systems; groundwater protection
District heating network	Municipality + Authority for Consumers and Markets (Heat Act)	Tariff regulation; security of supply; possible designation of a heat concession area
SCE subsidy	Rijksdienst voor Ondernemend Nederland	Application 2026: March 2 to October 1; max. 1 MWp per application

table 1 chosen energy systems with considerations

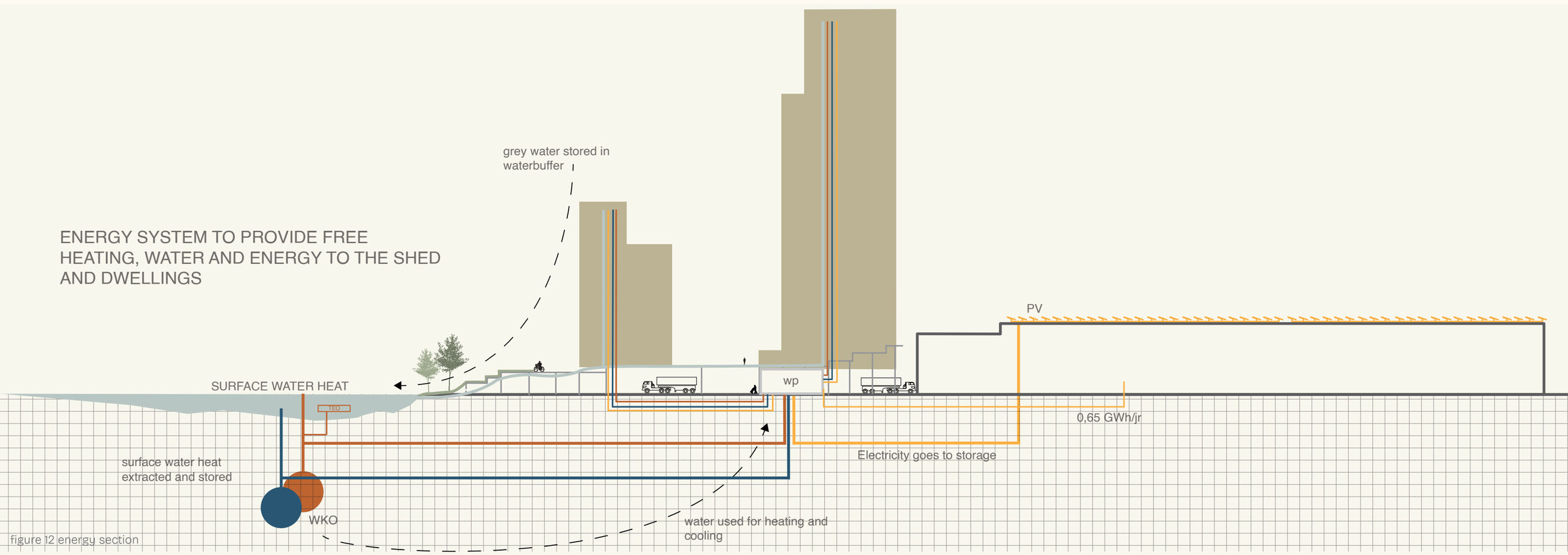


figure 12 energy section

Architecture

The architecture reinforces the catalyst in three ways (figure 13):

1. Corridors and apartments look toward the industry (the solar roof) and Midden-Delfland (the water buffer), reminding people every time they come home of the benefits of living here.
2. The setback on the south façade adapts the building for passive solar gain in winter and sunshading in summer.
3. The corridor is opened up so daylight enters in the morning and afternoon, exactly the moments when people leave for work or arrive home.

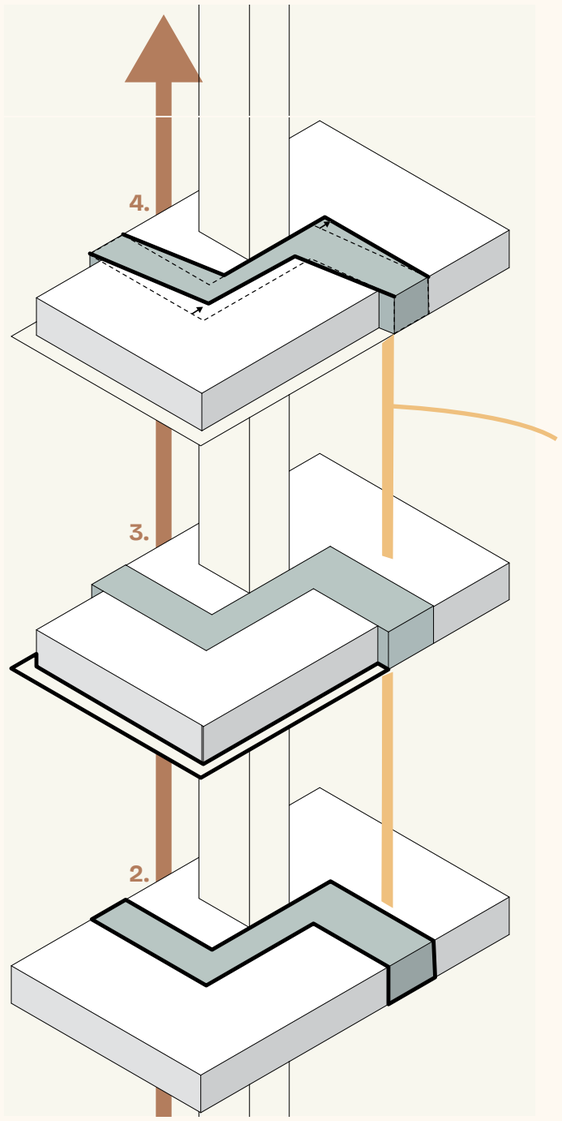


figure 13 attraction in three ways

Stormwater is routed visibly across the concrete-to-green gradient toward the water buffer.

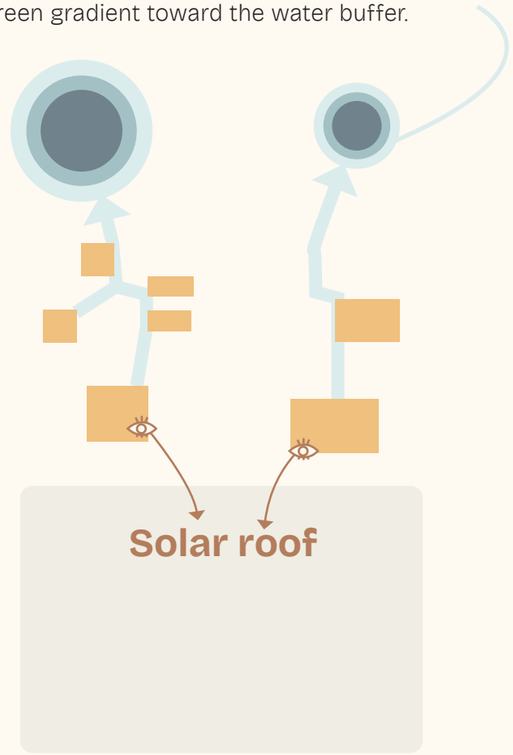


figure 14 catalyst as a visible element

Energy-system pipes are visible on the open park levels between the building volumes. The catalyst only attracts pioneers if they can see what they are getting.

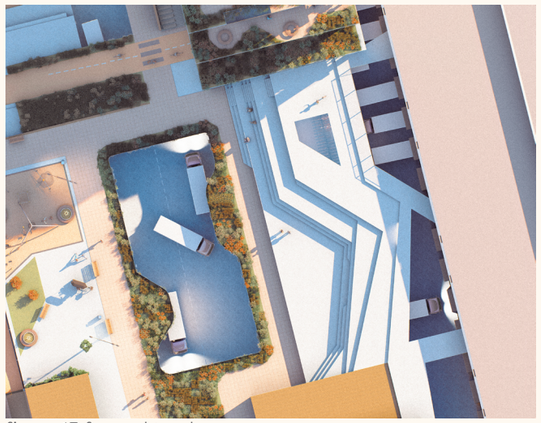


figure 15 framed trucks

Trucks are framed as art through openings in the public deck, while noise and safety risks stay under control. The openings move from large to small and act as a sneak peek into the lives of the "doers", giving residents a positive first relationship with the industry.



figure 16 outdoor parks

The car and bike parking and the parks between the volumes stay as outside spaces, expressing openness in contrast to the closed-off private sheds around the site. The corridors on each floor have a glass wall with a setback, giving the same open feel.

Industrial identity is made visible as well. Following Next21 (Utida et al., 1994) the staircases sit on the outside of the volumes and are expressed as a piece of architectural dynamism, mirroring the trucks driving through the site and the loading and docking below.



figure 17 outside materials

Industrial materials extend into the heart of each tower (the heart of the building representing the heart of the area, the industry itself), and the functions in the plinth, such as the workshop and the productive school, reinforce this identity. The industry can feel proud rather than displaced and accept the residents as neighbours; the shared facilities described in chapter 3.3 work in the same direction.



figure 18 indoor materials



figure 19 - elevation 1:200 (scaled)



figure 20 - elevation 1:200 (scaled)

So the energy system and the industry are not hidden: they are the public face of the project. The neighbourhood and the buildings present the energy as a free shared resource that reminds people why they live here, and they frame the industry like art, giving residents and workers a first form of mutual acceptance and a shared identity to build on.

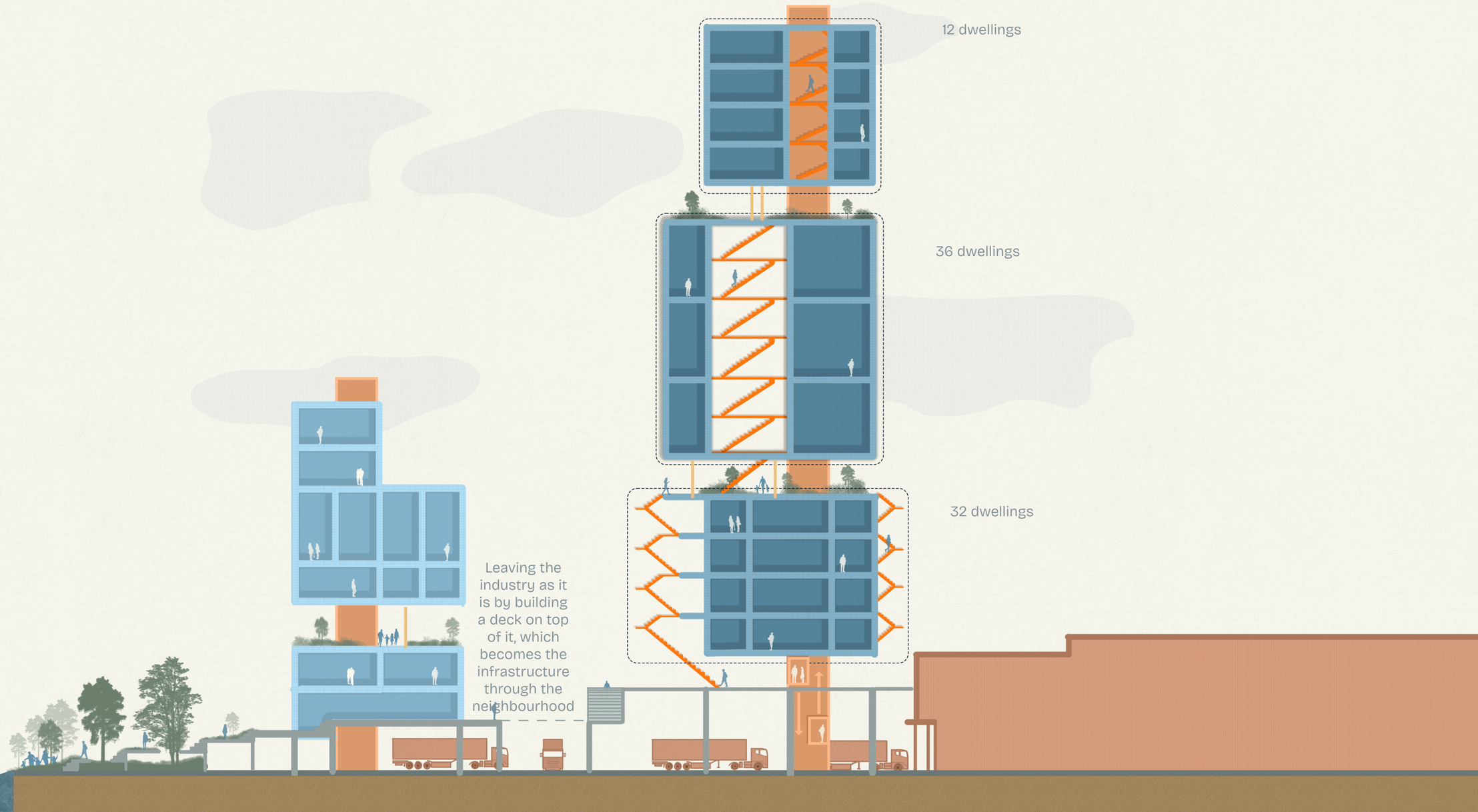


figure 21 architectural narrative

3.3 BOND

Between makers and thinkers
Sub-question 3 & 4

Attraction	Bond	Stay
Architecture and benefit from shared resources	Shared facilites and stimulated encounters	Attachment needs time

To bring together two populations that the modernist city deliberately separated (knowledge workers, and practically trained workers in logistics and repair), social cohesion has to be built over time. This section draws on the discourse of the productive city (Architecture Workroom Brussels, 2016; Ryckewaert, Zaman and De Boeck, 2021) and on place-attachment research (Lewicka, 2011; Scannell and Gifford, 2010) to argue that cohesion between these groups is not automatic: it has to be designed through shared infrastructure, shared spaces, and (in §3.4) a spatial framework that lets people stay long enough for attachment to form.

Further explaination on the neccesity of symbiosis can be found in Appendix 2.

<u>Shared infrastructure: encounters</u>
The site is designed to attract knowledge-worker starters and industry-worker starters and to mix them inside the buildings, where everyday encounters stimulate interaction. When residents and workers arrive on site they all arrive as equals: trucks, cars, bicycles and pedestrians enter at the same point before separating vertically (figure 23). This is the first interaction of the day.


figure 22 visual connection with the bike parking


figure 23 entering the site as equals


figure 24 open entrance

People park their cars on the ground or first floor and their bicycles on the first floor, where the bike parking is visible through holes in the public park above. The entrances to the parking stay open to the outside, so the route from car to apartment runs through the open landscape, with a visual connection to other people along the way.

The parking structure is also the most concrete piece of governance in the design. Residents pay parking rent to the logistics company, which financed the parking in exchange for that recurring income (Appendix 7): the industry benefits directly from the presence of residents, and the residents benefit from covered parking on industrial land forming a bond between the groups.

The deck above is cross-financed in the same spirit: the logistics company pays for the parking layer, the municipality contributes the public deck as urban infrastructure, and the developers above buy air rights. Each party only pays for the layer it uses, while gaining the benefit of all the layers together.

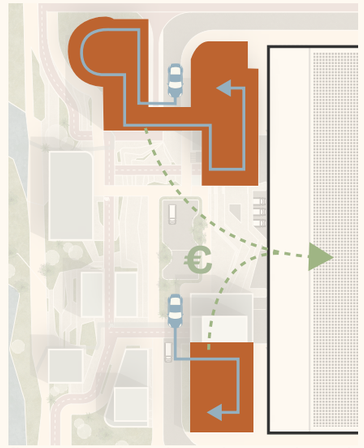
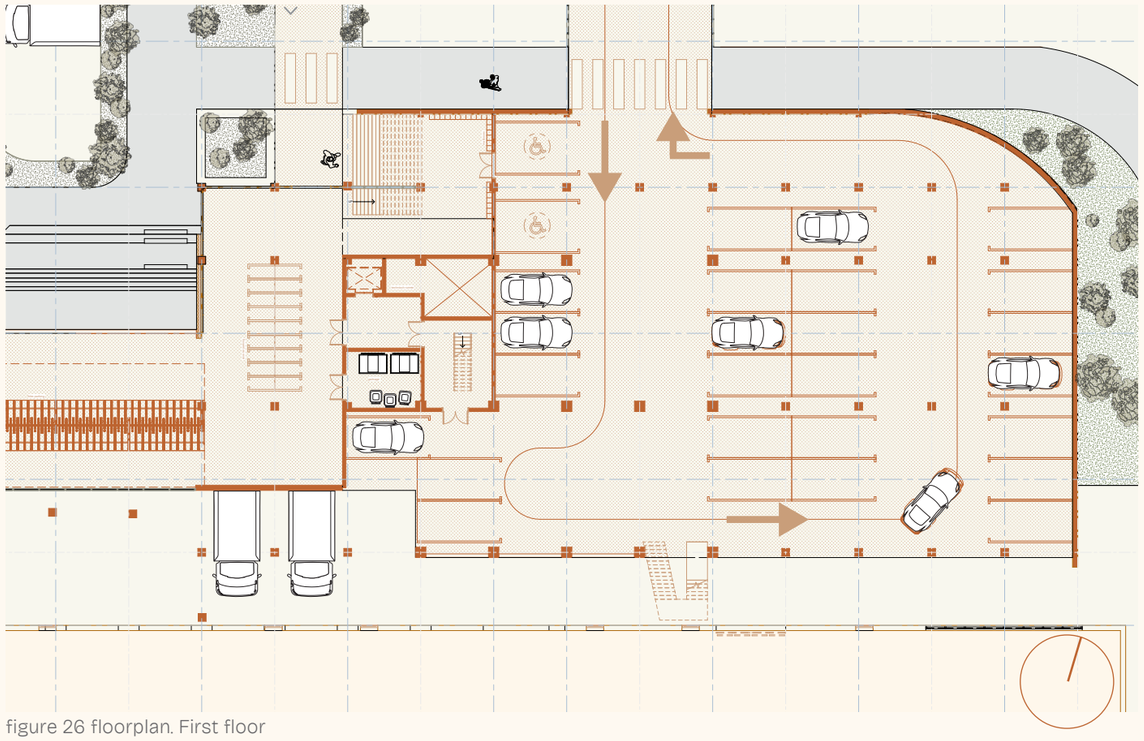


figure 25 interdependency through parking spaces


figure 26 floorplan. First floor

At the main entrance, a visual connection with the workshop and a view of the shed itself give residents a daily encounter with the industry.

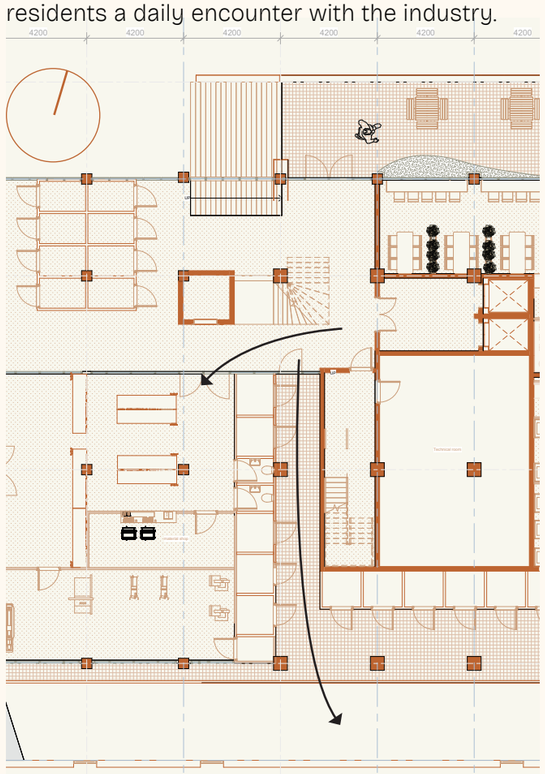


figure 27 visibility on productive activities

The corridors have holes that connect them vertically, and windows toward the corridor connect the dwellings with the "street", giving both visual contact and a form of social control.

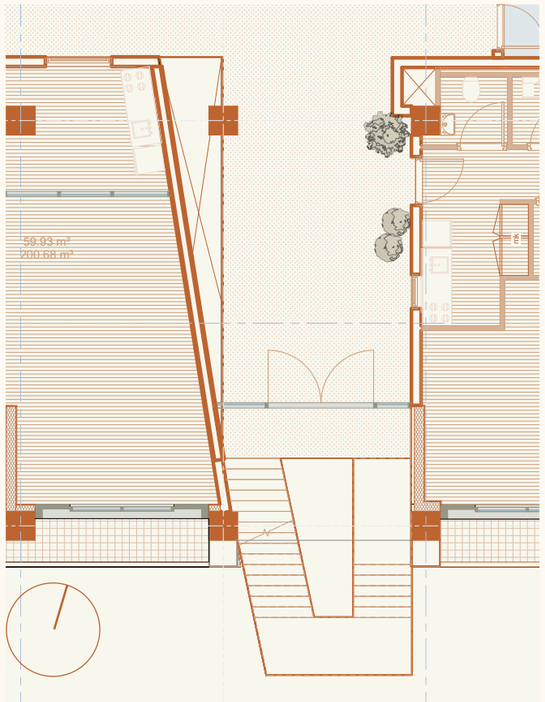


figure 28 visual connection with the neighbours

Following Next21's three-dimensional-street principle (Utida et al., 1994), the 4.2 m wide corridors are treated as real streets rather than transit spaces: wide enough for planting and seating, opened to daylight from above, with sightlines toward both shed and polder.



figure 29 render of open corridors with windows towards the apartments

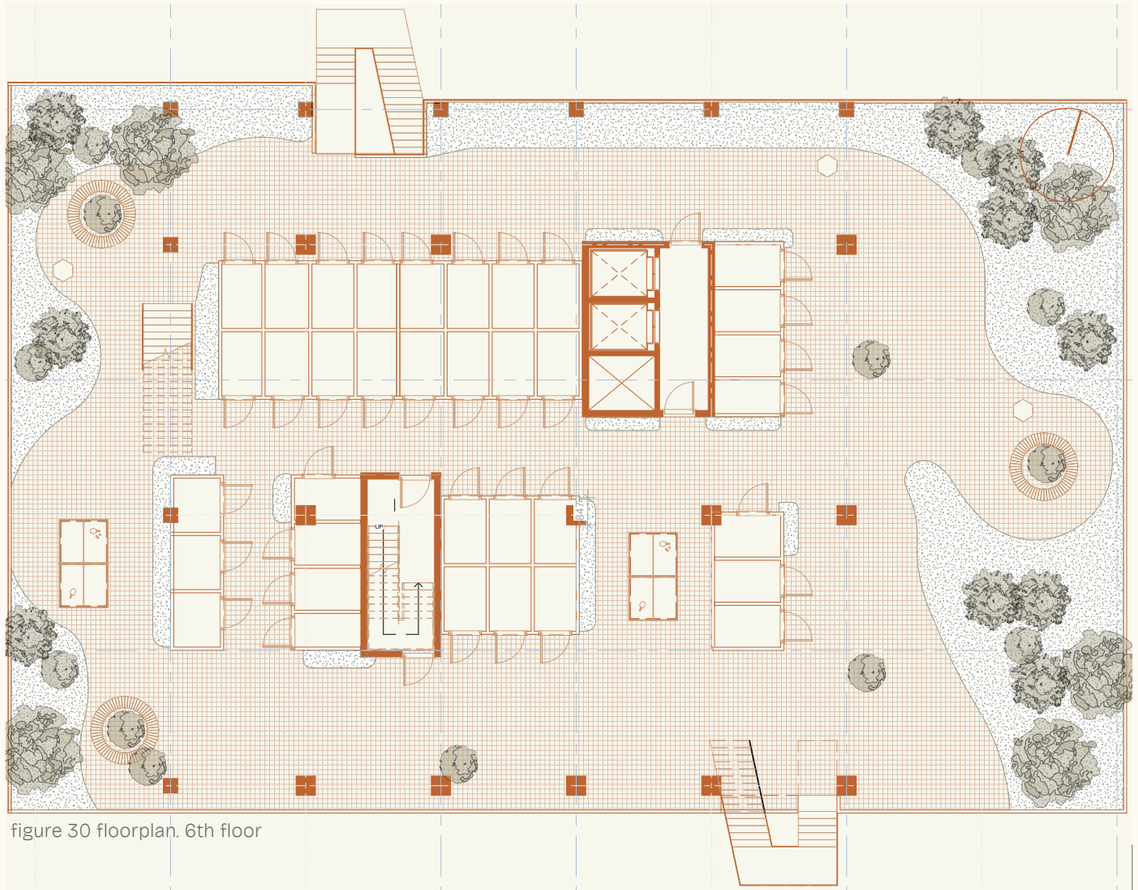


figure 30 floorplan. 6th floor

storage spaces, encouraging residents to use the sky parks and turning the levels into informal meeting spaces.



figure 31 render. 6th floor

Together, the three-dimensional streets, the open park levels between the volumes, and the visible staircases counteract the anonymity that high-rise housing usually produces. Anonymity blocks bonding; deliberate openness invites the encounters on which symbiosis depends.

figure x location open parks

Shared spaces (appendix 7)

The shared functions are determined in appendix 7. A productive school lets children connect with "making" from an early age: they learn by making, and they learn that the industry around them matters. In the evening the school is used for sports lessons, adult education and community events. The school also owns the workshop, used by residents and workers outside teaching hours. Dwellings are delivered casco (a Superlofts-derived strategy), encouraging residents to invest effort in making them their own. That effort builds a bond with the home and reduces the chance of moving away after a few years, which is exactly what long-term symbiosis requires. Residents can build partition walls and edit their furniture in the workshop, where they also meet their neighbours.

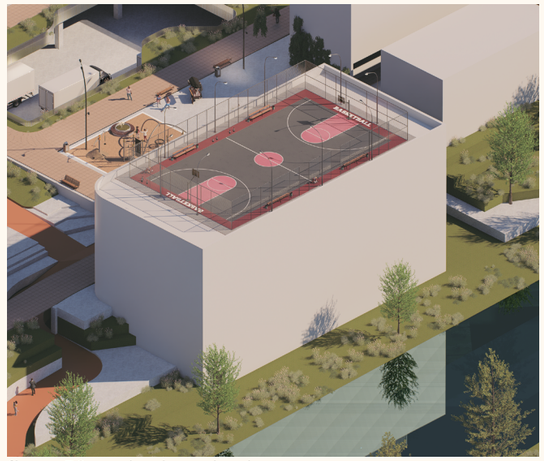


figure 32 productive school

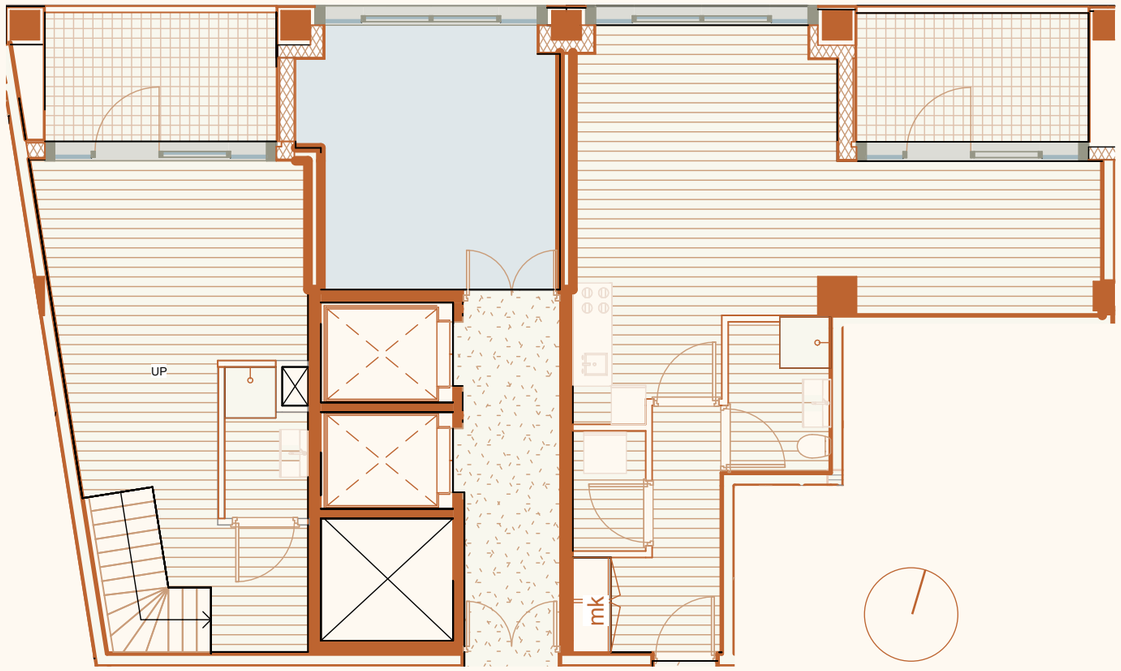


figure 33 casco apartment delivery

Cafés and coffee places on the deck encourage workers to walk through the park, where they meet residents. A daycare facility on site lets both residents and workers drop off their children before work. The supermarket, on the ground floor of a building closer to the truckers' zone, encourages residents to walk through the working part of the site.

Together, these encounters and shared spaces produce the interdependence the productive city discourse describes and that the modernist city lost.

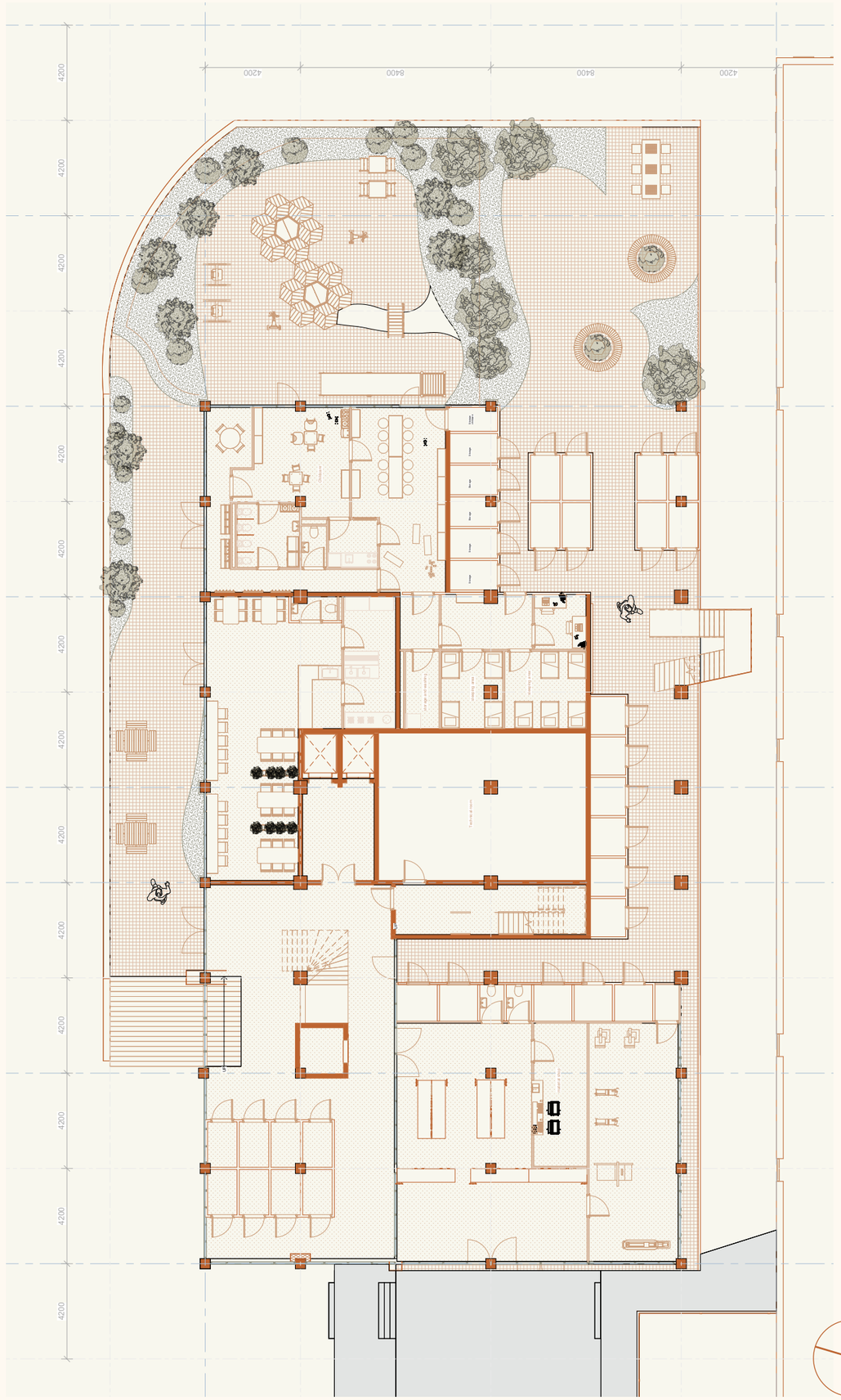


figure 34 floorplan. 2nd floor

3.2 STAY

A flexible grid that grows with its needs to stimulate attachment over a longer period of time
Sub-questions 1 and 2

Attraction	Bond	Stay
Architecture and benefit from shared resources	Shared facilites and stimulated encounters	Attachment needs time

People are attracted and the encounters of the previous section make symbiosis possible, but symbiosis takes time (Appendix 1). People typically move neighbourhood at every new life phase and only commit when they buy a house and start a family, at which point turnover stalls (figure 35). The short-term living of the earlier phases works against symbiosis, so a system is needed that accommodates every life phase in one place.

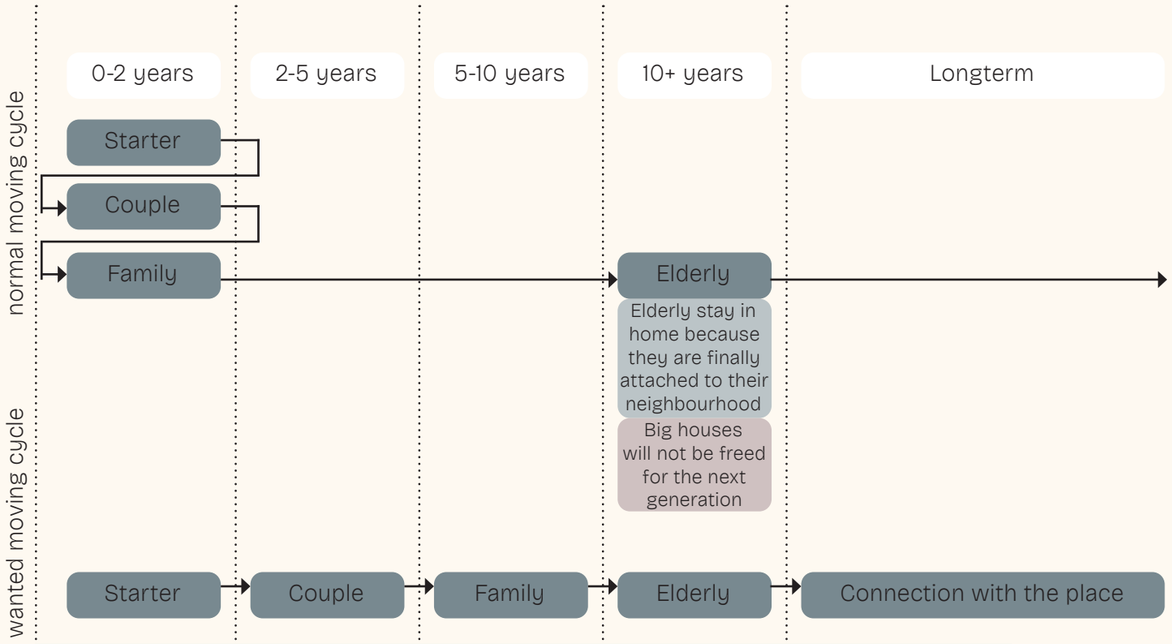


figure 35 moving cycles

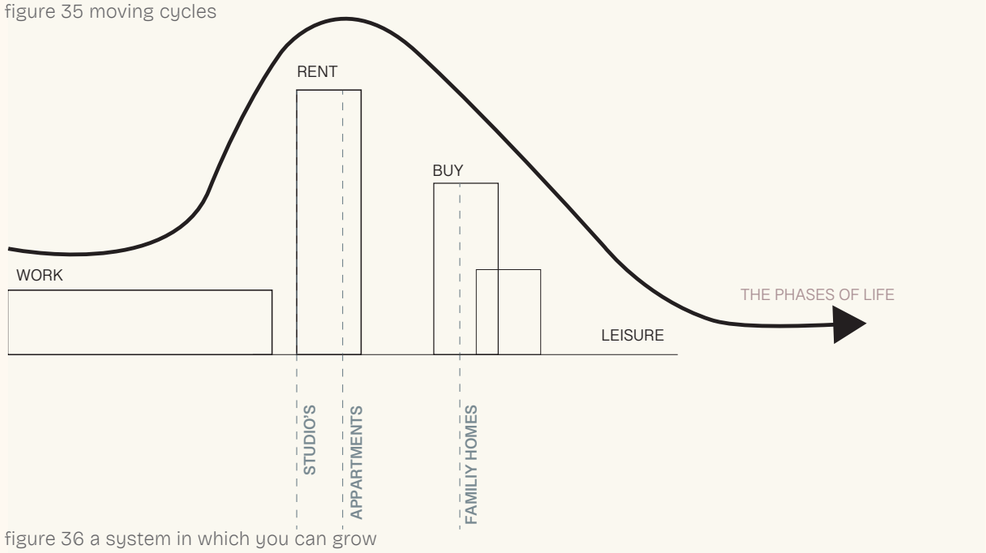


figure 36 a system in which you can grow

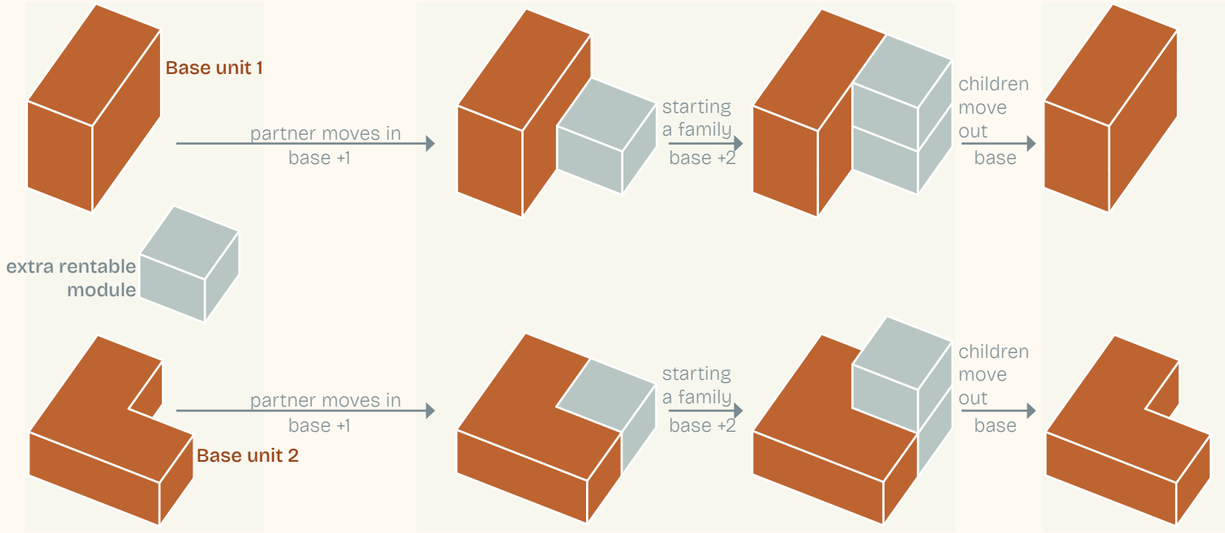


figure 37 modules principle

The modular tenure system is the answer. Next21 showed that residents stay when they can edit their homes through the phases of life rather than moving, and Superlofts (Marc Koehler Architects) adds the casco logic in which apartments are delivered as a shell and residents give them an infill of their own.

In this neighbourhood, residents rent/buy a 50 m² base unit and add rentable 16 m² modules illustrated in figure 37. Figure 36 shows how a resident can arrive in the rental tower, add a module when their partner moves in, move to the cooperative tower closer to the polder when they expand into a family household, and shrink again as the children leave, all without leaving the neighbourhood. Because the extra modules are rented monthly on top of the bought or rented base unit, elderly owners have a direct financial reason to give them back once the children move out so each module circulates to the next family that needs to expand instead of being locked inside an empty nest. Lewicka's (2011) finding that length of residence is the strongest predictor of attachment becomes a design brief.

The two towers are governed differently. The rental tower is run by a housing corporation delivering base units to starters at middle-segment rents. The cooperative tower is funded by a pension-fund backed cooperative: residents buy a cooperative membership tied to a base unit and rent extra modules from the cooperative's stock as their household grows. The pension fund accepts a lower return because adaptivity reduces long-term risk. The adaptivity that lets residents stay is the adaptivity that makes the building investable.

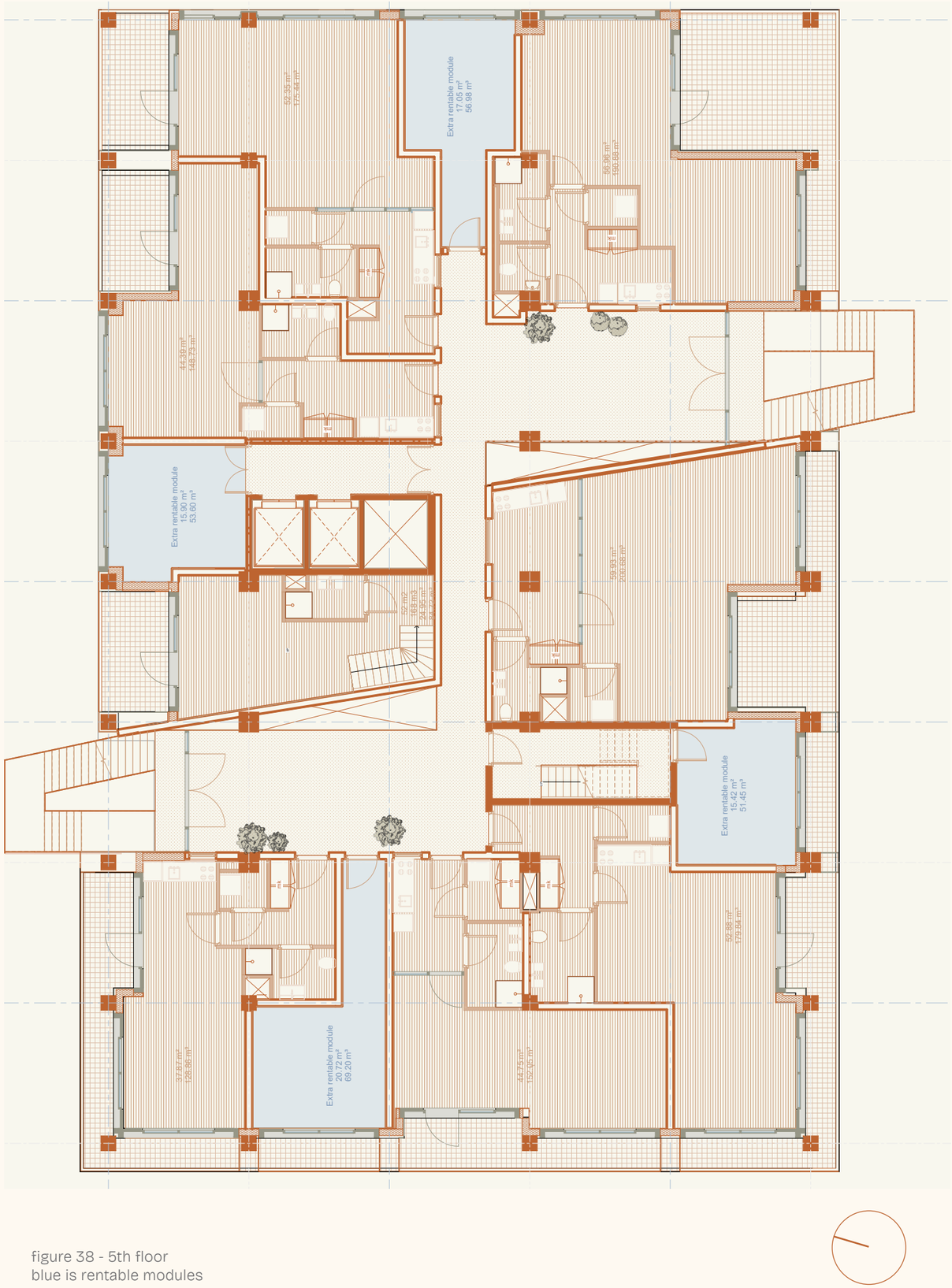


figure 38 - 5th floor
blue is rentable modules



figure 39 - 9th floor
blue is rentable modules

The rentable modules sit along the façade. When not rented as part of a dwelling they can be rented as a meeting room, co-working space, library or guest room (the Joker principle from Kalkbreite, Müller Sigrist, 2014), treating temporarily unused private space as a circulating shared resource rather than vacancy. Modules usually attach to two apartments but can also be stacked. Because their function shifts with demand, the risk of vacancy is small and the risk of obsolescence smaller still. The full module typology is documented in Appendix 8.

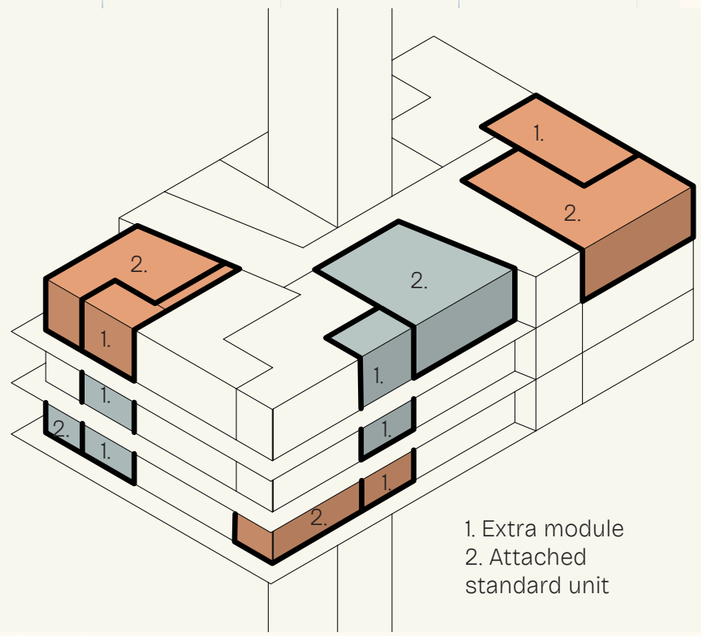


figure 40 - basic units and rentable spaces

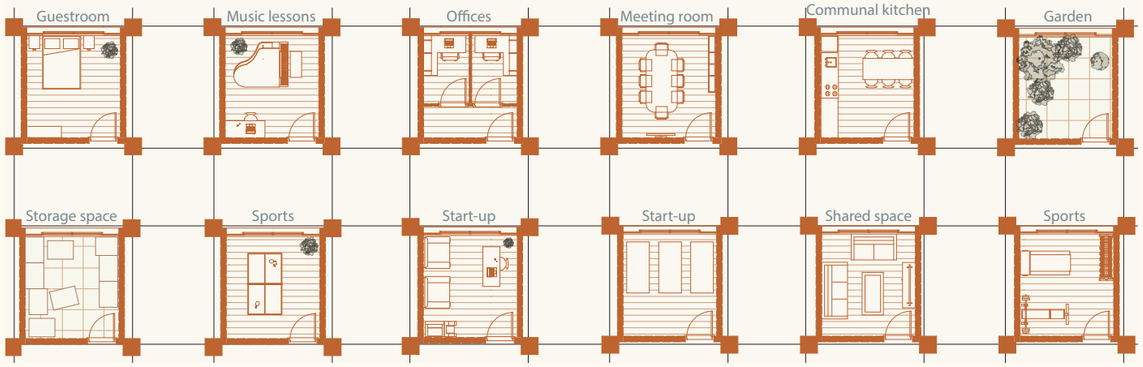
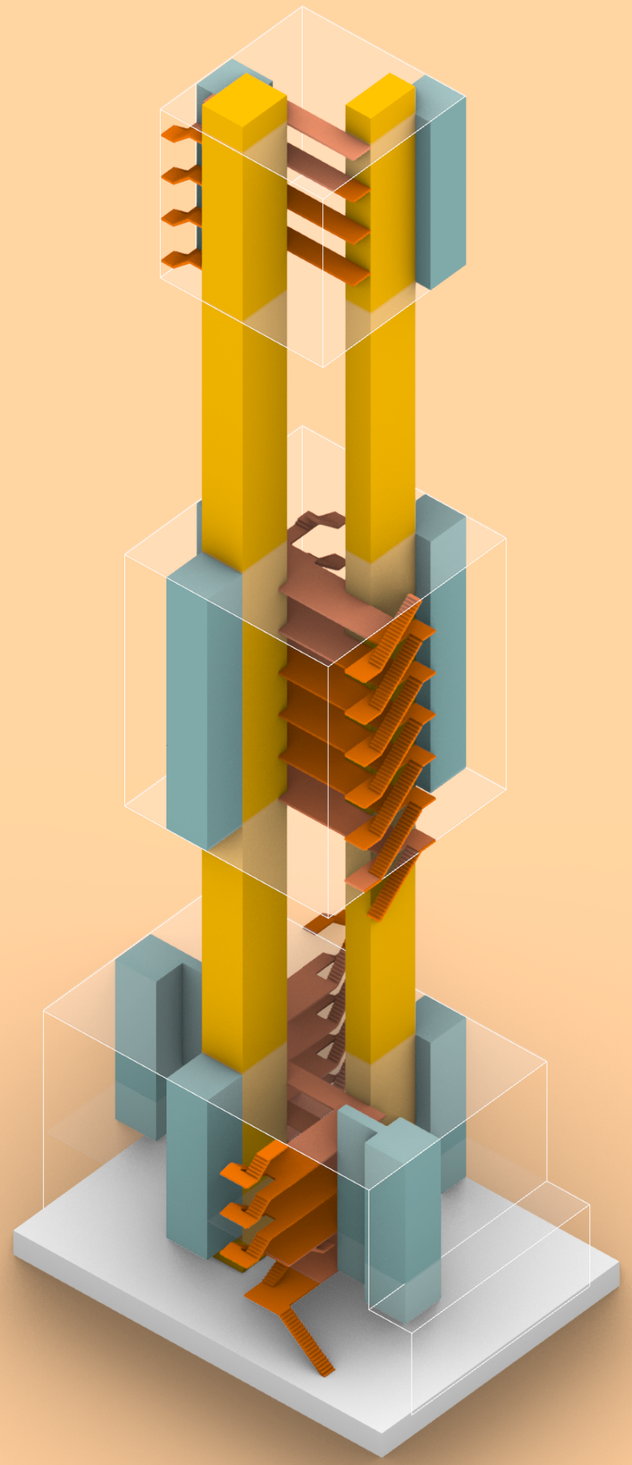


figure 41 possible module functions



figure 42 possible configurations



The modules allow people to start exploring the building to see which functions there are. This stimulates encounters to create symbiosis. Because the functions of the not rented modules are flexible it can adapt to needs, removing the uncertainty of what the future wants making it attractive for long term investors.

figure 43 the the module system helps exploring

A grid study underpins this flexibility (Appendix 4). Using the Handboek Superplinten (Heren 5 et al., 2021), an 8.4 by 8.4 metre main grid was established that accommodates two truck parking lanes, three car spaces, and the depths required for retail, workshops, offices, education and housing. Subdividing yields a 4.2 by 4.2 metre dwelling sub-grid that fits two bedrooms or a living room across its full width. A grid built around the dimensions of logistical activity is also an expression of respect for the industry. Floor heights are 5.0 m at ground level (4.5 m clear for truck docking plus the slab) and 4.0 m above, within the adaptive range for hospitality, workshop, retail, office and care.

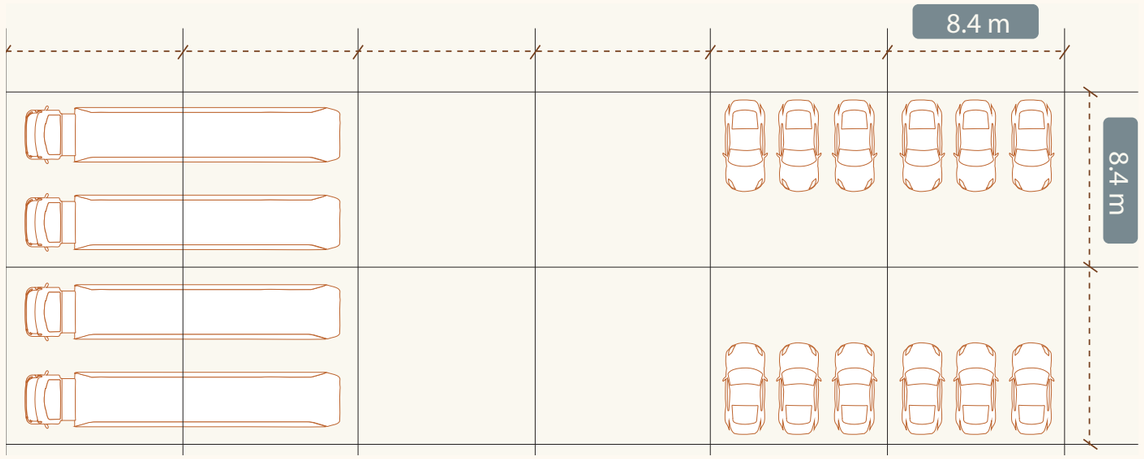


figure 44 the 8.4x8.4 meter grid

Any residential floor can later become commercial, educational or care space without structural modification, which is what Habraken's support and infill logic demands at the neighbourhood scale (Next21, Utida et al., 1994).

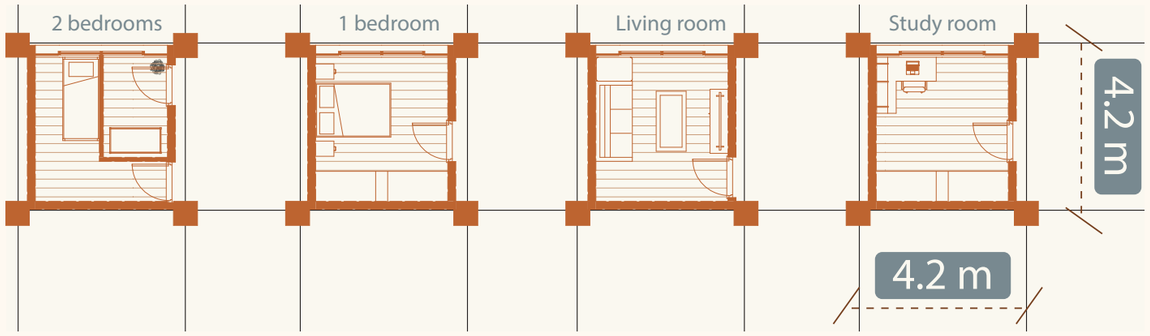


figure 45 the 4.2x4.2 meter sub-grid

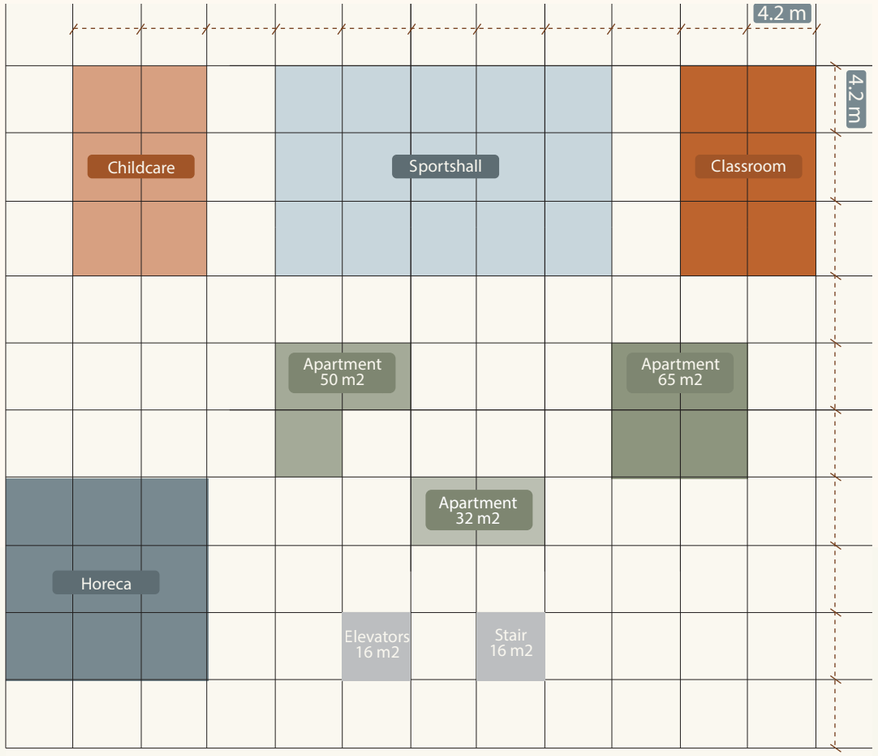


figure 46 functions fitted inside the grid

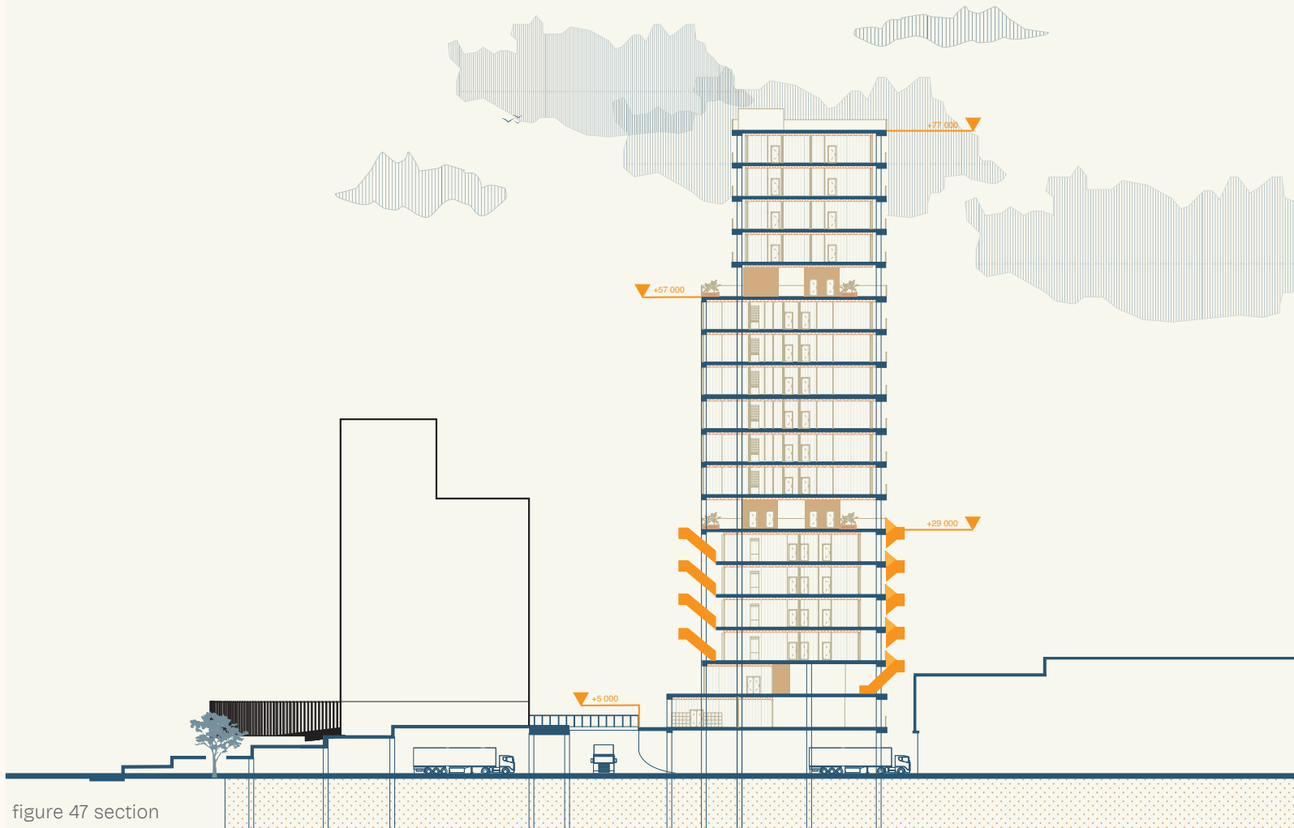
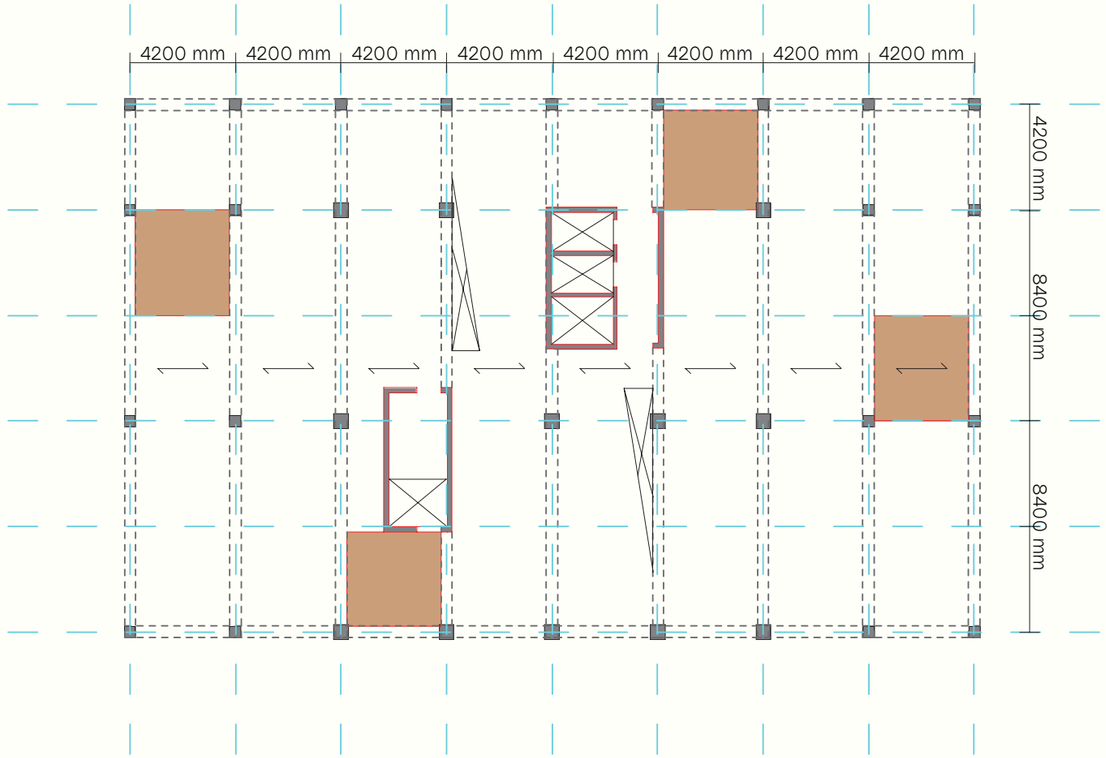
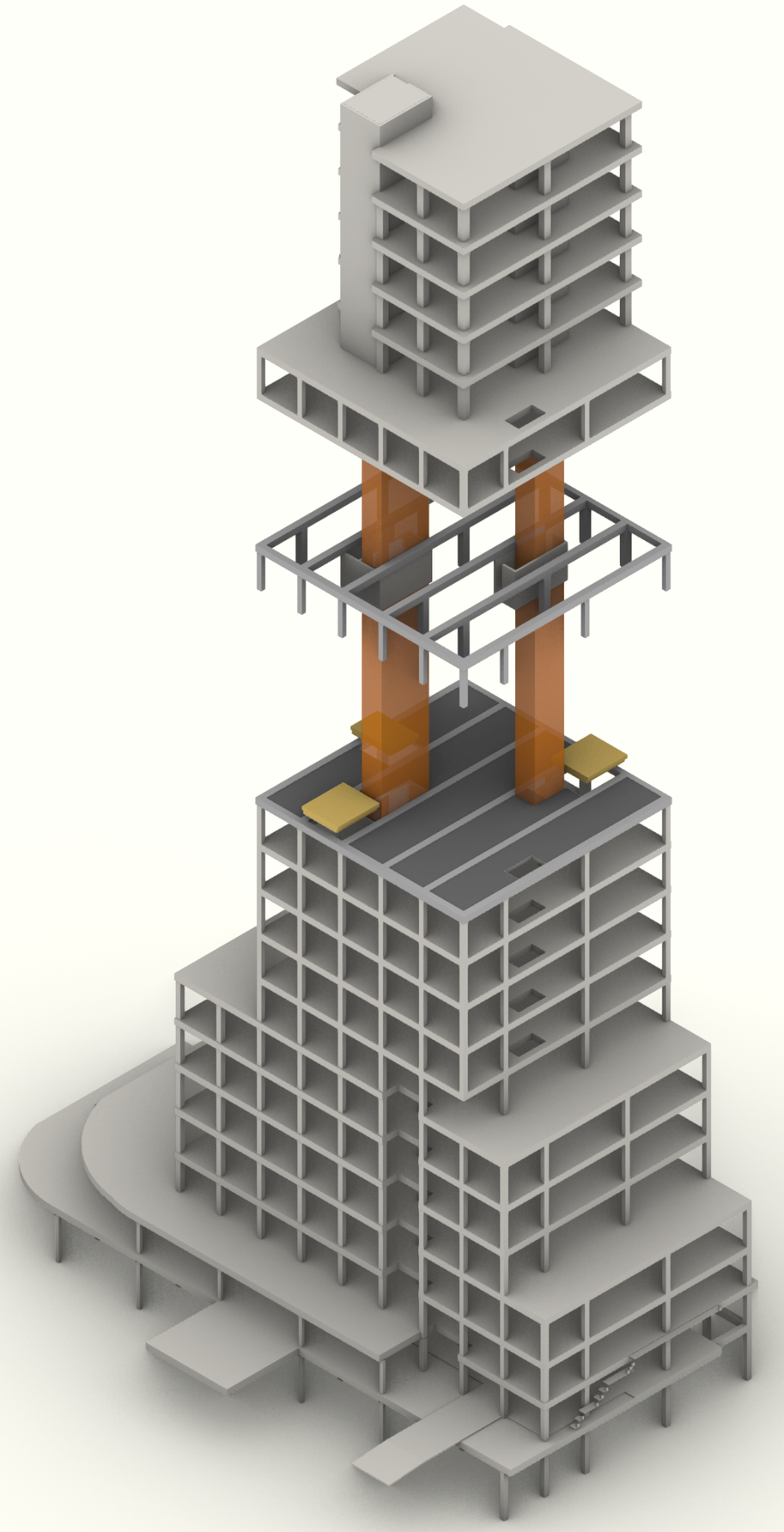


figure 47 section





The grid is the support, everything inside is infill

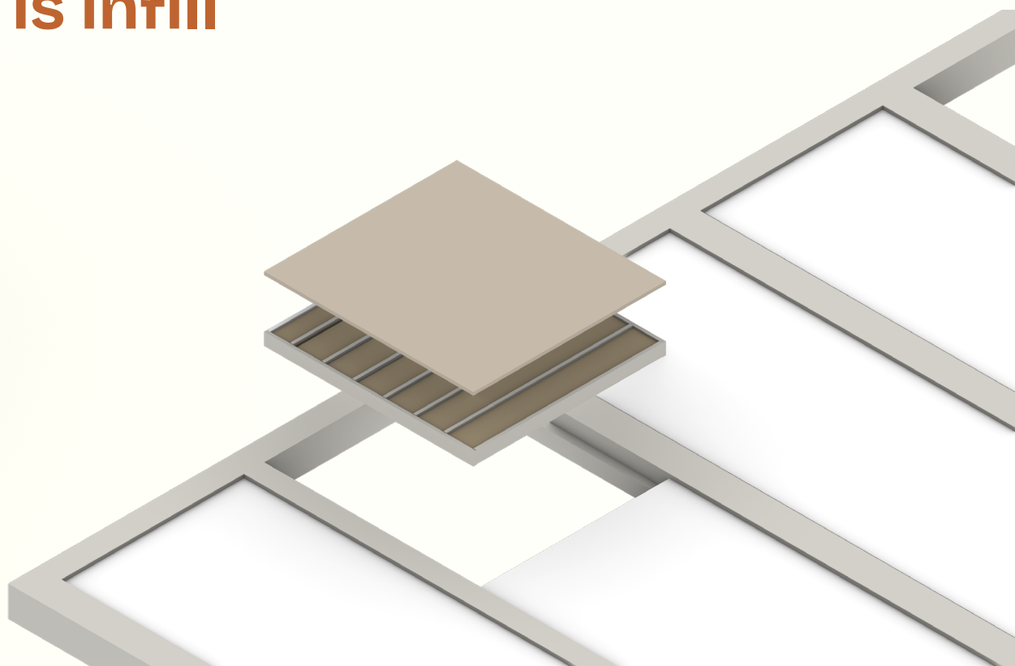
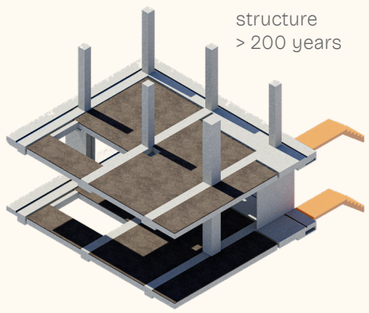


figure 48 construction

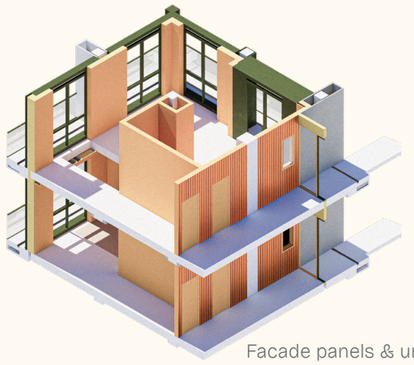
The infill is organised in four explicit lifespans illustrated in figure 49. Interior walls can be repositioned by residents, floors between adjacent modules can be opened so a dwelling expands vertically, and façade panels can be exchanged when a function changes. The façade is modular but not freely adjustable by individual residents, to avoid storing hundreds of panels.



figure 49 lifespans

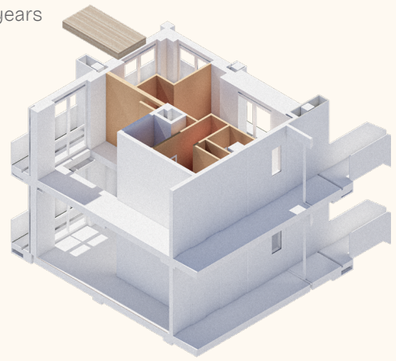


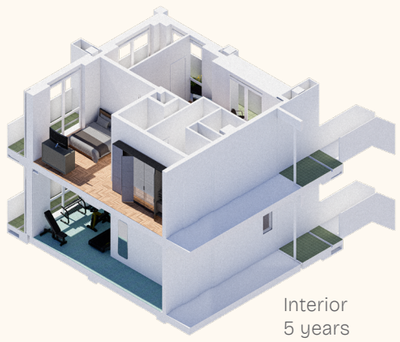
structure
> 200 years



Facade panels & unit seperations
50 years

Inteior walls and walls/floor connecting
to extra module
15 years





Interior
5 years

figure 50 - permanent vs variable

The fragment shows how support and infill come together and how the catalyst is embedded in the detail. The architectural decision of putting the structure on the outside of the insulation line serves the catalyst (passive performance), the adaptivity (modular panels and continuous envelope), and the symbiosis (the basic units are framed in the elevation).

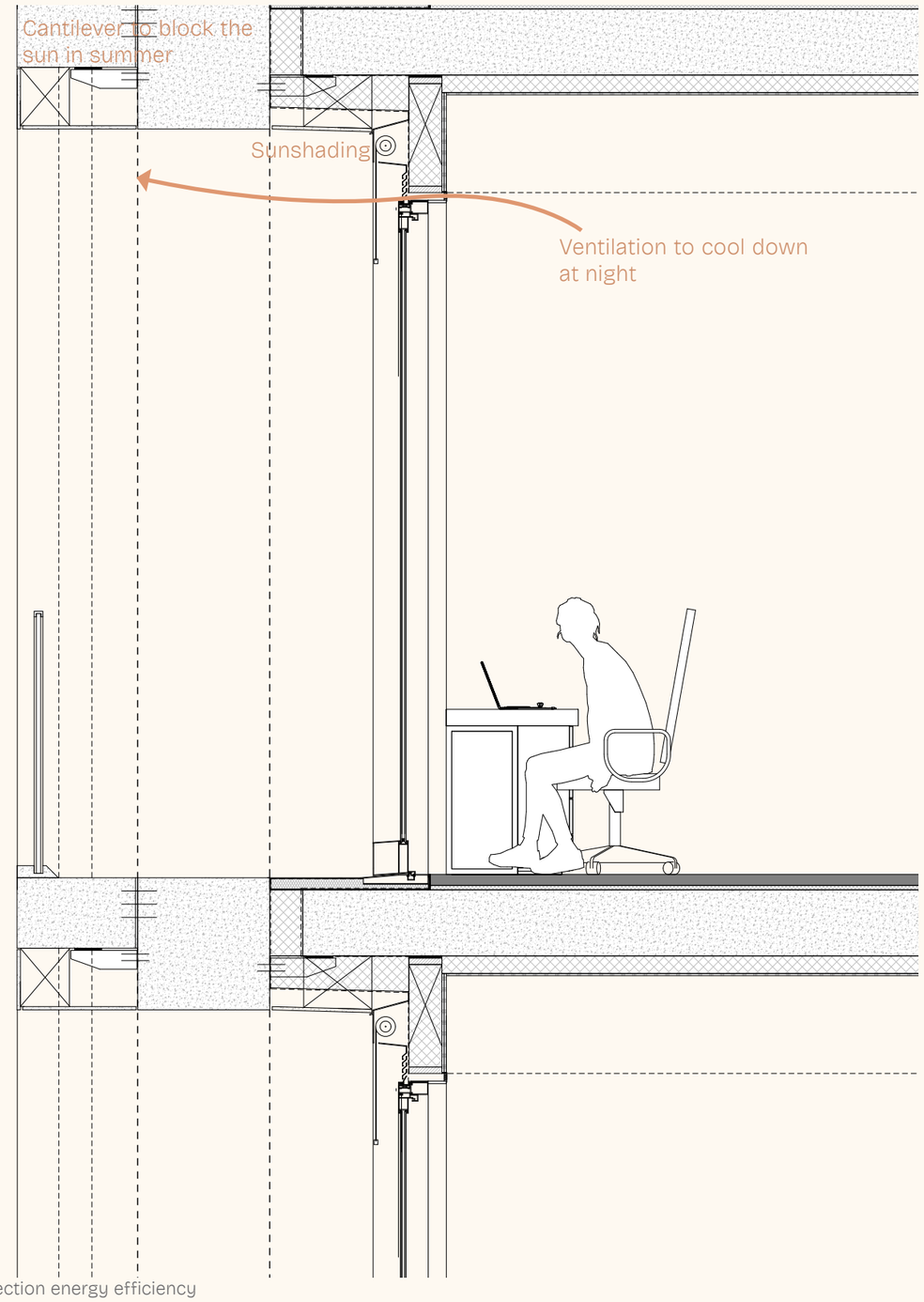
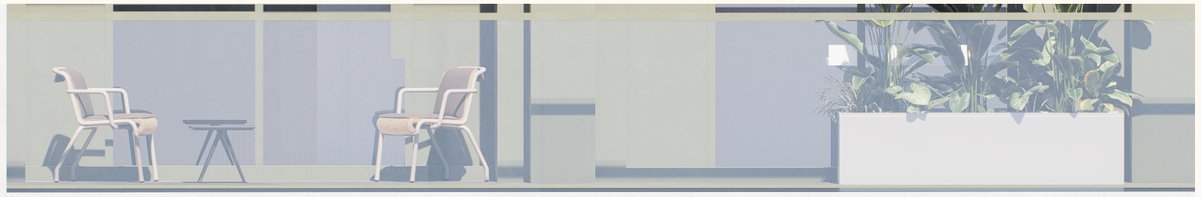


figure 51 fragment section energy efficiency





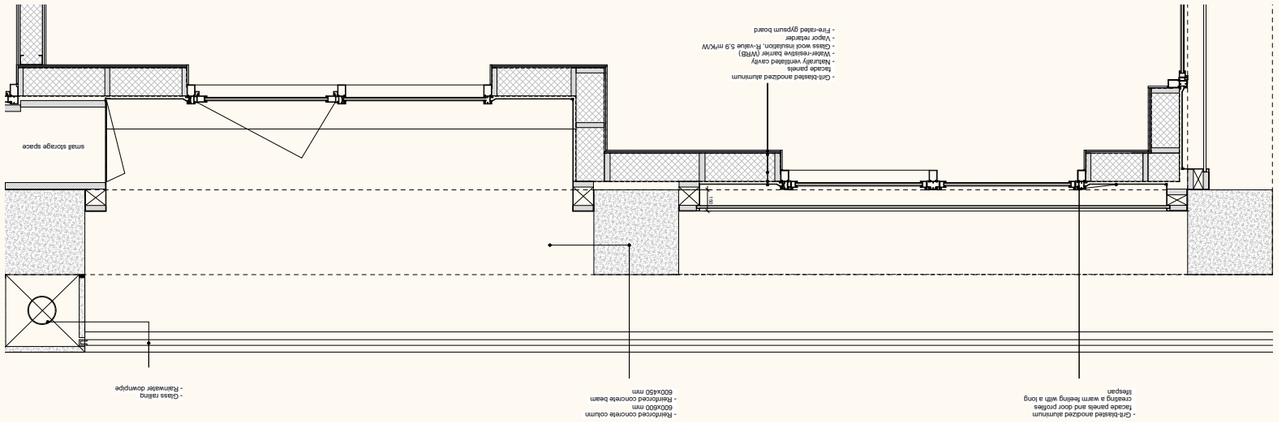
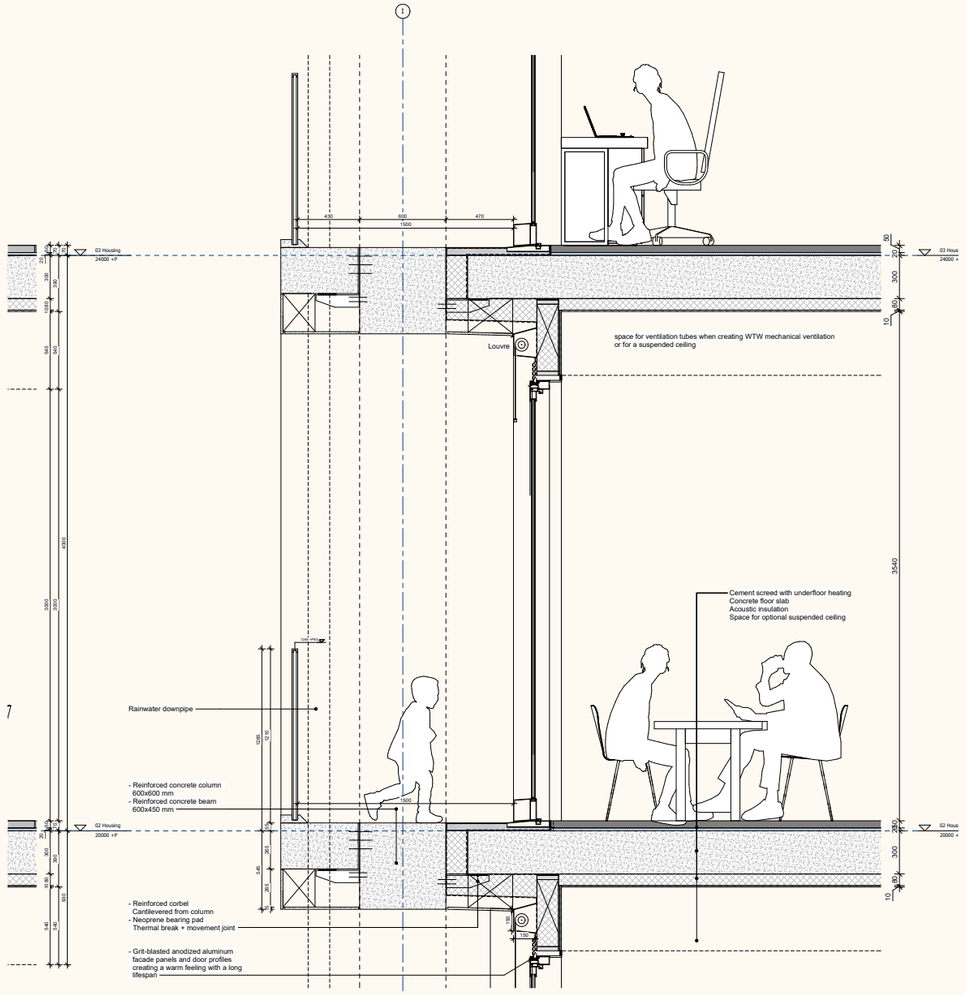


figure 52 fragment



The division between te baseunits are visible in the facades because the structure is on the outside of the insulation line.

4 CONCLUSION AND DISCUSSION



4.1 CONCLUSION

The main question asked how an adaptive spatial framework, based on Open Building principles, can enable the densification of a logistics site in Berkel en Rodenrijs, while integrating living, production and landscape into a system that can evolve over time. The answer of this report is that no single architectural or financial instrument achieves this alone. Three principles have to operate together as a closed loop.

Catalyst

Free shared energy is the decisive argument for pioneers to settle on a low-image industrial edge. The catalyst is both technical (near-zero bills) and symbolic, since the energy infrastructure is also the public face of the project. The catalyst is also financial, for both residents and investors. Stacked land use puts trucks, parking, deck and 250 dwellings on the same plot, so the land cost per square metre of housing falls well below any greenfield equivalent, and reusing existing infrastructure (the shed roof, the road network, the proximity of Metro Rodenrijs) avoids money spent on site preparation. The cross-financing model distributes the remaining cost across stakeholders who each benefit from a different layer: the logistics company finances the parking layer in exchange for rent from residents, the municipality contributes the public deck as urban infrastructure because money doesn't have to be spend on other infrastructure, and the developers above buy air rights. Investors are pulled in because each party only pays for the layer it directly uses while gaining the benefit of all the layers together, which turns a difficult industrial-edge plot into a risk-shared, returns-stable asset. This financial strategy works as a catalyst to attract investors.

Symbiosis

The spatial relationship between the logistics hall, the polder and the dwellings is mediated by a gradient deck inspired by The City Dune, stepping materially from concrete near the shed to planting near the polder. This continuous public landscape gives the neighbourhood its identity as a gateway into Midden-Delfland, and the openings in the deck frame the trucks below as part of the daily landscape, turning the logistics operation into a visible, productive presence rather than something hidden. No party is forced to compromise: the trucks keep operating underneath at full capacity (no nuisance for the industry), residents look down on the activity from a safely separated height (no nuisance from the industry), and the polder gains a soft ecological edge rather than a hard fence (no nuisance for the landscape).

Mutual dependence is then built through shared infrastructure and shared programme. The productive school, the workshop in the plinth, the cafés on the deck, the daycare, and the supermarket closer to the truckers' zone produce the daily routines through which residents and industry workers become functionally interdependent, and the financial structure also creates that interdependency: residents pay parking rent to the logistics company that financed the parking, the logitics company get a stable cashflow in return. Over the years, with residents staying long enough for attachment to develop (Lewicka, 2011), this interdependence matures into a shared place identity rather than two adjacent and indifferent populations, which is the place-identity that strengthens cohesion over time.

Adaptivity

The grid is what holds the diverse dimensions of truck logistics, car parking, retail, workshops, schools, offices, care and housing inside a single adaptive framework. An 8.4 by 8.4 metre main grid accommodates two truck parking lanes, three perpendicular car spaces, and the depths required for the commercial and educational functions; it subdivides to a 4.2 by 4.2 metre dwelling sub-grid. Floor heights are dimensioned so any floor can later carry a different function without structural modification. The Open Building support then carries a variable infill of dwellings, modules and façade panels with four explicit lifespans, so renovation becomes a continuous process rather than a periodic demolition.

This changeability reduces risk for every stakeholder. For residents, the modular tenure system (adapted from Superlofts and combined with Kalkbreite's Joker principle) lets one resident move through starter, couple, family and elderly configurations without leaving the neighbourhood, so their casco infill, their attachment and their social network are never sunk by a forced move. For investors, the pension fund that backs the cooperative accepts a lower return because the asset cannot become obsolete: every floor can change function, so the building stays leasable across economic and demographic cycles. And for the municipality, the same adaptivity means a fragment of the city that absorbs future needs (more

elderly care, more childcare, a shifted retail mix) without new construction, demolition costs or large-scale rezoning, which keeps the tax base intact through every wave of programmatic change.

The loop is the contribution. Kalkbreite shows that stacking on active infrastructure is financially viable. Next21 shows that the support and infill approach works at the building scale with multiple architects. The City Dune shows that a hard infrastructural edge can be mediated by gradient public space. Superlofts shows that casco delivery and resident customisation produce attachment. None of them, however, combines the three principles into a self-reinforcing loop in which the architectural decisions, the tenure model and the governance structure close on each other. This project demonstrates that closure. Free energy attracts pioneers; modules let them stay; staying produces attachment; attachment produces symbiosis with the industry; symbiosis produces social resilience; resilience protects the investment; protected investment attracts further commitment; that commitment improves the neighbourhood; and the improved neighbourhood, together with the still-free energy, attracts the next cohort. Each cycle deepens the system rather than depreciating it.

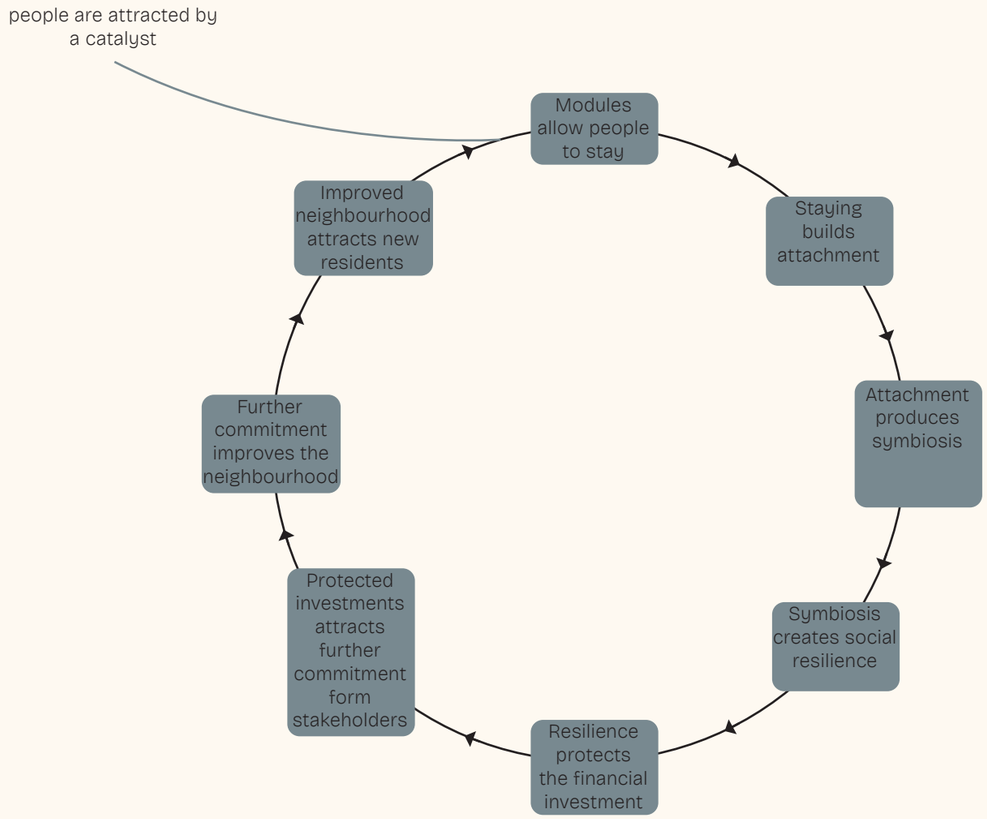


figure 53 conclusion cycle

4.2 IMPLICATIONS AND RECOMMENDATIONS

<u>For practice</u>
The most transferable result is the combination of the group's tool (which would need to be extended) catalogue with the three-principle loop, used together as a method for densifying industrial edges. The Randstad has many monofunctional industrial estates immediately adjacent to protected or ecologically valuable landscapes, and the typological options developed in the group masterplan (top up, take bites, wrap, repurpose, intensify, split up, multipurpose, empty plot, lifted platform) can be applied to comparable edges. The cross-financing model, in which the logistics company finances the parking layer in exchange for parking rent from residents, the municipality contributes to the public deck as urban infrastructure, and the developers above buy air rights, is replicable wherever an active logistics operator owns serviced land next to a housing-pressured urban edge.

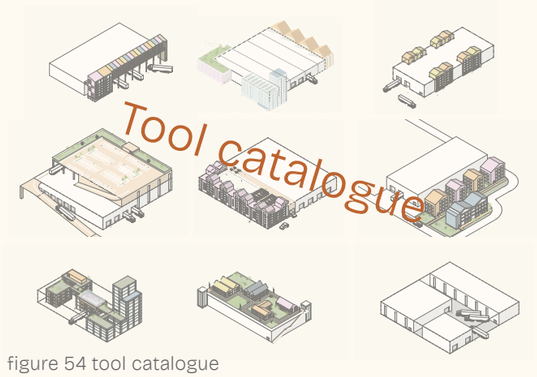


figure 54 tool catalogue

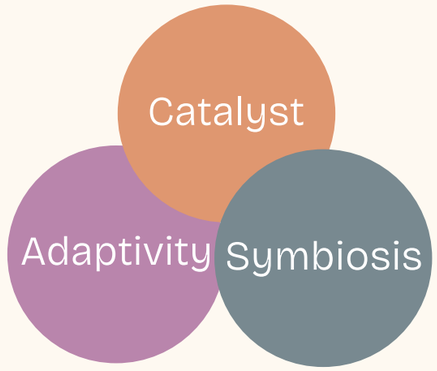


figure 55 three principles as an interdependent whole



figure 56 scalability map

For Open Building
The project demonstrates an explicit extension of Habraken's support and infill from the building to the neighbourhood. The four time layers (structure, façade, module, interior) and the modular tenure that aligns each layer with a separate financial instrument suggest that Open Building's social ambition can only be realised when its architectural distinctions are matched by tenure and governance distinctions. Future research could test whether the same four-layer logic operates at urban scale, for example whether a public deck can itself be treated as a "support" with shifting "infill" over decades.

For the productive city
The productive-city discourse (Architecture Workroom Brussels, 2016; Ryckewaert et al., 2021) is mostly programmatic: it argues that productive functions should return to the city and proposes social instruments such as the Maison de Quartier Productif or the Work Palace, but offers little architectural specification for how a building should embody those ambitions. This project shows that several architectural moves can give the discourse a visible form. The visible workshop in the plinth, the exterior staircase mirroring the dynamism of the trucks below, and the openings in the deck framing the logistics operation as part of daily life translate the productive-city ambition into something residents and workers actually see and inhabit.

For policy
The 2017 designation of Midden-Delfland as a Special Provincial Landscape is the political precondition that made this project possible. Without it, the easier path of greenfield expansion would have absorbed the demand. Similar designations along the wider Randstad edge, combined with active municipal participation in air rights on industrial estates (as Zürich did at Kalkbreite), would create the legal and financial frame within which this project type can scale.

4.3 REFLECTION

Approach
The research-through-design loop worked. The strongest moments in the process were the ones where a spatial question sent me back to a precedent I had already studied: a question about three-dimensional corridors returned me to Next21 with new eyes; a question about deck financing returned me to Kalkbreite; a question about how to keep residents in place returned me to Superlofts, and to the place-attachment literature, where Lewicka (2011) made the link between adaptivity and attachment intellectually explicit. The risk of the method is that the iteration can be infinite; the studio's deadlines made it converge.

Contribution
Each of the three principles exists in built form, on its own. The argument that they form a closed loop, and that the loop is what produces resilience under uncertainty, is the part I most want to defend. The single decision that most clearly carries this argument is the rentable module along the façade. It is small architecturally but large conceptually, because it is at the same time an adaptivity decision (the dwelling grows and shrinks), a symbiosis decision (the vacant module becomes a place of encounter), a catalyst decision (the building stays attractive even between cohorts), and a governance decision (the income flow to the cooperative continues regardless of household composition, and vacancy is reduced).

On limits
The financial figures are illustrative rather than fully engineered. A real development would require detailed cost modelling, structural verification of the spans across the truck zone, and consultation with current residents of Berkel en Rodenrijs and with JoyLogistics employees. The park, currently designed at 1:500, would need to be developed in more detail at a finer scale. The acoustic separation between the truck zone and the residential floors above is treated as an assumption: it is technically solvable (Kalkbreite demonstrates this above a tram hall), but a real project would have to demonstrate it explicitly. The energy system has been sized on TNO, RVO and CBS reference values; a real project would model the seasonal mismatch in detail and validate the aquathermal yield through pilot measurement at the ZUS buffer.

On integration
The biggest design challenge was holding the three principles together so that a single architectural decision simultaneously serves the catalyst, the adaptivity, and the symbiosis. For example, placing the structure on the outside of the insulation line created the cantilever that gives the building its passive performance (catalyst: energy), exposed the division between base units and modules on the elevation (symbiosis), and allowed the modular panels between the beams and columns to be removed easily when a function changes (adaptivity). The fragment had to be redrawn many times before the insulation line, the modular connection, the sunshading and the ventilation cavity all read together. The same was true at plan level: making the modules fit the façade, attach to the basic units and work with the structural grid took several iterations. The moment I am proudest of is when all of these begin to fall into place at once, so that one architectural decision answers more than one question at a time.

REFERENCES

ABF Research. (2024). Primos Prognose 2024: De toekomstige ontwikkeling van bevolking, huishoudens en woningbehoefte. ABF Research.

ABN AMRO. (2025, January 15). Housing market - building according to need. ABN AMRO Research. https://www.abnamro.com/research/en/our-research/housing-market-building-according-to-need

Architecture Workroom Brussels. (2016). A Good City Has Industry. Atelier Brussels - The Productive Metropolis. https://www.architectureworkroom.eu/en/transformations/2756/a-good-city-has-industry

Brand, S. (1994). How buildings learn: What happens after they're built. Viking.

Brown, B., Perkins, D. D., and Brown, G. (2003). Place attachment in a revitalizing neighborhood: Individual and block levels of analysis. Journal of Environmental Psychology, 23, 259–271.

Centraal Bureau voor de Statistiek. (2022). Woonbase 2021: Gemiddeld woonoppervlak per persoon. CBS. https://www.cbs.nl

Cittaslow International. (n.d.). Midden-Delfland. Retrieved from https://www.cittaslow.it/network/midden-delfland

De Nederlandsche Bank. (2025). Housing market outlook. DNB. https://www.dnb.nl/en/current-economic-issues/housing-market/

Dodd, N., Donatello, S., & Cordella, M. (2020). Level(s) - A common EU framework of core sustainability indicators for office and residential buildings. European Commission, Joint Research Centre. Publications Office of the European Union.

Economisch Instituut voor de Bouw, Metabolic, & SGS Search. (2020). Vormfactoren voor gebouwtypen in Nederland. EIB.

Habraken, N. J. (1961). De dragers en de mensen: Het einde van de massawoningbouw. Scheltema & Holkema.

Habraken, N. J. (1972). Supports: An alternative to mass housing (B. Valkenburg, Trans.). The Architectural Press. (Original work published 1961)

Habraken, N. J. (1998). The structure of the ordinary: Form and control in the built environment. MIT Press.

Heren 5, STIPO, and AM. (2021). Handboek Superplinten.

Hidalgo, M. C., and Hernández, B. (2001). Place attachment: Conceptual and empirical questions. Journal of Environmental Psychology, 21(3), 273–281.

Hofkamp, R., Rijksvastgoedbedrijf, & Ministerie van Binnenlandse Zaken en Koninkrijksrelaties. (2015). Kerngetallen werkplekoppervlak per persoon voor rijkskantoren. Rijksvastgoedbedrijf.

Informatiepunt Leefomgeving (IPLO). (n.d.). Daglichttoetreding: Regels bij nieuwbouw. Retrieved from https://iplo.nl

Kendall, S., & Teicher, J. (2000). Residential open building. E & FN Spon.

Koehler, M. (n.d.). Superlofts & Superwoods. Marc Koehler Architects. https://marckoehler.com

Korthals Altes, W. K. (2008). Municipal strategies for introducing housing on industrial estates as part of compact-city policies in the Netherlands. Cities, 26(3), 151–160. https://doi.org/10.1016/j.cities.2008.03.001

Lewicka, M. (2010). What makes neighborhood different from home and city? Effects of place scale on place attachment. Journal of Environmental Psychology, 30, 35–51.

Lewicka, M. (2011). Place attachment: How far have we come in the last 40 years? Journal of Environmental Psychology, 31, 207–230.

Marchal, S., & Müller Sigrist Architekten. (n.d.). Kalkbreite. Müller Sigrist Architekten. https://muellersigrist.ch

Milieu Centraal. (n.d.). Gemiddeld energieverbruik huishoudens. Retrieved from https://www.milieucentraal.nl

N.L.NIK, & Hayman, S. (2005). Daylight design rules of thumb. In Proceedings of the Passive and Low Energy Architecture Conference.

Plusoffice Architects, & WRKSHP collectif. (2016). AND / OR / EITHER / NOR: Working models for the productive metropolis. Atelier Brussels - The Productive Metropolis. Architecture Workroom Brussels.

Rabobank. (2025, December 17). Dutch housing market quarterly: No signs of cooling even as supply grows. RaboResearch. https://www.rabobank.com/knowledge/d011508452-dutch-housing-market-quarterly

Ratajszczak, M. (2014, November 13). The dark art of conceptual design in privately funded public space. Land8: Landscape Architects Network. https://land8.com/the-dark-art-of-conceptual-design-in-privately-funded-public-space/

Rijksdienst voor Ondernemend Nederland (RVO). (n.d.). Handboek aquathermie: Kengetallen en randvoorwaarden. RVO. https://www.rvo.nl

Ryckewaert, M., Zaman, J., & De Boeck, S. (2021). Variable arrangements between residential and productive activities: Conceiving mixed-use for urban development in Brussels. Urban Planning, 6(3), 334–349. https://doi.org/10.17645/up.v6i3.4274

Scannell, L., and Gifford, R. (2010). Defining place attachment: A tripartite organizing framework. Journal of Environmental Psychology, 30(1), 1–10.

SLA. (n.d.). The City Dune - SEB. SLA. https://www.sla.dk/cases/the-city-dune-seb/

SLA. (n.d.). Sund Nature Park. SLA. https://www.sla.dk

Stichting Architecten Research (SAR). (1976). Variations: The systematic design of supports. MIT Laboratory for Architecture and Planning.

TNO. (n.d.). Kengetallen zonne-energie op daken. TNO. https://www.tno.nl

TU Delft Repository. (2024). Midden-Delfland: The metropolitan park towards 2070. TU Delft. https://repository.tudelft.nl/record/uuid:03f753d5-957b-463e-9ed0-7b130f378547

TU Delft Vision Team Wonen. (2024). Room for housing: Towards an integrated approach to the Dutch housing challenge. TU Delft Faculty of Architecture and the Built Environment.

Utida, Y., & Shu-Koh-Sha Architecture and Urban Design Studio. (1994). Next21 [Experimental housing project]. Osaka Gas Company, Osaka, Japan.

Washington State. (2024). WAC 51-50-1004: Section 1004 - Occupant load (International Building Code, Table 1004.5). Washington Administrative Code.

ximageAmsterdam. (2024, July 2). NEXT21: An experiment, full movie [Video, original documentary 2009]. YouTube. https://www.youtube.com/watch?v=YBCPET4hIR4

ZUS [Zones Urbaines Sensibles]. (n.d.). Water buffer proposal Midden-Delfland [Unpublished project documentation].

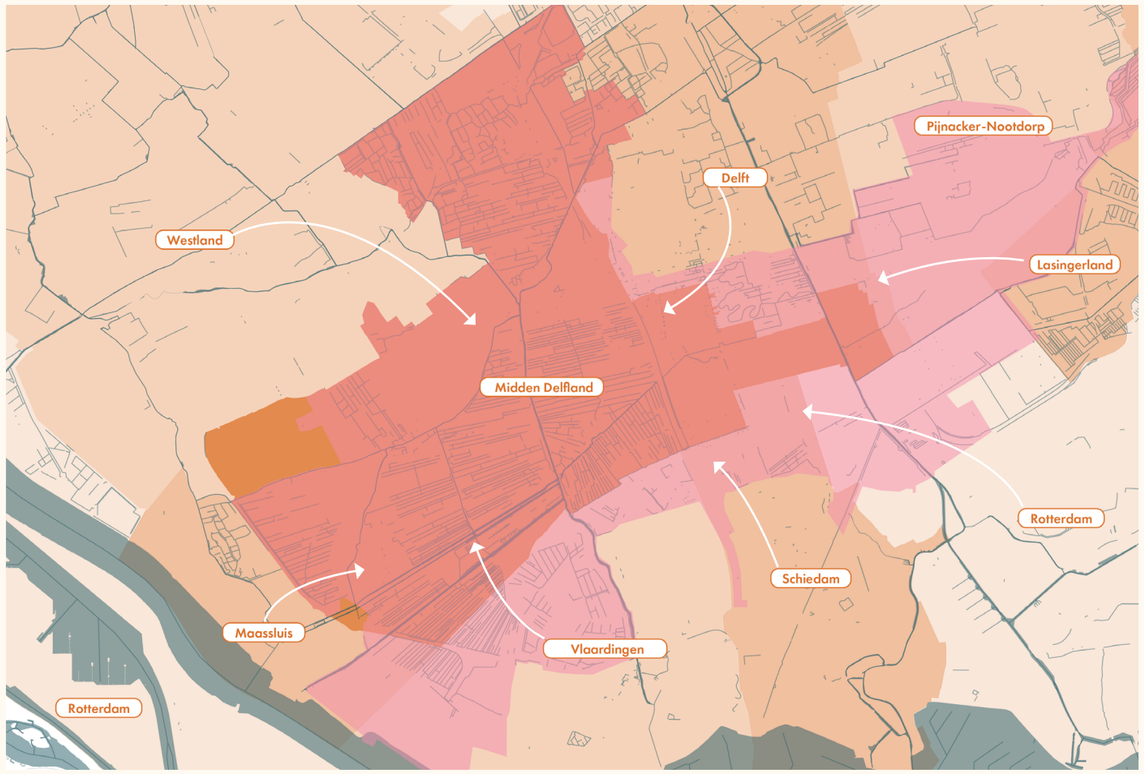
On AI use
Generative-AI tools such as claude and ChatGPT were used as a writing and structuring aid (clarifying argument structure, checking phrasing, summarising reference texts I had already read). All the researched information, all design decisions, all calculations, all drawings and the conceptual loop that structures the report are my own work.

APPENDICES

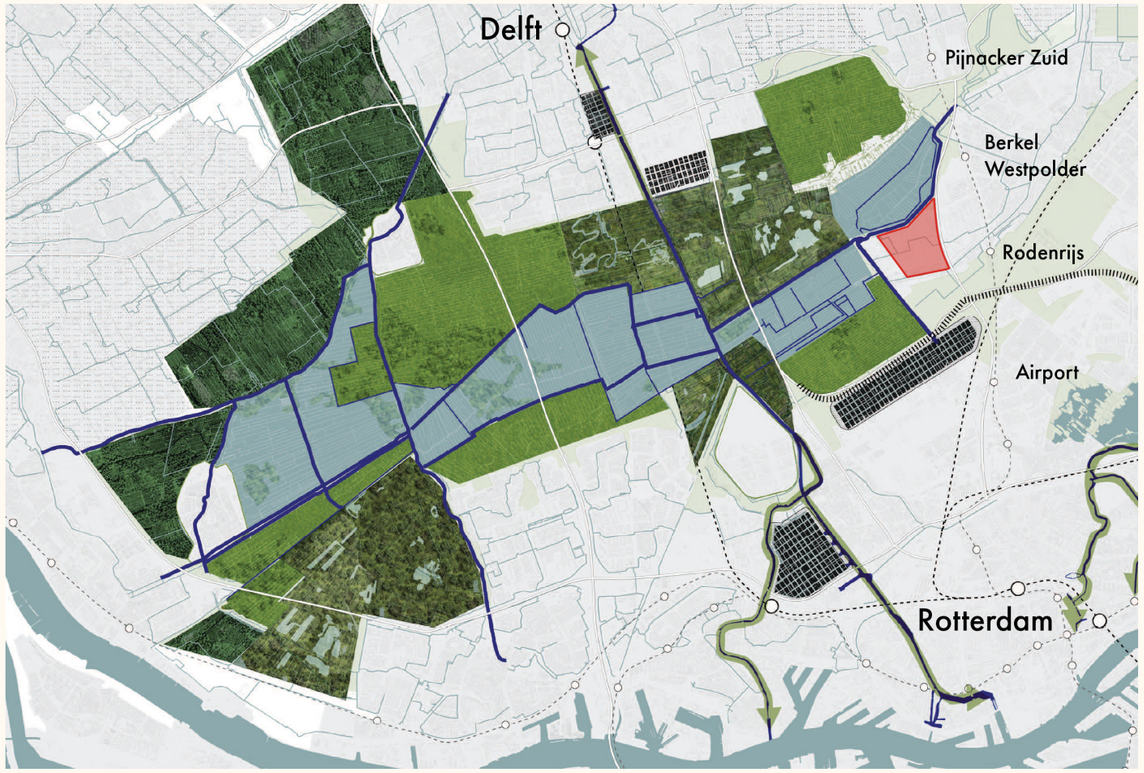
APPENDIX. 01 LOCATION ANALYSIS

1 Regional context: Midden-Delfland under pressure
The municipality of Midden-Delfland was established in 2004 through the merger of the former Maasland and Schipluiden municipalities, together with smaller parts of neighbouring municipalities at its edges. The formation of this new municipality was motivated by the desire to unite the open, rural, and agricultural area between the dense cities of the Randstad under a single administrative body, so it could preserve its green character and protect the landscape between the surrounding urban zones.

In 2017, the area was designated as a Bijzonder Provinciaal Landschap (BPL), the first of its kind in the Netherlands. This protected green area connects to other surrounding green zones, helping to support both ecological values and recreation. Within the BPL, development and spatial changes are only permitted if they do not damage the area's core qualities: its ecological landscape and cultural-historical values. However, the BPL does not coincide neatly with the administrative borders of the municipalities around it, revealing how political boundaries are at odds with the identified ecological boundaries.

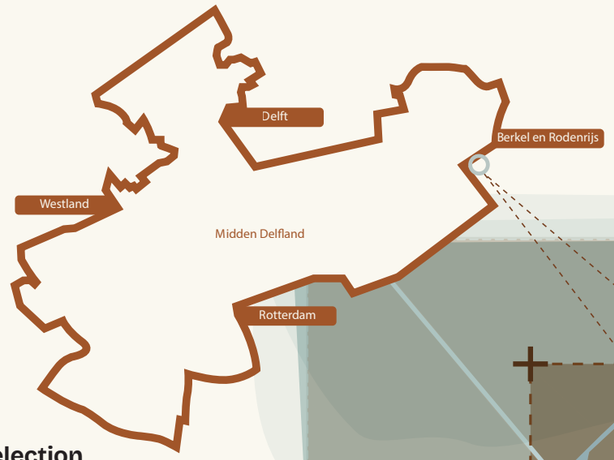


Over the centuries, the Midden-Delfland landscape has undergone multiple transitions shaped by poldering and dyking, which established its primary structural framework. In earlier periods, technologies such as windmills and essential water-management infrastructure were visually prominent, making the landscape's core functions legible at a glance. Over time, however, technological progress has produced a clear tendency to visually camouflage infrastructure and blend it into the environment (particularly within the Midden-Delfland BPL itself). Outside Midden-Delfland, on the urban edges, structures and landmarks are more prominent. **This observation can be translated into a design principle: camouflaged design within the landscape and more prominent design on the edges.** The edges could function as a dynamic ring around a quiet green core. In any case, a limit to further expansion is needed to protect or even reinforce the area's flat, open character.



2 The ZUS vision and the decision to build on the edge
ZUS (Zones Urbaines Sensibles) has proposed a strategic vision for Midden-Delfland that divides the landscape into four main types: wet areas for water storage, zones for new forms of agriculture, areas for wood production, and natural reserves. The ZUS plan presents a bold vision addressing major challenges such as water management, biodiversity, urban sprawl, and food and resource production. Crucially, the ZUS plan also proposes a large water buffer in the polder directly bordering the project site (Figure X), which offers potential for aquathermal energy extraction and stormwater management, both of which are incorporated into the design (see Chapter 4.3 and Appendix Energy).

Based on the regional analysis and the BPL designation, the decision was made to build on the edges of Midden-Delfland rather than within it. Building on the edges allows for more prominent volumes (which translates to higher density and therefore more housing) without compromising the protected open landscape. Along these edges, a significant number of monofunctional and underperforming industrial estates exist. These areas occupy large amounts of land while contributing little to urban quality, and their existing infrastructure (roads, utilities, parking) represents an investment that can be reused rather than duplicated on greenfield sites. The project therefore chose to build on industrial land on the edge of Midden-Delfland.



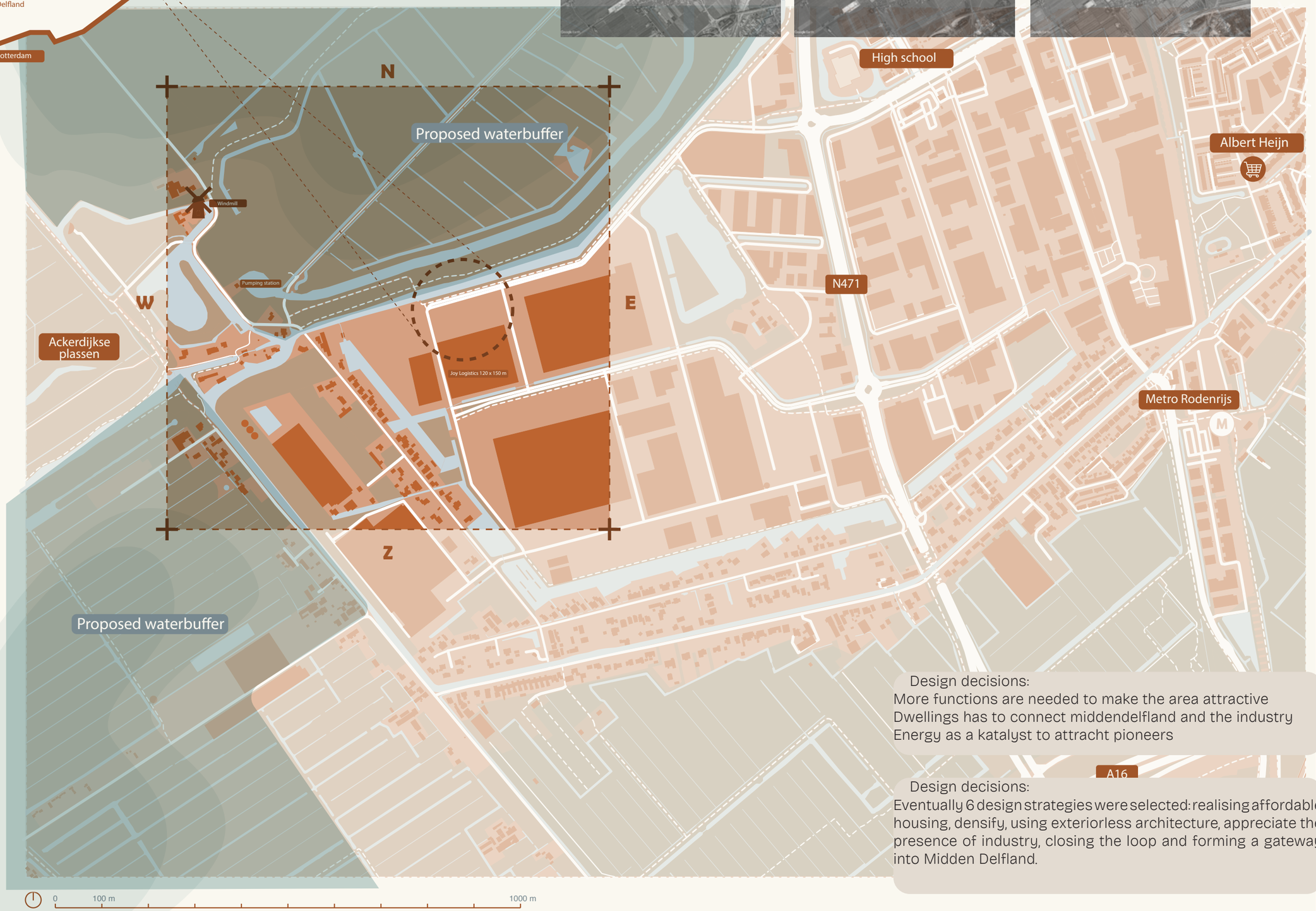
Aerial photographs from 2005, 2019, and 2024 show the rapid urbanisation of Berkel en Rodenrijs over the past two decades, confirming that development pressure on the area is intensifying and that the industrial edges are increasingly surrounded by residential fabric.



3 Site selection

Within the wider industrial edge, a specific site in Berkel en Rodenrijs was selected. The site is located adjacent to a large logistics shed operated by JoyLogistics (approximately 120 × 150 metres, with a roof area of roughly 18,000 m²). It borders Midden-Delfland on three sides and is close to public transport (Metro Rodenrijs is within a 10-minute cycling distance or 30-minute walk from the furthest point of the site).

The surrounding context analysis revealed several important conditions. The nearest supermarket (Albert Heijn) is far from the site, a deficit that the design addresses by including a supermarket on the western edge of the masterplan. A high school is located nearby. The large, flat roof of the logistics shed presents a significant opportunity for solar energy generation (see Appendix Energy). The proposed ZUS water buffer directly north-west of the site can contribute energetically through aquathermal systems and visually through the stormwater drainage integrated into the landscape design. The site also sits within a buffer zone between the Midden-Delfland landscape and the existing sheds, making it a natural transition point between industry and polder.

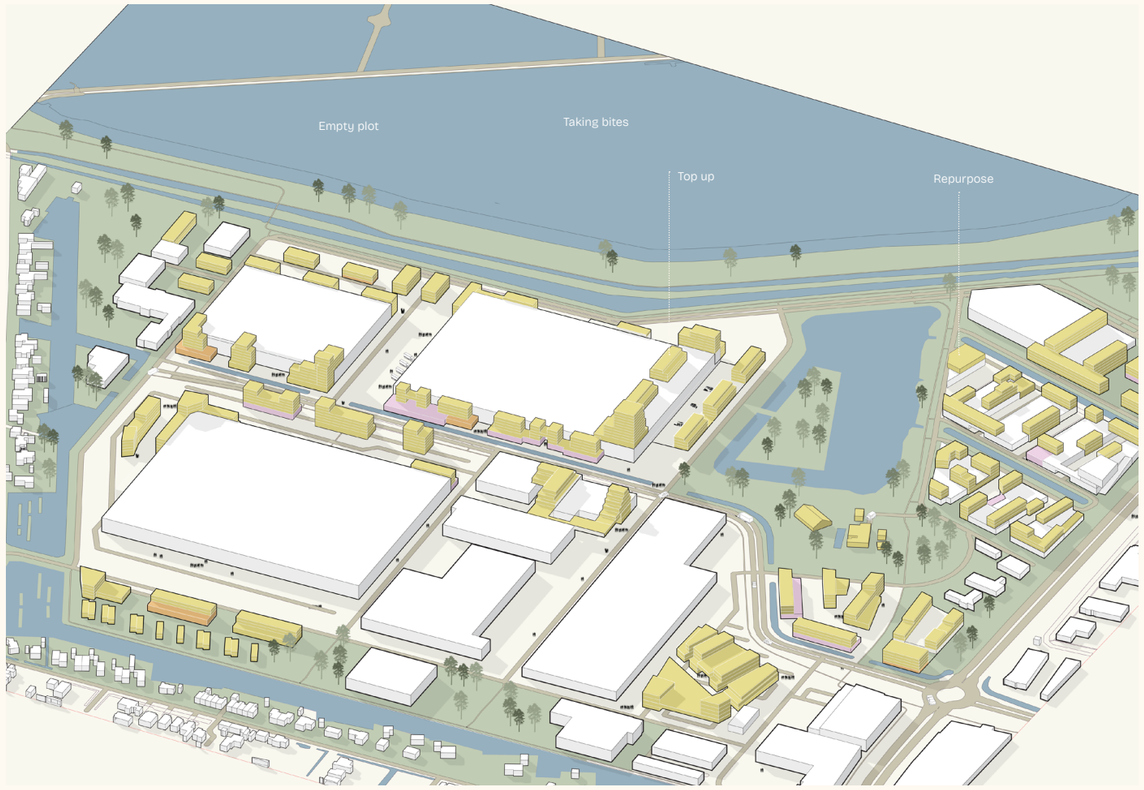


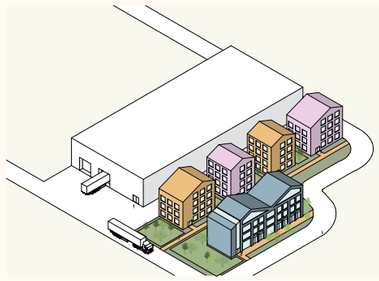
Design decisions:
More functions are needed to make the area attractive
Dwellings has to connect middendelfland and the industry
Energy as a katalyst to attracht pioneers

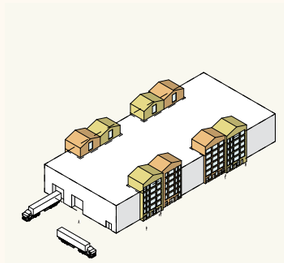
Design decisions:
Eventually 6 design strategies were selected: realising affordable housing, densify, using exteriorless architecture, appreciate the presence of industry, closing the loop and forming a gateway into Midden Delfland.

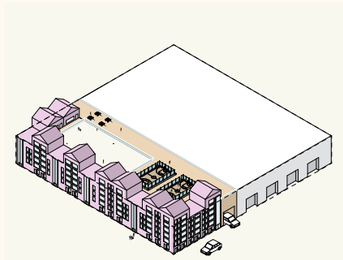
4 Exploration of densification typologies

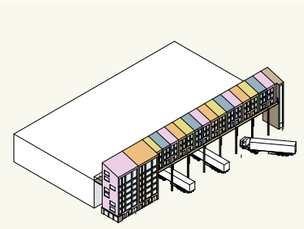
To understand how densification could work on industrial land, a series of typological explorations were conducted on the site early in the design process. Nine distinct strategies were tested, each evaluated against six criteria: relation to industry, types of rooftops, affordability, densification potential, use of exteriorless architecture, and target group. These strategies ranged from building on empty adjacent plots, to topping up existing sheds, to wrapping buildings around sheds, to creating entirely new elevated platforms above logistics zones. The typologies were applied to the wider industrial area to test their scalability. The results of this exploration informed the final design strategy (building next to and above parking functions of the shed on an elevated deck) which scored highest on the combination of affordability, density, and respect for the existing industrial operation.



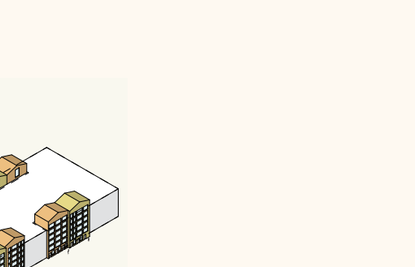


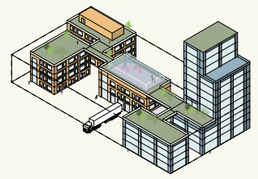


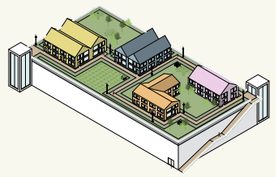


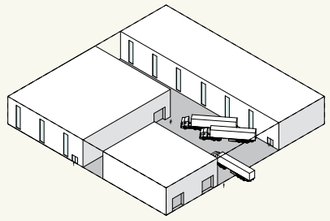












5 Site-specific analysis
A detailed site analysis was conducted to map the constraints and opportunities for densification around the JoyLogistics shed. Six thematic maps were produced (Figure X).

No-go zones
Areas where building is not possible due to active truck docking zones, loading and unloading areas, and the need to preserve daylight access to the shed interior. These zones define the buildable envelope and ensure that the logistics operation is not disrupted by the new development.

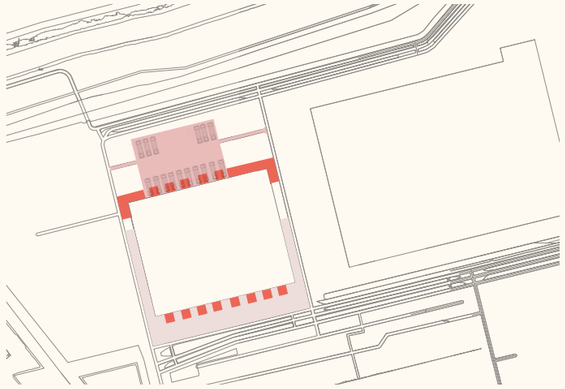
Sightlines
Analysed from the perspective of the logistics workers: the central area of the site is the truckers' hotspot, and sightlines toward Midden-Delfland and toward the shed and access road must be maintained. These sightlines informed the positioning and height of the new buildings to ensure that the openness of the landscape remains perceptible from the working area.

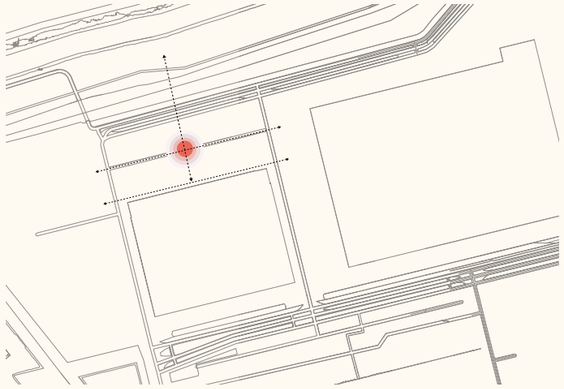
Walking routes
Future residents and visitors can enter the site from several directions. These entry points were mapped to inform the positioning of building entrances, public functions, and the two shared arrival zones where all modes of transport converge before separating vertically.

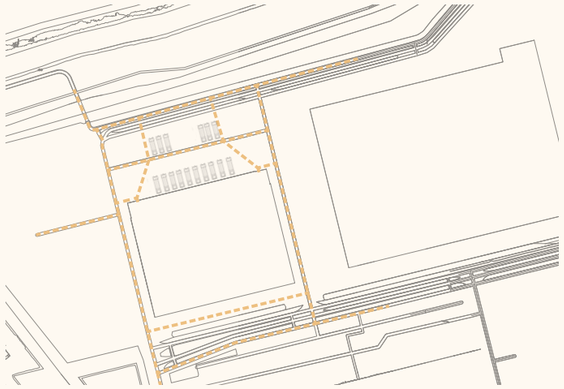
Connection between functions
For the combination of housing and industry to make spatial and social sense, a visual and functional connection between the two must be maintained. The analysis identified the key points where this connection should be strongest, particularly at the deck level, where openings allow views down to the truck operations below.

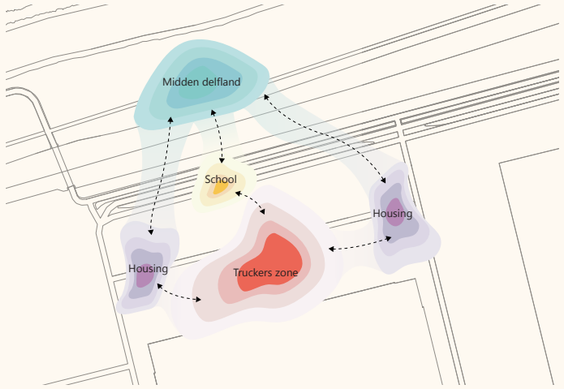
Truck routes
The proposed truck routes through the site are shown. To keep the connections with the natural polder element, the truck/car route around the site is removed. Because the design seeks to respect and celebrate the existing industry the route through the landscape is preserved and has to stay visible. The elevated deck and the residential volumes are positioned to work around (not against) the established logistics circulation.

Design decisions:
No buildings directly connecting to the shed to allow daylight into the shed
Truckers have to have a view towards Midden Delfland
Residents and workers enter the area as equals
Functions have to connect to resident and workers
Truck routes have to stay visible

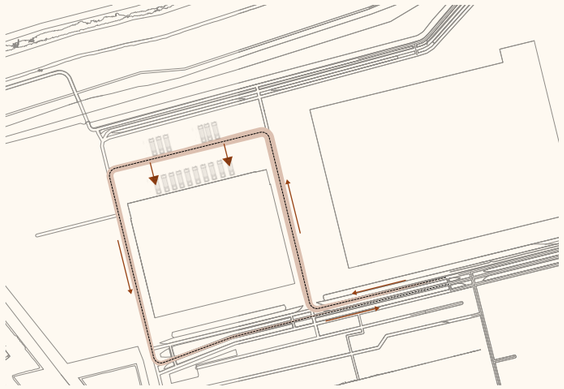

No go zones


Sightlines


Walking routes



Connection between functions


Truck routes

APPENDIX. 02 SOCIAL COHESION AND TARGET GROUP

1 The challenge: building community at the edge of industry
The central social question of this project is not whether people can live next to a logistics hall, but whether they will want to stay. Densifying industrial land only succeeds if the resulting neighbourhood develops a social fabric strong enough to sustain itself over time. Without that fabric, pioneer residents will treat the location as a temporary stepping stone and leave as soon as they can afford to move elsewhere. The neighbourhood would then become a transient settlement rather than a rooted community.

This appendix examines the conditions under which social cohesion can develop between two populations that the modernist city deliberately separated: knowledge workers and practically trained workers employed in the adjacent logistics, repair, and manufacturing sectors. It draws on the discourse of the productive city (Architecture Workroom Brussels, 2016; Ryckewaert, Zaman & De Boeck, 2021) and on place attachment research from environmental psychology (Lewicka, 2011; Scannell & Gifford, 2010) to argue that social cohesion between these groups is not automatic but must be designed through shared infrastructure, shared spaces, and, crucially, through a spatial framework that allows people to stay in place long enough for attachment to form.

2 The productive city: why industry and housing need each other
The discourse of the productive city, developed most explicitly by Architecture Workroom Brussels in their programme A Good City Has Industry (2016), begins from a diagnosis: European cities have become places of consumption without production. The displacement of manufacturing, repair, and logistics to peripheral estates has created a geographic and social separation between those who think (knowledge workers in the service economy) and those who make (practically trained workers in production and logistics). This separation has three consequences.

1. It impoverishes the urban economy. Innovation, as Ryckewaert, Zaman and De Boeck (2021) argue, arises most powerfully at the interface between knowledge and craft, between the designer and the maker. When these groups occupy separate geographies, the synergy is lost, and the city's economic base narrows to services alone.
2. It deepens social inequality. Workers in logistics and manufacturing become invisible to urban residents; their labour is neither valued nor understood; and their neighbourhoods receive less public investment because they lack political visibility.
3. It produces spatial waste. Monofunctional industrial estates occupy large amounts of land while generating little urban quality: they are inward-looking, poorly connected, and surrounded by fences rather than streets.

The productive city reverses this logic. Rather than separating functions, it interweaves them: housing next to workshops, schools next to factories, cafés next to loading docks. As Architecture Workroom Brussels states: urban public space connects thinkers and makers in a solidary city. The goal is not nostalgia for the pre-industrial city but a new form of coexistence made possible by the fact that modern production (CAD/CAM, 3D printing, automated logistics) is cleaner, quieter, and more flexible than the heavy industry that originally motivated functional separation (Architecture Workroom Brussels, 2016).

Design decisions:
Spatial framework that allows residents to build a connection with the industry through time

3 Place attachment: staying long enough to care
Place attachment research in environmental psychology provides the theoretical basis for understanding how people come to identify with a neighbourhood. Lewicka's comprehensive review of four decades of research (2011) identifies three consistent predictors of place attachment: length of residence, the strength of local social ties, and home ownership. Of these, length of residence is the most fundamental, because it is the precondition for the other two: social ties take time to develop, and ownership is itself a commitment to staying. Key predictors including residence length, social ties, and ownership status are consistently linked to stronger emotional bonds with places across multiple studies (Lewicka, 2011).

The implication for design is direct: if you want residents to develop attachment to a place, you must create the conditions for them to stay. A neighbourhood that forces people to relocate every time their household changes size (from studio to family apartment to downsized elderly home) systematically breaks the accumulation of residence time and, with it, the possibility of attachment. Each move resets the clock. Each new address means new neighbours, new routines, and a new period of being a stranger.

Brown, Perkins and Brown (2003) demonstrated that place attachment operates at both the individual and the block level: blocks with higher proportions of long-term residents and home owners showed stronger collective attachment, independent of individual characteristics. This means that residential stability is not only a personal benefit but a public good: it strengthens the social fabric of the entire neighbourhood, not just the individual household.

Hidalgo and Hernández (2001) showed that place attachment develops before place identity: people first feel connected to a place (attachment), and only later begin to define themselves through it (identity). This sequence matters for the project, because it means that the initial phase of settlement (when pioneer residents arrive at an unfamiliar industrial edge) is precisely the period when design must do the most work: creating the conditions for early attachment (shared spaces, visible energy infrastructure, encounters with industry workers) before identity can form organically over the following years.

3.1 The conventional relocation cycle
In a conventional housing market, a household that changes in size must move. A starter rents a studio; when a partner joins, they move to a two-bedroom apartment; when a child is born, they seek a larger family home; when children leave, they downsize; when elderly, they may move to assisted living. Each of these five or six transitions produces costs (financial, social, emotional), temporary vacancy for the landlord, and a complete restart of the place-attachment process. Over a 40-year adult life, a resident may live in five different addresses which results in never staying long enough in any single one to develop the deep attachment that Lewicka's research associates with civic participation, neighbourhood care, and community identity.

3.2 The modular alternative
The modular tenure system proposed in this project eliminates this relocation cycle. By allowing residents to grow and shrink their dwelling within the same building (adding a rentable module when a partner moves in or a child is born, releasing one when children leave) the system removes the primary reason people move. A resident who arrives as a starter in a 48 m² base unit who can rent extra modules attached to the base unit can live through every life phase (couple, young family, full family, empty nest, elderly) in the same neighbourhood. Over a 20–30-year period, this accumulation of uninterrupted residence time produces exactly the conditions that place-attachment research identifies as essential: long tenure, deep local ties, and a sense of ownership (whether literal or through cooperative membership).

Design decisions:
Attract people (attachment) by using energy as a catalyst, together with social spaces
Make sure identity can be formed by designing an open framework where people can create their own identity: shell delivery with flexible interior for residents
Make sure identity can grow by making the framework suitable through the phases of life by offering attachable modules for households to be able to grow through their phases of life.

The social consequence is profound. Instead of a neighbourhood populated by transient strangers, the modular system produces a community of long-term inhabitants who have grown together with the place, who remember its first years, who have shaped its collective spaces, and who identify with its industrial character not because they were told to but because they have experienced it daily for decades.

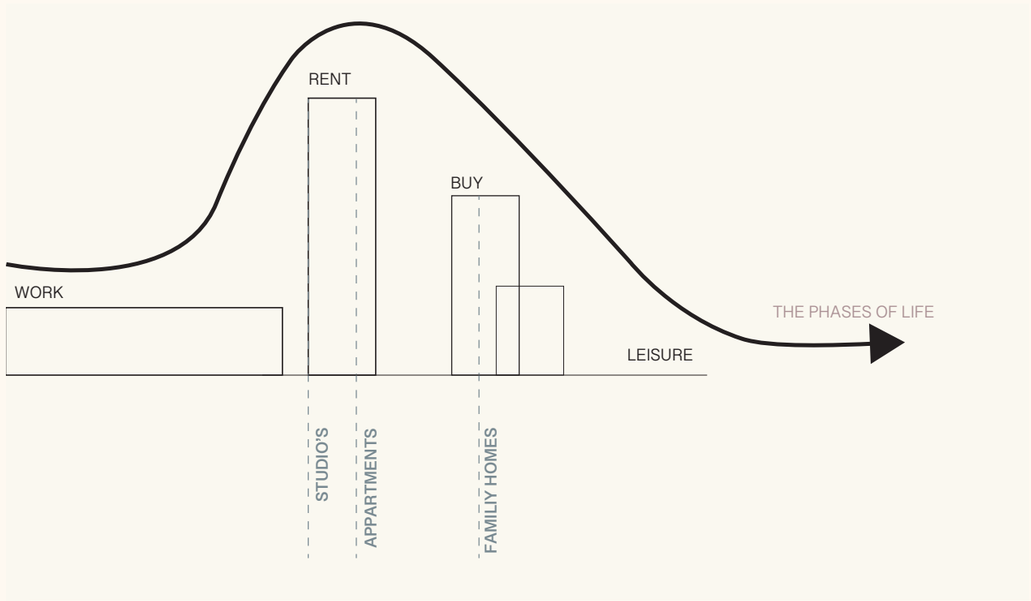
4 Target group: a deliberately mixed population

The project is designed for a mixed population of pioneers willing to settle at the edge of industry, spanning every stage of adult life. The site accommodates starters and single-person households (the group most affected by the current affordability crisis), couples, small and larger families, and downsizing elderly residents. Crucially, the target group bridges the two worlds that the modernist city separated: knowledge workers from Delft and Rotterdam, and practically trained workers employed in the adjacent logistics, repair, and manufacturing sector.

The neighbourhood-wide tenure ratio is approximately 60% middle-segment rental and 40% cooperative purchase / free sector. This ratio reflects the income distribution of the surrounding regional economy. The middle-segment rental housing is concentrated in the tower closest to the shed (where their is a direct connection with the energysource (the shed) showing the affordability, attractive for starters), while the purchase housing is positioned closer to Midden-Delfland (where the quieter, greener setting appeals to families and elderly households seeking long-term stability).

4.1 Life stages as a gradient in the landscape

The spatial distribution of housing types follows a gradient from industry to polder. Starters and single-person households (the most mobile and adventurous demographic) occupy the rental tower directly adjacent to the logistics shed, where the industrial character is most visible and the energy benefit most tangible. Families and elderly households (seeking stability, green space, and proximity to the productive school) occupy the quieter volumes closer to Midden-Delfland. This gradient is not a rigid separation: the modular system allows a resident to move through the gradient over a lifetime (from rental studio near the shed to a purchased family apartment near the polder) without ever leaving the neighbourhood. The entire life cycle unfolds within a single social ecosystem.



Design decisions:
Put emphasis on the dynamic flow in the dwellings close to the shed. Put emphasis on the peacefullness in the dwellings close to Midden Delfland.

5 Mechanisms for building social cohesion over time

Social cohesion between residents and industry workers does not emerge automatically from physical proximity. It must be cultivated through a deliberate sequence of spatial and organisational interventions that deepen interaction over time. Drawing on the productive city literature, the design embeds four mechanisms that operate at different timescales.

5.1 Short term: visibility and encounter

The first step is making industry visible. The design lifts residents above the truck zone on an elevated deck with openings that reveal the loading and unloading below. Trucks are not screened off but framed: their movement becomes part of the daily visual experience of the neighbourhood, restoring what Architecture Workroom Brussels (2016) calls pride in production. The workshop embedded in the plinth of the rental tower places 'making' litterally at the entrance of the building (residents pass through production every time they come home). Two shared arrival points bring all users (trucks, cars, cyclists, pedestrians) to the same place before they separate vertically, reinforcing the principle that all modes of using the site are equally legitimate.

5.2 Medium term: shared facilities and the productive school

As the neighbourhood matures, shared facilities deepen the interaction. The productive school (positioned facing Midden-Delfland as a low-rise volume at the end of the gradient) is the social and pedagogical anchor. Drawing on the concept of the Maison de Quartier Productif and productive learning systems described by Architecture Workroom Brussels (2016), the school is designed as a skill-based learning hub in which children use residual materials from the logistics operation, and local businesses gain access to the school's machines (located in the workshop in the residential tower) outside teaching hours. In the evening, the school's sports hall is available for residents and workers. This dual programming creates what the productive city discourse calls a hybrid between incubator and community centre: a place where learning, making, and living overlap.

Other shared facilities: a neighbourhood supermarket on the western edge, lunch cafés near the shed serving both residents and truck drivers, and the activated vacant modules that function as co-working spaces, guest rooms, or yoga studios

They form a network of informal meeting points distributed throughout the site. Each of these points creates occasions for encounter between people who would otherwise never cross paths: a resident buying coffee next to a logistics dispatcher, a child learning woodwork from a truck mechanic's partner, an elderly resident tending the rooftop garden alongside a warehouse worker on a break.

Design decisions:
Frame the trucks in the landscape making it a daily visual experience seen from landscape and dwellings
Embed the workshop in the rental tower in the plinth next to the entrance: residents pass through production every time they come home and thereby slowly creating identity with the place.
Landscape design: two shared arrival points where cyclists, pedestrians, trucks and car all arrive showing they are equal.
Add a productive school as a kickstarter to introduce to importance of making to peoples lifes
Other shared facilities: a neighbourhood supermarket on the western edge, lunch cafés near the shed serving both residents and truck drivers, and the activated vacant modules that function as co-working spaces, guest rooms, or yoga studios

5.3 Long term: shared resources and urban industrial symbiosis

The deepest form of social cohesion arises when residents and industry become functionally dependent on each other through shared resource flows. The project creates two such dependencies.

1. Energy: the PV system on the shed roof generates electricity for both the logistics operation and the dwellings, managed through a shared energy cooperative (see Appendix Energy System). Residents depend on the industry for their zero-cost energy; the industry benefits from the energy as well
2. Water: stormwater from the buildings and the deck is routed visibly through the landscape toward the ZUS water buffer in Midden-Delfland, where it feeds the aquathermal heating system.

These shared flows produce what the productive city literature calls urban industrial symbiosis: a condition in which residents and businesses are bound together by mutual benefit rather than forced coexistence. Over time, this functional interdependence generates social cohesion not as an abstract ideal but as a practical reality: people care about the industry because their heating, electricity, and children's education depend on it, and the industry cares about the residents because they are its energy partners, its customers, and its neighbours.

Phase	Mechanism	Design element	Social outcome
Year 0–5	Visibility and encounter: making industry visible and creating shared arrival points.	Elevated deck with openings; workshop in plinth; two shared entry zones; visible truck routes.	Curiosity and acceptance; industry becomes familiar rather than foreign.
	Shared resources: functional dependency through energy, water, materials.	Energy cooperative; aquathermal heat from water buffer; circular material exchange via productive school.	Mutual dependence; shared decision-making; community identity.
Year 5-10	Shared facilities: hybrid spaces where residents and workers meet.	Productive school; workshop; supermarket; lunch cafés; activated vacant modules.	Routine interaction; first friendships across the thinker-maker divide.
Year 10+	Urban industrial symbiosis: residents and industry are inseparable.	All of the above, deepened by time and accumulated experience.	Place identity; pride in the industrial character; residents advocate for the industry rather than against it.

6 Conclusion

The research on place attachment and the productive city discourse converge on a single conclusion: social cohesion requires time, and time requires staying. If residents are forced to leave every time their household changes, the neighbourhood can never accumulate the long-term inhabitants who form the backbone of community identity. If the building cannot adapt to changing functions, it risks obsolescence and eventual depopulation. If the relationship between residents and industry is not anchored in shared resources, it remains superficial and vulnerable to conflict.

The adaptive spatial framework proposed in this project (the modular grid, the rentable modules, the flexible floor heights, the dual tenure system) is therefore not only a technical or financial strategy but also a social strategy. It creates the conditions under which people can stay, under which buildings can change, and under which the relationship between living and production can deepen rather than dissolve. Lewicka's (2011) finding that length of residence is the strongest predictor of place attachment is not just an empirical observation; it is a design brief. The modular system is the architectural answer to that brief: it eliminates the need to move, and in doing so, it gives people time to form relationships and create an identity with the place.

APPENDIX. 03 ENERGYSYSTEM

1 Introduction
This appendix describes the proposed energy system for the new neighbourhood next to the existing JoyLogistics industrial shed in Berkel en Rodenrijs. The goal is to deliver a neighbourhood in which the pioneer residents pay €0 for both electricity and for space heating and domestic hot water. This document underpins the technical feasibility, identifies the relevant regulations, and refers to authoritative sources.

The system rests on two main pillars: solar PV on the roof of the shed for electricity, and aquathermal energy (TEO) combined with seasonal storage (WKO) for space heating and domestic hot water. Supplementary components are a neighbourhood battery, a smart energy management system (EMS), and a legal structure in the form of an energy cooperative under the Subsidieregeling Coöperatieve Energieopwekking (SCE).

2. Elektriciteitsopwekking: PV op de shed
2.1 Basis of calculation and assumptions
The industrial roof has a gross surface of approximately 18,000 m². After deducting edges, skylights and technical installations, 70 % is usable for PV panels (TNO, n.d.). Power density on a flat roof is approximately 200 Wp per m² of roof area; TNO uses 200 W/m² with a Performance Ratio (PR) of 90 % as the basis for yield calculations. Specific yield in the Netherlands lies between 850 and 1,000 kWh per kWp per year; the CBS uses 875 kWh/kWp as a reference figure.

2.2 PV calculation outcome

Parameter	Value
Usable roof area	18,000 × 0.70 = 12,600 m²
PV capacity	12,600 × 0.200 kWp/m² = 2.52 MWp
Annual generation (poor year, 850 kWh/kWp)	2,142,000 kWh = 2.14 GWh
Annual generation (good year, 1,000 kWh/kWp)	2,520,000 kWh = 2.52 GWh
Average (calculated value)	~2.33 GWh/year
Own consumption (shed)	~648,000 kWh/year (0.65 GWh)
Net available for neighborhood	~1.68 GWh/year

A typical Dutch household consumes around 2,430 kWh of electricity per year (Milieu Centraal, n.d.). In a fully electrified new dwelling (induction cooking, heat-pump boiler for hot water, contribution to a collective heat pump, EV charging) consumption rises to roughly 4,300–5,200 kWh per dwelling. On this higher-consumption basis the PV system can serve approximately 280–320 dwellings per year.

2.3 Seasonal mismatch and mitigations
About 75 % of the PV yield falls in the period April to September, while around 65 % of electricity consumption (mostly heating) takes place between October and March. CBS research from 2024 confirms that dwellings with a heat pump have a strongly season-dependent electricity profile, with a peak in the cold winter months (Centraal Bureau voor de Statistiek, 2024). Without further measures the neighbourhood would have to import electricity in winter.
The following measures reduce this mismatch:
- Neighbourhood battery (1–2 MWh): absorbs day-night fluctuations. PV electricity stored during the day is delivered to residents in the evening. After the end of the salderingsregeling (the Dutch net-metering scheme) on 1 January 2027 (Wet beëindiging salderingsregeling, Parliamentary Document 36.611), self-consumption becomes economically critical.
- Smart energy management system (EMS): schedules charging of electric vehicles, heat-pump boilers and the neighbourhood battery so that it coincides with PV surplus hours.
- Small wind turbine (optional): complementary to PV because wind in the Netherlands peaks in winter. RVO reports 30,000 to 185,000 kWh per year for a single small turbine. In Lansingerland, pilot studies into local wind potential are currently underway.

3. Heat supply: aquathermal energy, WKO and LT heat network
3.1 System description
The heat system consists of four components that together form a seasonal buffer:
- TEO (Thermische Energie uit Oppervlaktewater, thermal energy from surface water): a heat exchanger extracts heat in summer from the nearby water buffer in Midden-Delfland. The water is cooled by a few degrees and returned; there is no net withdrawal of water (Netwerk Aquathermie, n.d.).
- WKO / ATES (seasonal heat-cold storage): the summer heat is stored in the subsoil at approximately 100 metres depth. In winter the heat is pumped back up (Rijksdienst voor Ondernemend Nederland, n.d.).
- Collective heat pump: upgrades the stored heat to a usable supply temperature. The system reaches a seasonal performance factor (SPF) of approximately 3.7 to 4.1 at project sizes of 5,000 to 40,000 GJ per year, according to RVO reference figures (Rijksdienst voor Ondernemend Nederland, n.d.).
- Low-temperature heat network (LT network): distributes heat at approximately 40 to 55 °C to the dwellings. This is well suited to underfloor heating and well-insulated new-build.

3.2 Why aquathermal energy on this site?
The site borders watercourses in the Lansingerland polder, and a large water buffer is being realised in the adjacent Midden-Delfland. The Netwerk Aquathermie currently lists more than 100 initiatives in the Netherlands. Deltares and the Hoogheemraadschap van Delfland, together with Eteck, are conducting ecological research into the effects of TEO, including a study at the Plas van Van Buijsen near Pijnacker (Deltares and Hoogheemraadschap van Delfland, n.d.). The findings indicate that TEO in still water can have neutral or even positive ecological effects, since cooling can suppress blue-green algae and botulism.

3.3 Hot water and cooking
- Domestic hot water is supplied via the LT heat network, with a booster heat-pump boiler per dwelling that raises the temperature to at least 60 °C (legionella prevention). The booster preferably operates during the day on PV electricity, controlled by the EMS.
- Cooking is fully electric (induction). The associated consumption is included in the PV calculation.
- Underfloor heating is fed directly from the LT network, without an individual heat pump per dwelling.

3.4 Heat-system key figures

Parameter	Value/source
Heat demand per new-build dwelling (space heating)	~3,000 kWh thermal/year
Heat demand per dwelling (domestic hot water)	~2,500 kWh thermal/year
SPF of collective heat pump (TEO + WKO)	3.7–4.1 (RVO reference values) [6]
Electricity consumption of heat pump per dwelling	~1,500 kWh/year (at SPF 3.8)
Scale range for a viable TEO system	5,000–40,000 GJ/year (≥385 dwellings) [6]

4. Legal and financial structure

4.1 End of the salderingsregeling (1 January 2027)

The salderingsregeling (the Dutch net-metering scheme) ends on 1 January 2027 (Wet beëindiging salderingsregeling, Parliamentary Document 36.611). The national government has stated that from 2027 owners of solar panels can no longer offset their generation against their consumption; they receive a feed-in tariff instead (Rijksoverheid, n.d.). This makes collective self-consumption within the neighbourhood economically much more attractive than feeding into the grid.

4.2 Subsidieregeling Coöperatieve Energieopwekking (SCE)

The SCE is an operating subsidy from RVO with a guaranteed term of 15 years (Rijksdienst voor Ondernemend Nederland, n.d.). Energy cooperatives receive a subsidy per generated kWh. In 2026 the available budget is €78 million. The SCE forms the legal bridge between the PV roof on the shed and the residents of the neighbourhood: residents become members of the cooperative and receive their share of the yield.

Since 2026 the SCE has been expanded: applications are possible for installations up to 1 MWp on a large-consumer grid connection (previously 500 kWp). This is relevant for the 2.52 MWp PV system on the shed, which may need to be split across several SCE applications.

4.3 Collective connection / energy hub

In addition to (or instead of) the SCE, the neighbourhood can be designed as an energy hub with a collective grid connection. In this model the neighbourhood acts as a single large consumer towards the grid, and the PV yield is distributed internally. This reduces the load on the public grid (grid congestion) and maximises the value of self-consumption. RVO explicitly notes that plans for PV are slowing down because of a fuller grid, and that self-consumption is therefore becoming increasingly important.

4.4 Financing the heat system

The investment in the TEO / WKO / heat-network system is too large to be borne by individual residents (€15,000 to €25,000 per dwelling for the complete system). Two options are available for financing:

- ESCo / heat company: a third party invests, operates the heat network, and delivers heat to residents at a fixed tariff. The SDE++ subsidy for aquathermal energy (base load, 6,000 full-load hours) can support the business case (Rijksdienst voor Ondernemend Nederland, n.d.).
- Cooperative model (the option applied in this project): the energy cooperative owns both the PV system and the heat network. PV income (SCE subsidy plus self-consumption savings) partly finances the heat operation, allowing residents to be offered a combined €0 energy tariff.

5. Analysis of all energy options considered

The following tables provide an overview of all options considered for electricity generation, heat supply, and hydropower. For each option, suitability for the site, potential yield, and the resulting conclusion for the project are noted. The options are based on the project's own energy study and supplemented with RVO and TNO reference figures.

5.1 Electricity generation and storage

Option	Suitable?	Potential yield	Investment	Conclusion for this project
Rooftop solar panels	Very promising	1.8–2.9 GWh/ year at 2.2–2.9 MWp	Medium	Primary pillar. Large flat roof makes this the most cost-effective option. Organizing self-consumption via a hub/collective is crucial after net metering ends.
Solar PV carports	Promising	~0.18 MWh/ m² carport per year	Medium–high	Additional generation above parking areas. Not suitable for this projects because the carparking is provided in the towers.
Solar façade (BIPV)	Moderately promising	Lower than rooftop; can broaden daily profile	High	Can spread peaks (morning/ evening sun). Higher cost per kWh than rooftop PV. Project-specific. requires simulation.
Small wind turbines	Promising	30,000–185,000 kWh/ year per turbine (RVO)	Medium	Complementary to PV: wind peaks in winter. Pilot projects underway in Lansingerland. Requires permits.
Large wind turbine(s)	Uncertain	~2,000,000 kWh/year per MW (RVO)	High	High potential but long lead time. Policy and environmental sensitivity in densely populated areas. Not included in base design.
Neighborhood battery	Very relevant	No generation; increases self-consumption	Medium–high	Crucial after net metering ends (2027). More self-consumption = more value. Included in base design.
Smart EMS / grid-aware design	Very relevant	Virtual yield: lower peaks, better PV utilization	Medium	Reduces system costs through peak reduction. Requires coordination with grid operator. Included in base design.

Included in the design

5.2 Heat supply

Option	Suitable?	Key figures	Investment	Conclusion for this project
All-electric (individual air-to-water heat pump)	Promising, but risks	Performance depends on insulation + low-temperature heat distribution	Medium	Grid congestion impact must be managed. Outdoor units cause noise. More expensive per dwelling than collective systems. Not chosen as base option.
Ground energy WKO/ATES	Promising	High seasonal efficiency with low-temperature network/heat pump	High	Strong structural reduction in heating costs for clusters. Permit required. Included in base design.
Aquathermal energy TEO + heat pump + LT network + WKO	Very logical	SPF 3.7–4.1; costs decrease with scale (RVO)	High	Very suitable due to nearby surface water. Investment costs can be distributed among all housing development projects within the master plan area. Sustainable heat with stable costs. Helps reduce grid congestion. Included in base design.
Aquathermal energy TED (drinking water)	Not suitable here	Source in pipeline network; strict management	High	Only viable with large transport pipelines. Requires cooperation from drinking water company; niche application. Eliminated.
Solar thermal / solar boiler / PVT	Moderately promising	Can reduce heat pump electricity use; project-specific (TNO)	Medium	With limited roof space, PV is preferred. Often tailor-made. Not in base design, but optional for later phase.
Geothermal energy	Too large-scale	Requires 5,000–10,000 dwellings	Very high	Scale is too large for a single neighborhood of 280 dwellings. Very long lead time. Mining Act permits required. Eliminated.

5.3 Hydropower

Option	Suitable?	Potential	Conditions	Conclusion for this project
Micro-hydropower in polder waterway	Not promising	A few thousand kWh/year with small weirs	Requires flow + head	Usually low potential in the Netherlands due to limited height differences. No specific drop point available. Eliminated.
Energy recovery at pumping stations/ sluices	Moderately promising	Concept proven by Rijkswaterstaat (reverse pumping)	Pump type +	Worth investigating because a pumping station is located near the project area. To be explored further in later research.

Included in the design

6. System summary

Component	Function	Capacity / key figure
PV on shed	Primary electricity generation	2.52 MWp; ~2.33 GWh/year on average
Neighborhood battery	Day-night buffering, peak reduction	1–2 MWh
EMS	Demand response, EV charging, heat pumps	Software + metering infrastructure
TEO heat exchanger	Heat from polder water / water buffer	Summer source; return to waterway
WKO/ATES	Seasonal heat storage in the ground	~100 m depth; balanced heat/ cold
Collective heat pump	Upgrading ground heat	SPF 3.7–4.1; low-temperature supply
Low-temperature heat network	Distribution to homes	40–55°C supply temperature
Booster per dwelling	Domestic hot water to ≥60°C	Small heat pump boiler
SCE cooperative	Legal structure; €0 bill concept	15-year subsidy; ≥75% of members within postcode area

7. Sizing: how many dwellings?

The following table shows the estimated electricity consumption per fully electrified new-build dwelling:

Consumption category	kWh/year
Household electricity + induction cooking	~2800
Share of collective heat pump (space heating, SPF 3.8)	~790
Domestic hot water (booster, SPF 3.8)	~750
EV charging (50% ownership, 10,000 km/year average)	~900
Total per dwelling	~5,240
Total excluding EV charging	~4,340

With 1.68 GWh net available:

- Including EV charging: 1,680,000 / 5,240 ≈ 320 dwellings
- Excluding EV charging: 1,680,000 / 4,340 ≈ 385 dwellings

Recommendation: design for around 250 dwellings to maintain margin for poor solar years and for winter grid imports. With one small wind turbine, 300–320 dwellings is achievable.

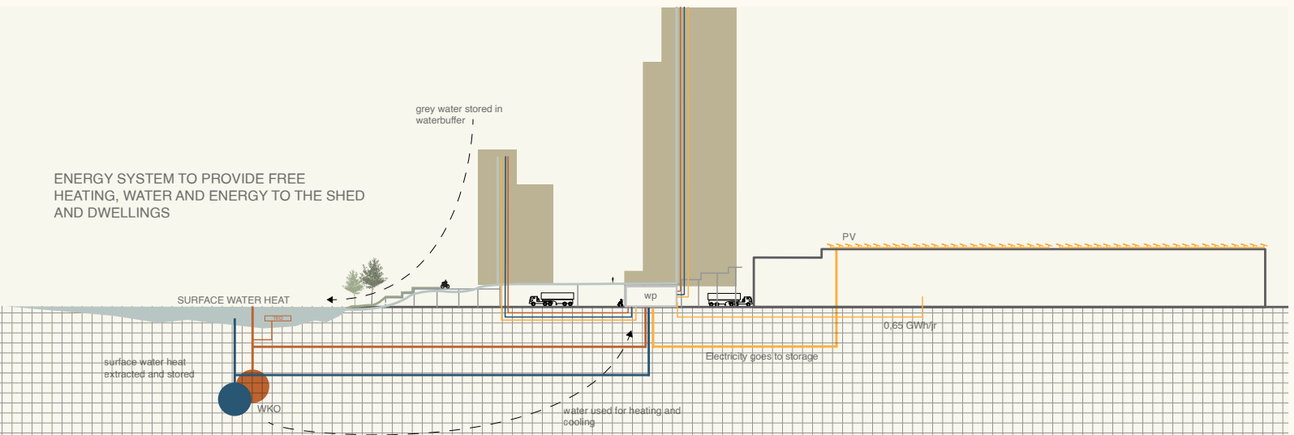
8. Permits and preconditions

Topic	Competent authority	Points of attention
Rooftop PV	Municipality (environmental permit)	Fire safety; structural integrity; grid connection (congestion)
TEO (heat extraction)	Hoogheemraadschap van Delfland	Ecological assessment; Assessment Framework for Cold Discharges (STOWA) [8]; return temperature
WKO sources	Province of South Holland	Subsurface energy master plan; interference with other WKO systems; groundwater protection
District heating network	Municipality + Authority for Consumers and Markets (Heat Act)	Tariff regulation; security of supply; possible designation of a heat concession area
SCE subsidy	Rijksdienst voor Ondernemend Nederland	Application 2026: March 2 to October 1; max. 1 MWp per application [10]

5. Conclusion

The combination of PV on the industrial shed, a neighbourhood battery with EMS, and a collective aquathermal system (TEO + WKO + LT heat network) forms a technically feasible and financially substantiated energy system for a neighbourhood of approximately 250 dwellings with a €0 energy bill. The site-specific advantages (large flat roof, proximity to surface water, the planned water buffer, new-build construction) make this a particularly suitable situation for the approach.

The end of the salderingsregeling from 2027 strengthens the business case for collective self-consumption. The SCE scheme provides 15 years of financial certainty for the cooperative. The aquathermal research by Deltares and the Hoogheemraadschap van Delfland indicates that TEO in polder waters can be deployed in an ecologically responsible manner. The critical success factors are: early involvement of the Hoogheemraadschap van Delfland for the TEO permit, coordination with the province on the WKO sources, and the establishment of a robust legal structure (cooperative or ESCo) that can guarantee the €0 tariff for the pioneers.



APPENDIX. 04 GRID AND CONSTRUCTION

This appendix documents the dimensional study that led to the selection of an 8.4 × 8.4 metre main grid and a 4.2 × 4.2 metre sub-grid as the structural framework for the project. The grid must satisfy a demanding set of requirements simultaneously: it must accommodate truck parking and docking for the JoyLogistics operation, provide efficient car parking for residents, and allow flexible residential floor plans that can change over time. The grid is therefore the permanent rule and the support in Habraken's terminology from which all further design decisions are derived.

The dimensional reasoning draws on three sources: the Handboek Superplinten (Heren 5, STIPO & AM, 2021), which provides principles for flexible mixed-use plinths in dense urban contexts; standard Dutch parking dimensions for trucks and cars; and the building-depth analysis for various functions compiled in the accompanying function table (see Appendix Functions). The Handboek Superplinten identifies five conditions for a flexible, future-proof plinth, of which two are directly relevant here: optimal horizontal and vertical divisibility through column structures and a generous grid dimension, and the separation of structure and infill (Heren 5 et al., 2021, p. 59).

1. Determining the grid dimension from parking

The starting point for the grid was the most demanding spatial requirement on site: parking and manoeuvring space for trucks. The design preserves the existing logistics operation, which means the structural grid must first accommodate the dimensions of heavy vehicles before it is tested against other functions.

1.1 Truck parking

A standard European truck (tractor with semi-trailer) has a width of approximately 2.55 metres. Including a clearance margin of 0.30 metres on each side for manoeuvring and door opening, a single truck parking lane requires approximately 3.15 metres. A structural column of 600 × 600 mm is positioned between two adjacent lanes. Two truck parking lanes plus one column therefore require: 3.15 + 0.60 + 3.15 = 6.90 metres between column centre lines. However, when additional tolerance is included for the column base and fire separation, the practical centre-to-centre distance increases. Testing various configurations showed that an 8.4 metre bay comfortably fits two truck parking lanes with generous clearance and a central column, while also allowing for small utility or walkway strips at the edges.

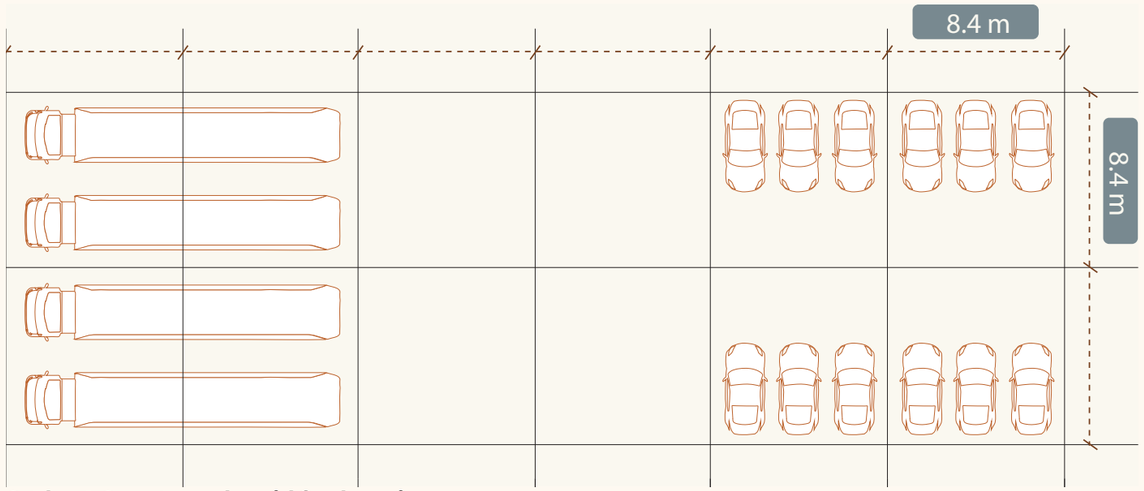
1.2 Car parking

A standard perpendicular car parking space in the Netherlands measures approximately 2.50 metres wide and 5.00 metres long (NEN 2443). Three car parking spaces side by side, including the columns between them, require: 3 × 2.50 = 7.50 metres plus two column halves of 0.30 metre each (half of 600 mm), totalling approximately 8.10 metres. Within the 8.1 metre bay, three cars fit and it accommodates one car in parallel parking position when there isn't much space (depth).

1.3 Translation to a grid of 8.4 metres

The 8.1 metre dimension is the smallest common denominator that works for both truck and car parking but, it isn't dividable easily. That's why a 8.4 meter grid is chosen. It is a multiple of 2.1 metres (a common modular unit in Dutch construction practice), and it divides neatly into halves (4.2 m), thirds (2.8 m), and quarters (2.1 m), all of which are useful increments for different spatial programmes. Finally, the grid is square in both directions, so parking layouts, circulation routes, and dwelling floor plans can be rotated 90 degrees without structural conflict.

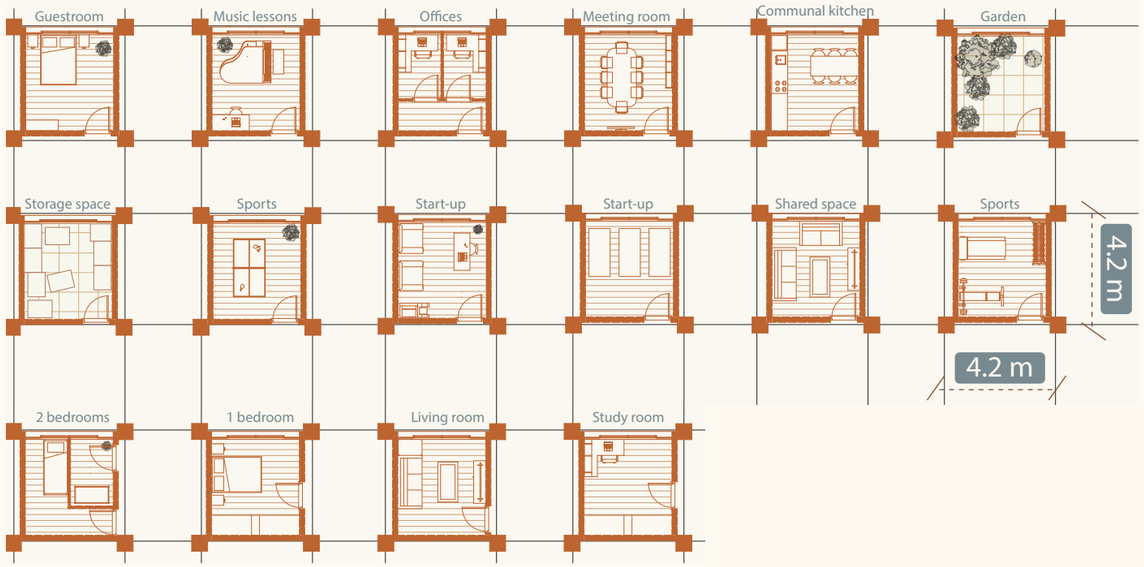
Vehicle type	Width per space	Spaces per bay	Total width used
Truck	3,15 meter	2	6,9 meter incl. column
Car	2.50–2.60 meter	3	7.50–8.10 meter incl. columns
Car	6 meters	1	7,4 meter inc. column

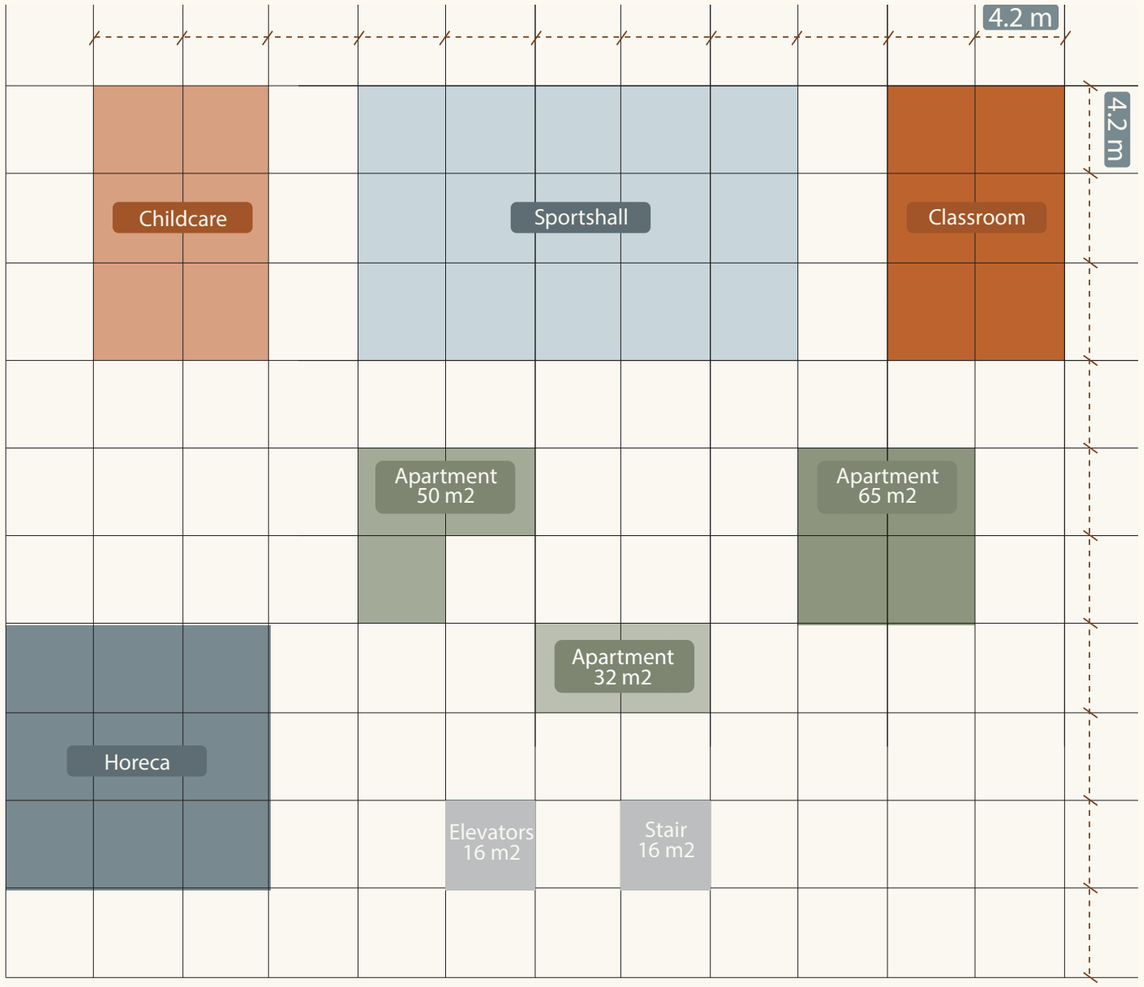


2. The 4.2 metre sub-grid for housing

Halving the 8.4 metre bay yields a dwelling module of 4.2 × 4.2 metres (17.64 m² gross). This dimension was tested against standard room sizes for Dutch housing. A 4.2 metre span comfortably fits two bedrooms side by side (each approximately 2.0–2.1 metres wide, with a partition wall between them), or one living room across its full width. A single module of 4.2 × 4.2 m can serve as a bedroom-pair, a living area, a kitchen-dining space, or a compact studio core. When two modules are combined (4.2 × 8.4 m = 35.28 m²), the resulting unit has the proportions and depth range typical of a well-lit Dutch studio. When three are combined a standard starters apartments is realised.

The 4.2 metre module is also the unit of expansion in the modular tenure system. When a resident rents an additional module (approximately 16 m² usable floor area after deducting walls and structure), the dwelling grows by one grid bay. This dimensional correspondence between structure and tenure is essential: it ensures that every expansion or contraction aligns with the column grid and does not require structural modification.





3. Floor heights
Floor heights follow the same logic of accommodating the most demanding function first. The ground level beneath the elevated deck must provide a minimum clearance of 4.50 metres for truck docking and manoeuvring (this includes the height of a standard semi-trailer of approximately 4.00 metres plus clearance for the docking mechanism and fire sprinkler systems). Including the structural floor slab thickness of approximately 0.50 metres, the first elevated level sits at 5.00 metres above ground level.
All upper floors have a floor-to-floor height of 4.00 metres. This is above the minimum required for housing (typically 3.00–3.30 metres floor-to-floor in Dutch practice), but it falls within the adaptive range recommended by the Handboek Superplinten for mixed-use buildings. A plinth height of at least 3.50 metres free height is necessary for retail, hospitality, and workshop functions; 4.00 metres floor-to-floor comfortably provides this while accommodating raised floors, suspended ceilings, or additional ductwork. Any residential floor can therefore, in the future, be converted into commercial, educational, or workshop space without structural modification, exactly the condition that Habraken's support-and-infill logic requires at neighbourhood scale.

Level	Floor-to-Floor height	Free height	Primary function
Ground (below deck)	5.0 meters	≥ 4.5 meters	Truck docking, parking
Deck level (level 1)	4.0 meters	~3.50 meters	Workshop, retail, café
Levels 2–n	4.0 meters	~3.50 meters	Housing (convertible)

4. Structural system
The primary structure consists of a reinforced concrete column-and-slab system. The columns are 600 × 600 mm in cross-section, positioned on the 8.4 × 8.4 metre grid. This column size is sufficient to carry the vertical loads of a residential building of up to approximately 10–12 storeys on an 8.4 metre span, which corresponds to the building heights in the design. At a concrete class of C30/37 and a typical residential floor load of approximately 3.5–5.0 kN/m² (including self-weight of the slab, finishes, and variable load), columns of this size provide adequate capacity with conventional reinforcement ratios.

The floor slabs span 8.4 metres between columns. For a residential building with 4.00 metre floor-to-floor heights, flat slabs of approximately 300–350 mm thickness or post-tensioned slabs of approximately 250–300 mm are feasible. The column-and-slab system is deliberately chosen over a wall-based system because it leaves the floor plan entirely free of load-bearing walls, which is the precondition for the Open Building approach: all interior walls are non-structural infill that can be repositioned by residents.

Lateral stability is provided by a limited number of concrete cores (housing staircases, elevators, and service shafts), positioned at the centre of each building volume. These cores are part of the permanent structure and are designed for the full lifespan of the building (>200 years). Because the cores concentrate all fixed elements in a compact zone, the remaining floor area is entirely flexible.

[image:]

5. Building depth: from grid modules to functions
A critical test for the grid is whether it can accommodate the full range of building functions that the adaptive neighbourhood may require over its lifetime. The following analysis maps each function against the 8.4 metre grid, expressed in the number of bays required for building depth. The building depth is the critical dimension because it determines daylight access, internal routing, and the ability to convert one function into another.

5.1 Translating the grid into building depths
The 8.4 metre bay produces a series of discrete building depths when multiplied. In the residential tower, two dwelling bays of 8.4 metres each are placed on either side of a central corridor of approximately 4.2 metres (one half-bay), resulting in a total building depth of approximately 21 metres (8.4 + 4.2 + 8.4 = 21.0 m). This is a standard and efficient depth for a double-loaded corridor apartment building: each dwelling has a depth of 8.4 metres, which stays within the daylight-critical range of 5-9 metres (the rule of thumb being 2–2.5 times the window-head height per facade). The following table summarises the available building depths and their relationship to the grid:

Grid bays	Total depth	Configuration	Typical functions
1 bay	8.4 meters	Single-loaded: dwellings on one side, open gallery	Gallery-access apartments, childcare, small offices
1.5 bays	12.6 meters	Single-loaded with deeper units or corridor	Lodging, student housing, consultation rooms
2 bays	16.8 meters	Double-loaded without central corridor (back-to-back)	Offices, education (double corridor), retail
2.5 bays	21.0 meters	Double-loaded with 4.2 m central corridor (2×8.4 + 4.2)	Apartment building (primary configuration)
3 bays	25.2 meters	Deep floor plate, potentially with atrium or lightwell	Supermarket, library, large retail, fitness
4+ bays	33.6 meters	Very deep: requires atrium/lightwell for daylight	Sports hall, hospital, theatre (double-height)

5.2 The apartment building: 21 metres as design depth for the base

The primary residential configuration in this project is the double-loaded corridor building with a total depth of approximately 21 metres. Each dwelling occupies two grid bays in width (8.4 m dwelling depth), with the central corridor occupying one half-bay (4.2 m). This configuration has several advantages. First, the 8.4 metre dwelling depth allows daylight to penetrate the full depth of the apartment from a single facade, as the depth-to-window-head ratio remains below 2.5 (assuming a floor-to-ceiling height of approximately 3.20 m and a window head at approximately 3.00 m: 8.4 / 3.0 = 2.8, which is near the upper limit but acceptable for a single-aspect dwelling; most units are dual-aspect). Second, the corridor width of 4.2 metres is generous enough to function as a three-dimensional street in the tradition of Next21: it accommodates planting, seating, and visual connections toward both Midden-Delfland and the shed. Third, the total building depth of 21 metres falls within the typical range for Dutch apartment buildings (18–24 m), meaning that the grid does not produce an unusual or inefficient building form.

5.3 Function table: all functions mapped to the grid

The table on the following page compiles the spatial requirements of all regular building functions. Not all of them are considered in the design they could be when buildings/ the site is transformed to future needs. For each function, the table gives the usable floor area per person (GO), the gross floor area per person (BVO), the GO/BVO efficiency ratio, the building depth range found in practice, the rational depth driven by daylight and core placement, and the adaptivity strategy (how the space can be converted to another function in the future). This table was developed using the Handboek Superplinten, NEN standards, and international building code references (WAC/IBC Table 1004.5), and all dimensions have been verified against the 4.2/8.4 metre grid.

The key finding is that every function fits within the grid without structural conflict. Residential depths of 8.4–12.6 metres (1–1.5 bays) fall within the daylight-critical range. Offices and education require 12–18 metres (1.5–2 bays), which the grid provides exactly. Retail can use deeper configurations of 18–24 metres (2–3 bays). Even large-scale functions like sports halls and theatres can be accommodated by combining bays and using double-height spaces. They could be accommodated under the lifted deck if cars are not the future anymore.

The 4.00 metre floor height exceeds the minimum free height requirements of all functions except sports halls (which require dedicated double-height spaces).

6 Adaptability and the grid as common denominator

The analysis in the preceding sections confirms that the 4.2/8.4 metre grid accommodates every function tested. The Handboek Superplinten emphasises that future-proof mixed-use buildings require generous grid dimensions and column-based structures that allow for horizontal and vertical re-division over time (Heren 5 et al., 2021, p. 59). This principle is applied here not only at the building scale but at the neighbourhood scale: the entire development shares one grid, so that a parking floor can in the future become a workshop, a workshop can become a classroom, and a residential floor can absorb commercial functions, all without altering the primary structure.

The building depth of 21 metres (2×8.4 + 4.2 corridor) is the standard configuration for the apartment towers, but within the same structure a single-loaded gallery building of 8.4 metres or a deep retail floor of 25.2 metres is equally possible. This flexibility is the spatial expression of the Open Building principle: the support defines the possible, while the infill determines the actual.

7 Conclusion

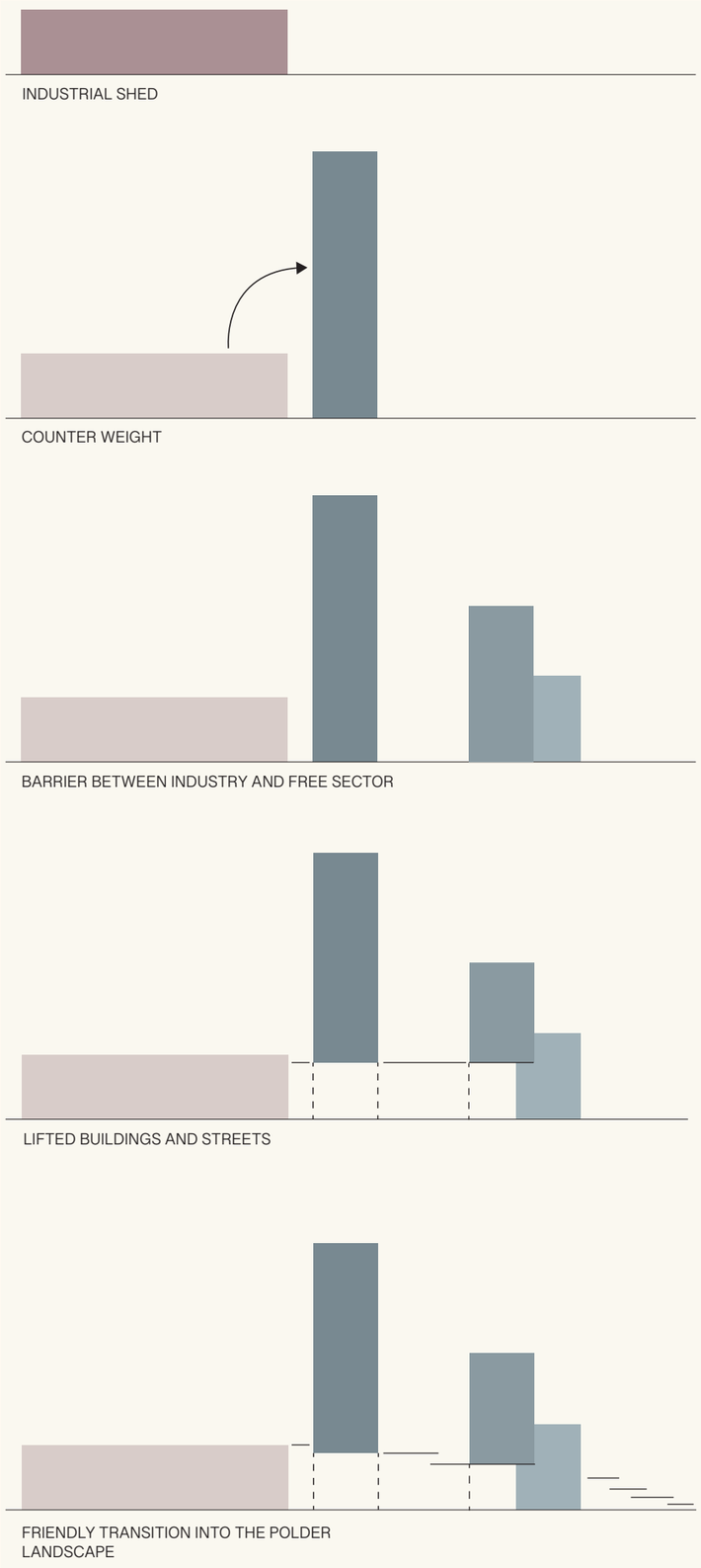
The 8.4 × 8.4 metre main grid and 4.2 × 4.2 metre sub-grid form the permanent structural framework of the project. The dimension originates from the functional requirements of truck and car parking and converges with the spatial needs of housing, retail, education, and workshop functions. The 600 × 600 mm reinforced concrete columns span 8.4 metres and support flat or post-tensioned slabs, leaving the floor plan free of load-bearing walls. Floor heights of 5.00 metres at ground level and 4.00 metres on all upper levels accommodate the truck clearance below the deck and provide sufficient free height for any residential or commercial function above it.

The function table demonstrates that every programme considered in the design (from a starter apartment to a sports hall, from a supermarket to a productive school) fits within the grid without structural modification. The building depth of approximately 21 metres for the apartment towers (two dwelling bays of 8.4 m plus a 4.2 m corridor) is both structurally efficient and daylight-compliant. This grid is the support; everything that fills it (dwellings, shops, workshops, schools) is the infill. By extending the dimensional logic from trucks to bedrooms and from parking bays to classrooms, the grid enables the adaptive, mixed-use neighbourhood that the project envisions.

Buildingfunction	Type of use	GO m²/person (typ)	Building depth (min–typ–max)	Grid bays (depth)	Fits in 8.4 meter grid?	Rational depth & daylight	Adaptivity strategy
Living (appartment)	Total area per resident	typ 53	10–12–18 m	1–2 bays	Yes	Daylight-critical: ~6 m per facade → ~12 m dual-aspect. 8.4 m single-aspect is within range (ratio 2.8).	Separate structure/infill; stackable wet cores; limited depth facilitates future conversion to office/workshop.
Office	Basic workplace incl. shared facilities	typ 22	12–18–24 m	1.5–2 bays	Yes	Limit depth to ≤18 m if future conversion to housing is desired; >18 m requires atrium.	Regular grid, demountable walls, installations in spine; reserve extra access for higher occupancy.
Meeting room	Tables/chairs	typ 2	12–18–24 m	1.5–2 bays	Yes	Place in facade zone for daylight; core for MEP.	Make rooms 'plug-in': demountable, scalable to classroom or workspace.
Education	Primary school per student	typ 5.1	10–16–18 m	1–2 bays	Yes	Classroom depth is daylight-critical (2–2.5× window-head); double corridor ~16 m if classrooms not too deep.	Design generic 'learning lofts'; limited fixed furniture; accessible installations for future function change.
Childcare	Indoor play area per child	typ 3.7	10–14–18 m	1–1.5 bays	Yes	Overview + daylight/ventilation: play zones along facade; avoid deep blind zones.	Wet functions in core; large open spaces make switch to classroom/ atelier straightforward.
Retail / Store	Sales floor	typ 6.4	18–24–35 m	2–3 bays	Yes	Retail can be deep; for future 'housing' conversion keep ≤24 m or add lightwells.	Shell & core: service grid, multiple entries, demountable units.
Horeca / Meeting	Sitting area (tables/ chairs)	typ 1.4	12–18–30 m	1.5–3 bays	Yes	MEP/logistics drive layout; daylight pleasant but not always required.	Position grease ducts as 'service spine'; make splittable into retail/ workspace.
Sports hall	Events (no fixed seating)	typ 2.0	24–36–60 m	3–4+ bays	Yes (double height)	Can be deep; if transformation to daylight function is desired, design lightwells now.	Design as generic hall (expo/market/ classroom) with robust floors and accessible service grid.
Fitness	With equipment	typ 5.7	18–30–45 m	2–3+ bays	Yes	Span/vibration/acoustics matter; depth less daylight-critical.	Choose generic column grid; demountable installations; allow splitting into smaller units.
Healthcare	Outpatient clinic	typ 10.6	24–36–60 m	3–4+ bays	Yes	MEP-intensive; adaptivity requires structure/infill separation and accessible shafts.	Work with module dimensions (consult/treatment); reconfigurable walls and services.
Lodging	Sleeping area (code-based)	typ 13.2	14–16–24 m	1.5–2 bays	Yes	Corridor typology: rooms along facade, corridor/core internal; daylight limits room depth.	Switch between lodging, student housing, and care hotel is feasible with stackable wet cores.

All building depth ranges verified against the 4.2/8.4 m grid. Daylight rules based on 2–2.5× window-head height. Adaptivity strategies derived from Handboek Superplinten (2021) and Open Building literature.

APPENDIX. 05 FORMSTUDY



APPENDIX. 06 CASESTUDIES

This appendix documents the four case studies that informed the design of Between Shed and Polder. Each project was selected because it isolates one of the four pillars on which the design rests: structural and programmatic adaptability (Next21), affordability through stacking on active infrastructure (Kalkbreite), the mediation between a hard built edge and a softer landscape (The City Dune), and a governance model in which residents complete and customise their own dwellings within a shared structural framework (Superlofts). Together, the four cases confirm that each pillar has a working precedent, but that no single existing project combines all four. Defining that combination is the contribution of this research. The first section also discusses the theoretical foundation of the Open Building approach as articulated by N. John Habraken (1961), because Next21 cannot be understood without it, and because Habraken's distinction between support and infill is the conceptual lens through which all four case studies are read in this project.

Casestudy	Pillar isolated	Translation into the project
Next21 + Habraken	Structural and programmatic adaptability (Open Building)	Permanent 4.2/8.4 m grid; modular dwellings; corridors as three-dimensional streets
Kalkbreite	Stacking on active infrastructure + affordability through cross-financing	Elevated deck above truck zone; cooperative + corporation + municipality + logistics-company financing model; activated unused modules (Joker principle)
The City Dune	Gradient from hard edge to soft landscape; visible water	Concrete-to-green gradient on the deck; visible stormwater routing toward ZUS buffer; lifted deck as mediating topography
Superlofts	Casco delivery + resident customisation as attachment driver	Base unit + rentable modules; dual tenure (rental / cooperative purchase); centralised service core

PROJECT: NEXT21

Location: Osaka, Japan
Program: 18 experimental dwellings, communal gardens, infrastructure
Year: 1994 (continuous renovations and remodelling since)
Architect: Yositika Utida, Shu-koh-Sha Architecture and Urban Design Studio
Client/Owner: Osaka Gas Company
Planning team: Utida, Tatsumi, Fukao, Takada, Chikazumi, Takama, Endo, Sendo
Structure: Reinforced concrete + modular façade system



1.1 Habraken's foundational text: De Dragers en de Mensen (1961)
In 1961 the Dutch architect N. John Habraken (1928–2023) published De Dragers en de Mensen: Het einde van de massawoningbouw, translated in 1972 as Supports: An Alternative to Mass Housing (Habraken, 1961/1972). The book is a critique of post-war Dutch mass housing, which Habraken argued had broken the natural relationship between residents and their homes by treating the dwelling as an indivisible, predetermined object delivered to a passive consumer. The serial, monotonous output of the post-war building industry ignored the fact that occupants are the primary actors of the home (Van Hoogstraaten, in Mass Support, 2023).

Habraken's response was to distinguish two "natures" within a single building, often illustrated through the metaphor of a bookcase: the support is the bookcase itself: the permanent, collective, structural part of the building, with a lifespan of a century or more.

The infill is the books: the individual, adaptable part that users can change according to their evolving needs, with a much shorter lifespan of fifteen to twenty years (Habraken, 1961; Open Building Foundation, n.d.). The support is part of the public domain; the infill belongs to the individual.

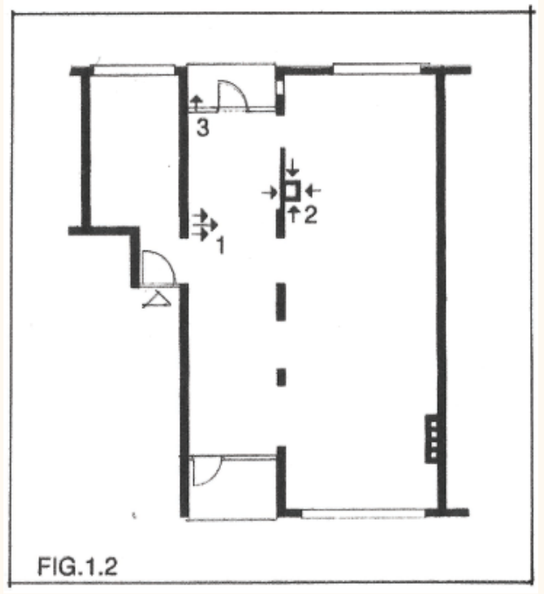


figure x - Permanent structure

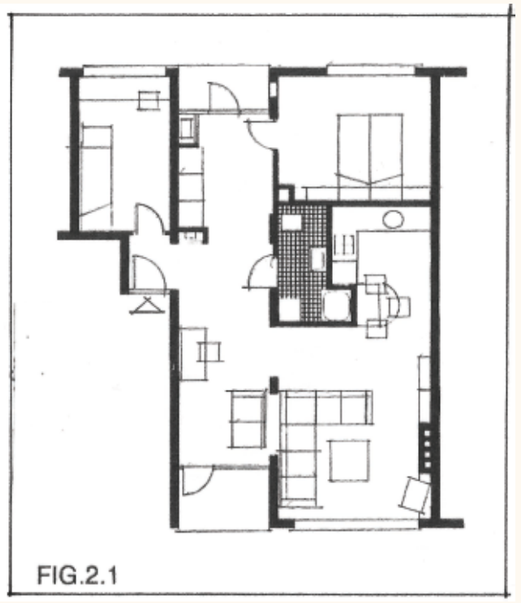


figure x - Possible infill 1

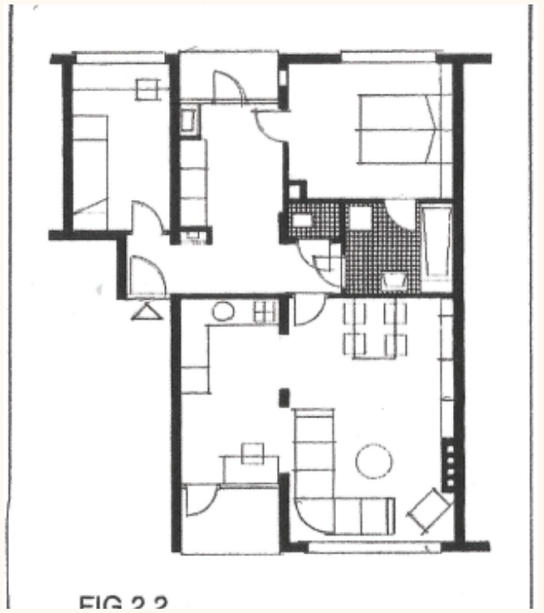


figure x - Possible infill 2

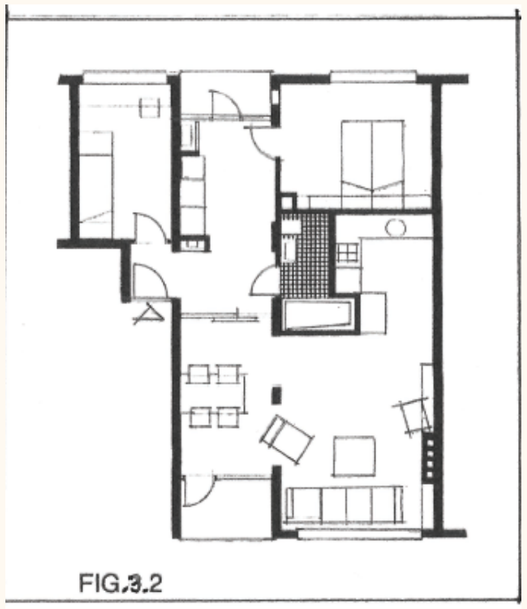


figure x - Possible infill 3

This separation has three consequences that are directly relevant to Between Shed and Polder.

- Technically, it converts renovation from a major intervention every forty years (typically requiring temporary relocation of residents) into a continuous, manageable process; the structure stays, the infill changes.
- Economically, it allows developers to deliver an empty structural frame and offer different infill options, rather than speculating on what buyers will want in five years.
- Socially, it restores a participatory role for the resident, who regains control over their own living environment.

Habraken further developed this approach at TU Delft, where he founded the Stichting Architecten Research (SAR) in 1965 (Bosma, 2000). The SAR developed dimensional methods, modular grids, and design rules through which the support–infill logic could be applied at the scale of building, block and neighbourhood. Habraken's later writings, in particular The Structure of the Ordinary (1998) and Palladio's Children (2005), expanded the concept by shifting the focus from the building's technical layers to how the support fits into the everyday built environment, prioritising the user over the structure. This shift from technical separation to a social and urban understanding is the bridge from Habraken's theory to the spatial strategy of this project, where the neighbourhood itself functions as the support and the dwellings as the infill.

1.2 Next21 as a built laboratory of Open Building

Next21 (1994), commissioned by Osaka Gas Company and led by Yositika Utida, is the most fully realised built example of the Open Building approach (Kendall & Teicher, 2000; Council on Open Building, n.d.). The project was conceived as a "model housing for the twenty-first century": an experimental five-storey building of eighteen dwellings in which Osaka Gas employees served as residents, and in which advanced modular design, energy-efficient technologies and shared spaces could be tested over decades. The design system separates three independently designed layers:

1. Skeleton (support): a reinforced concrete structural frame designed for a lifespan well beyond a century, with services and shafts integrated into a permanent service zone.
2. Infill: interior walls, floors, kitchens and bathrooms, designed and detailed by individual architects for individual dwellings.
3. Façade (cladding): also part of the adaptable infill: each dwelling unit has its own façade panels, exchangeable without scaffolding from the inside, designed by each architect to reflect the layout of the unit behind.

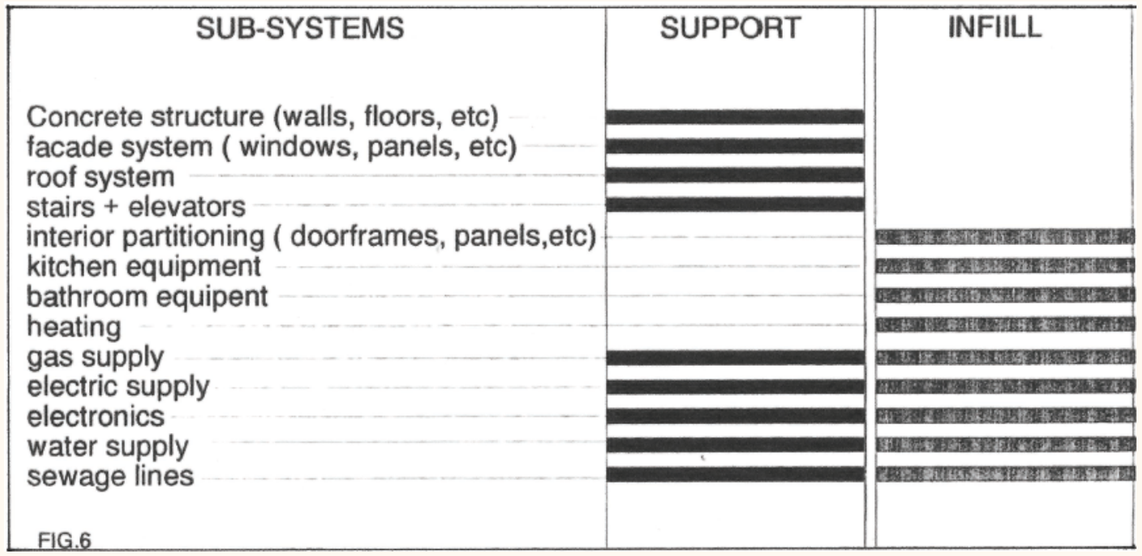
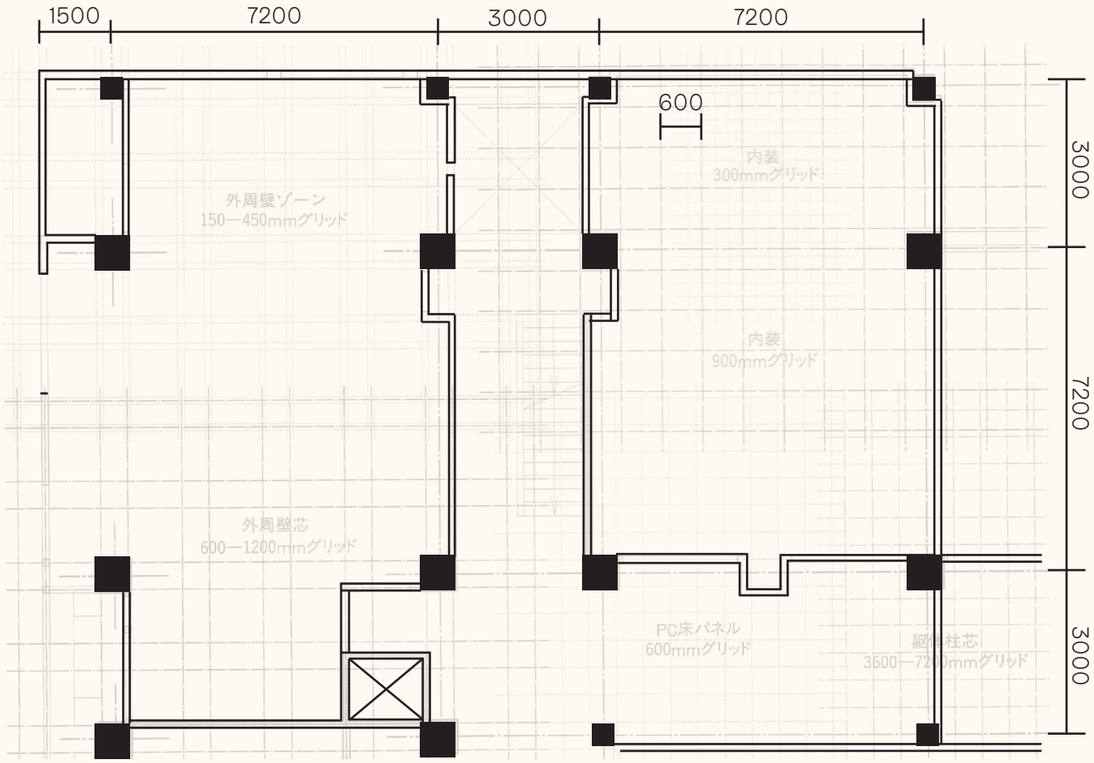
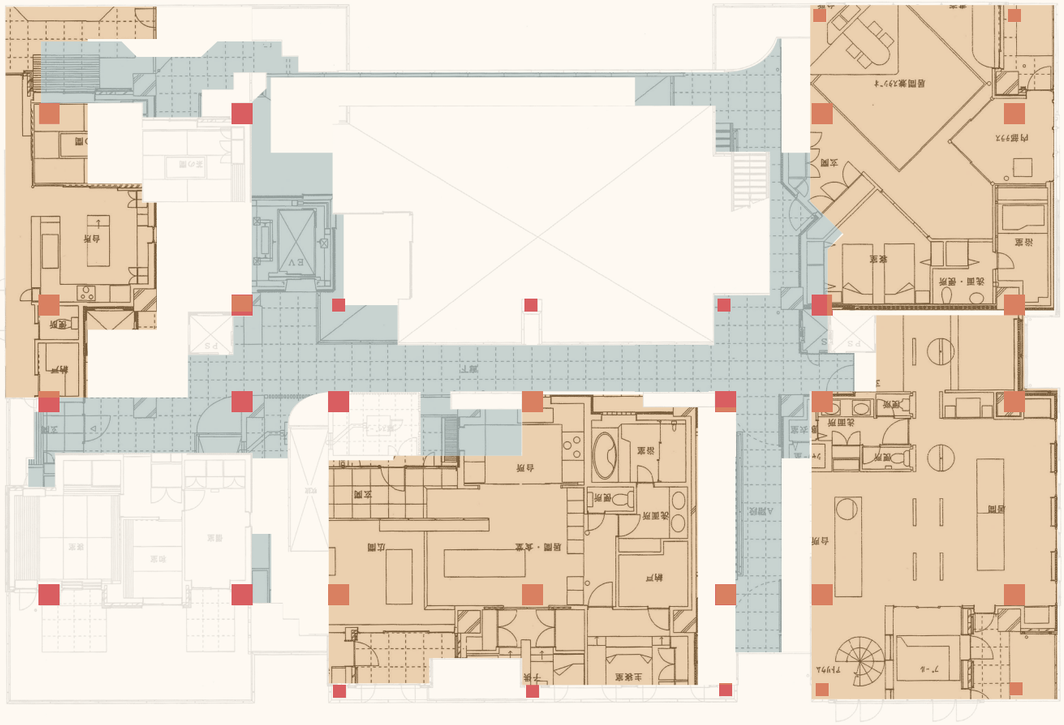


FIG.6



Crucially, thirteen different architects were invited to design the eighteen individual dwellings within the shared framework (Council on Open Building, n.d.). Each architect was given a specific lifestyle theme (a working couple, a family with children, an elderly resident with a garden, etc.) and designed their dwelling independently. The result is a single building with eighteen radically different interiors and façades, all coordinated by one structural and modular logic. This demonstrates that a fixed structural frame can accommodate dwellings designed by different parties and for diverse lifestyles, a principle that reappears in Between Shed and Polder as the gradient of housing types along the axis from industry to landscape within the same grid.





1.3 Three-dimensional streets

Utida himself described Next21 as “three-dimensional urban design” rather than a building (Utida, in Council on Open Building, n.d.). The base building does not only carry dwellings; it also provides a public network of bridges, elevators, stairs, corridors and pathways that connects a public garden on the ground floor with a roof garden, threading the urban tissue vertically through the volume. Just as a city is extended by streets, squares, trees and underground utility lines, Next21 extends the city upward. In a documentary on the project (Lendt, 2009), the design team explains that this principle was developed by close study of the surrounding Osaka neighbourhoods (which had not been destroyed during the war and retained a fine-grained street pattern). Four properties of those streets were identified and translated into the building:

1. A direct connection between dwellings and the street.
2. Public greenery as part of the street.
3. A legible internal network that allows easy circulation through the building.
4. Openness toward the sky: streets are not enclosed corridors but spaces with daylight and air.

These four principles became the guiding framework for designing the corridors, galleries and circulation cores of Between Shed and Polder.



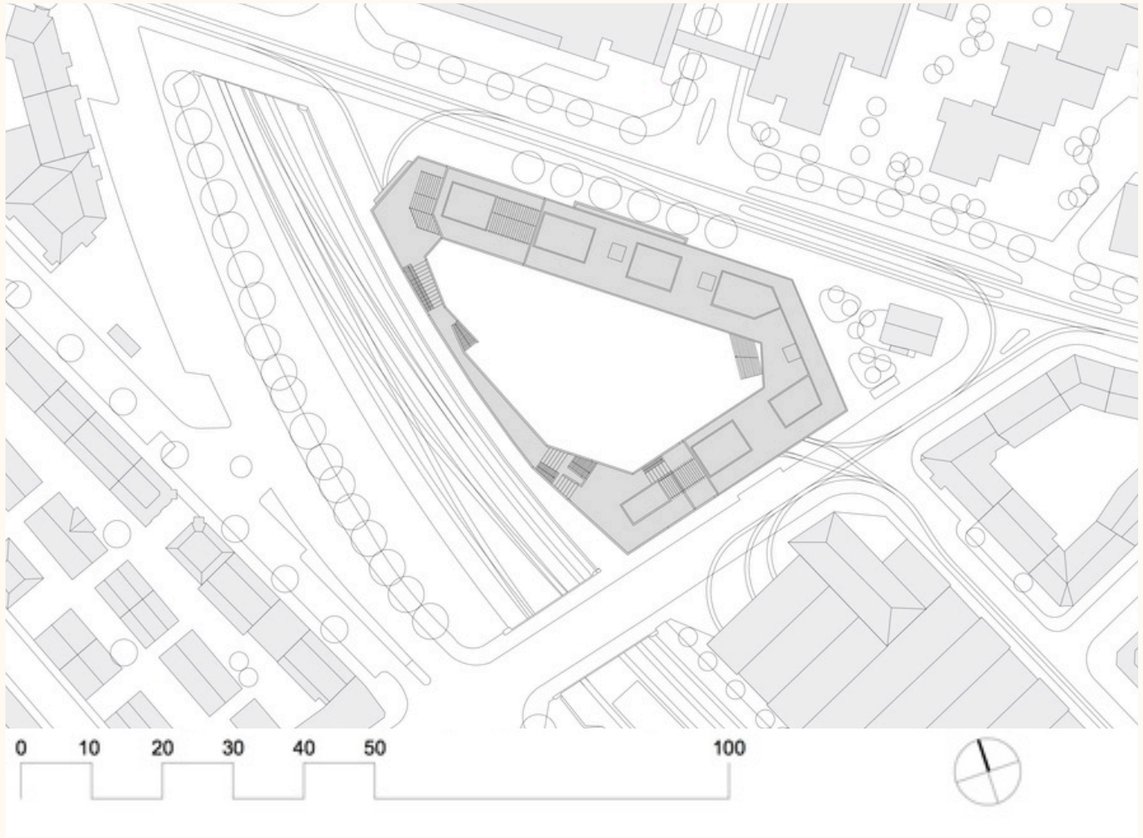
1.4 Continuing experiment
Next21 is not a frozen artefact. Since 1994, residents have moved in and out, and the infill has been remodelled repeatedly. Between 1994 and 2022 alone, eleven of the eighteen units were remodelled, in some cases more than once, and two units have been combined, divided or reorganised within the original support (Council on Open Building, n.d.). The building has therefore demonstrated, over more than three decades, that the Open Building principle works in practice: the structure remains, the dwellings change. This is the strongest empirical evidence available that the support–infill logic produces buildings capable of absorbing demographic, technological and economic change without obsolescence which is the resilience building dwellings in industrial areas needs.

Design decisions:
- Adopt the support–infill separation as the organising principle of the rental tower, with concrete columns, the circulation core, sewage and service shafts, and the loggias as permanent elements (>200 years), and with interior walls, modular floor connections between units and façade panels as variable infill (15–50 years).
- Use one structural framework that can host different dwelling configurations (starter, couple, family, elderly), so the building can absorb life-phase changes without renovation.
- Treat corridors and galleries as three-dimensional streets, designed with direct entry to dwellings, planting, daylight, and views toward Midden-Delfland and the JoyLogistics shed.
- Accept that the project will continue to change after delivery: design the support generous enough to accommodate change that cannot be predicted now.

Design decisions:
- Adopt the support–infill separation as the organising principle of the buildings, with concrete columns, the circulation core, sewage and service shafts, and the loggias as permanent elements (>200 years), and with interior walls, modular floor connections between units and façade panels as variable infill (15–50 years).
- Use one structural framework that can host different dwelling configurations (starter, couple, family, elderly), so the building can absorb life-phase changes without renovation.
- Treat corridors and galleries as three-dimensional streets, designed with direct entry to dwellings, planting, daylight, and views toward Midden-Delfland and the JoyLogistics shed.
- Accept that the project will continue to change after delivery: design the support generous enough to accommodate change that cannot be predicted now.

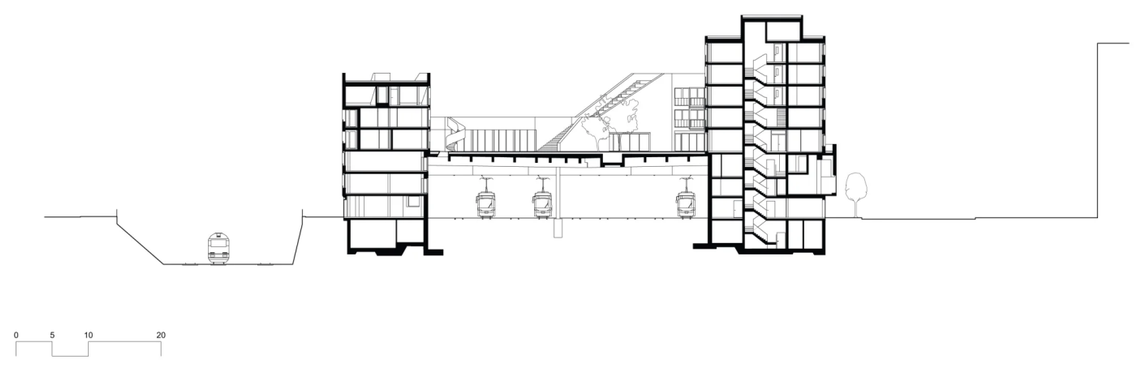
PROJECT: KALKBREITE

Location: Zürich, Switserland
Program: 97 dwellings, commercial and cultural functions, integrated tram depot
Year: 2014
Architect: Müller Sigrist Architekten
Client: Genossenschaft Kalkbreite (cooperative) and Stadt Zürich (tram hall)
GFA: 22900 m²
Construction cost: CHF 63.5 million for housing/commercial; CHF 10.5 million for tram hall



2.1 Stacking housing on active infrastructure
Kalkbreite stands on a 1.5-acre parcel in Kreis 4 that had served as an open-air tram depot since the early twentieth century. The parcel was bounded on two sides by busy thoroughfares and on a third by below-grade railway tracks; for decades it had been considered too noisy and too encumbered for housing (Metropolismag, 2016; Wiki P2P Foundation, 2014). Calls to develop housing above the depot were first made in the 1970s but rejected, until a citizen-led initiative in 2006 organised a series of public workshops that reframed the parcel as a potential mixed-use neighbourhood. The Genossenschaft Kalkbreite was incorporated, submitted a proposal in 2007, won the city's tender, and held a public competition in 2008 that was won by Müller Sigrist Architekten. The architectural problem of Kalkbreite is structurally identical to the problem in Berkel en Rodenrijs: how to build housing above an active, heavy-vehicle infrastructure that cannot be relocated. Müller Sigrist's answer was to fully integrate the tram hall into the building: trams enter at street level on the western edge, the tram hall occupies the entire ground floor, and the remainder of the building wraps around it as a perimeter block.

The roof of the tram hall, nine metres above street level, becomes a 2,500 m² publicly accessible courtyard for residents and the wider neighbourhood (Müller Sigrist, n.d.; Living the City, 2020). This decision (treating the roof of the depot as a new ground level for housing) is the direct precedent for the elevated public deck in Between Shed and Polder, where the same logic is applied above truck parking and docking zones. The structural strategy required to span the tram hall (large clear spans, heavy load transfer, careful coordination of vibration and acoustics) introduced significant cost. Kalkbreite's experience demonstrates that such cost can be carried, provided the project mobilises a financing model that distributes risk and reward across multiple stakeholders.

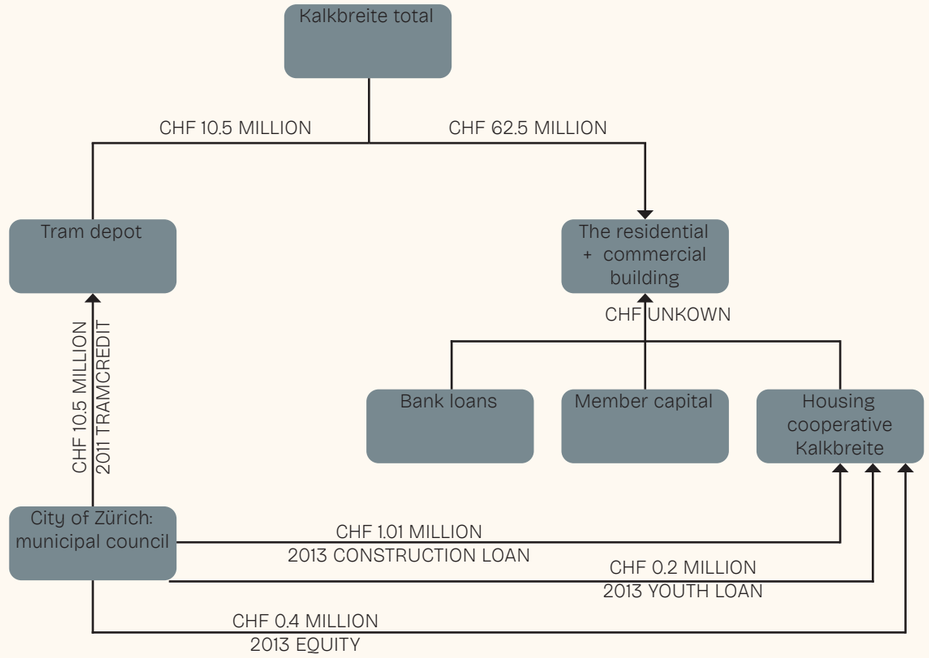


2.2 The cooperative financial model

Kalkbreite was financed through an unusual combination of public and cooperative instruments (Metropolismag, 2016; Premio Baffa Rivolta, n.d.):

The City of Zürich retains ownership of the land and grants the cooperative a long-term Baurecht (building right) on favourable conditions. The city additionally provided rent-free construction loans of CHF 1.01 million (for eleven supported units under the Wohnbauaktion 2011 programme), an additional CHF 0.2 million for youth housing, and a direct equity contribution of approximately CHF 0.4 million (around 10 %) to enable lower rents in selected units. The tram hall itself (CHF 10.5 million) was financed entirely by a city credit, since it serves a public transport function. Bank loans financed the bulk of the residential and commercial portion (CHF 62.5 million). Member capital was raised from cooperative members, who pay a CHF 1,000 entry fee and then deposit a refundable share corresponding to the size of their dwelling.

Rents are calculated as construction cost amortised over 60 years plus maintenance (cost rent) which produces rents of roughly 65% of comparable market rents in the same district (Premio Baffa Rivolta, n.d.). For example, a 100 m² unit costs around CHF 2,000 per month. This is an operational, not subsidised, affordability: the project is financially self-sustaining. The stakeholder configuration of Kalkbreite (city, cooperative, banks, members) served as the direct reference for the cross-financing model developed in this project (Appendix 07 Governance), in which costs are distributed across municipality, logistics company, housing corporation and pension-fund-backed cooperative. Like Kalkbreite, Between Shed and Polder argues that affordability emerges from how costs and revenues are organised, not from cheaper construction.



2.3 Compact private space, generous collective space

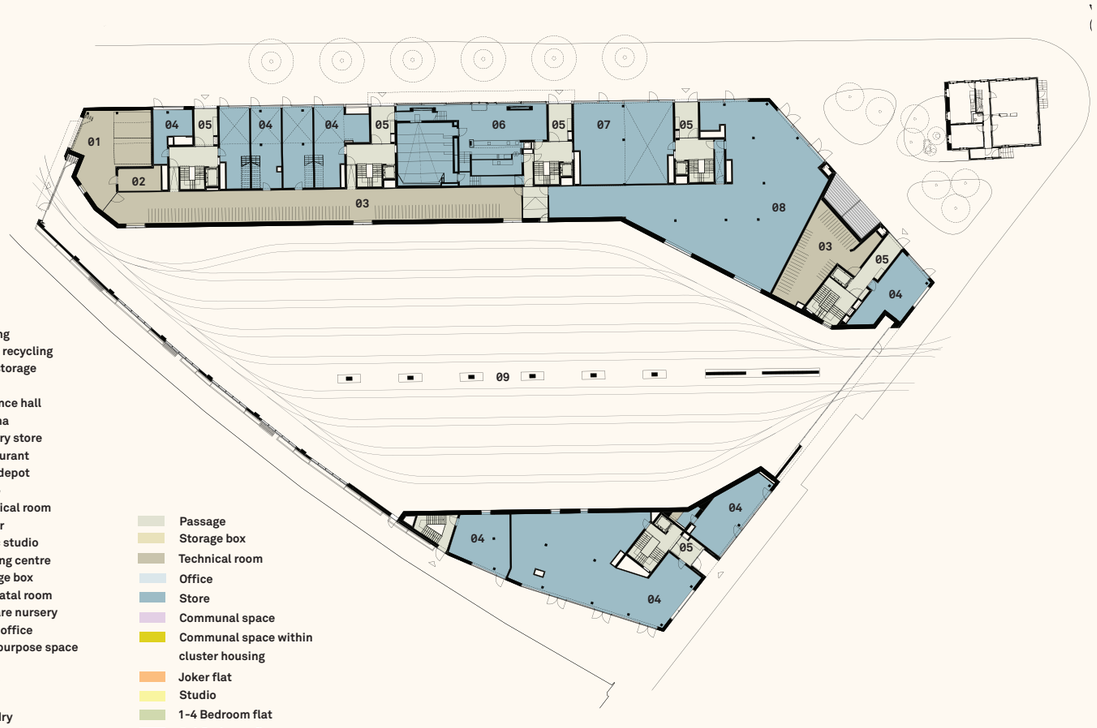
A second strategy that Kalkbreite uses to stay affordable is to deliberately reduce private living area and compensate with shared facilities (Living the City, 2020; Premio Baffa Rivolta, n.d.). Tenants agree to a maximum of 35 m² of private space per person (substantially below the Swiss average of around 50 m²). The space released is reinvested in shared programme: communal kitchens, a Großhaushalt (large-household kitchen) for fifty people, a sauna with outdoor pool, libraries, music rooms, a café, a foyer, a daycare, and a network of internal "streets" that connect them. The overall ratio of usable area is approximately 8,000 m² housing : 4,800 m² commercial/cultural : 600 m² communal indoor space, plus around 4,000 m² of green and outdoor space.

A particular innovation are the Jokerzimmer (joker rooms): small, fully equipped units that residents can rent on a temporary basis when guests come to stay or when extra workspace is needed. This converts what would otherwise be unused private space into a circulating shared resource. The principle is directly translated into the Between Shed and Polder design: when a rental module is not currently rented as part of a dwelling, it is automatically activated as a shared workspace, guest room, meeting room or yoga studio (Section 3.2 of the main report).

Design decisions:

- Stack housing on top of active heavy-vehicle infrastructure by treating the deck above the trucks/parking as a new public ground level, accessible to residents and the neighbourhood.
- Distribute the cost of the structural deck across multiple stakeholders (logistics company, municipality, housing corporation, cooperative/fund), so that no single party carries the burden alone.
- Compensate compact base units with a generous collective programme distributed through the building (workshop, productive school, supermarket, café, activated rentable modules).
- Add extra rentable modules and combine them with small base units
- Treat temporarily unused rentable modules as a circulating shared resource (Joker principle) rather than as vacant space.

0



01 Parking
02 Paper recycling
03 Bike storage
04 Store
05 Entrance hall
06 Cinema
07 Grocery store
08 Restaurant
09 Tram depot
10 Office
11 Technical room
12 Atelier
13 Music studio
14 Birthing centre
15 Storage box
16 Postnatal room
17 Daycare nursery
18 Joker office
19 Multipurpose space
20 Café
21 Foyer
22 Hall
23 Laundry
24 Guest bedroom
25 Communal dining room and kitchen
26 Courtyard

Passage
Storage box
Technical room
Office
Store
Communal space
Communal space within cluster housing
Joker flat
Studio
1-4 Bedroom flat
5-6 Bedroom flat
7-8 Bedroom flat
Cluster housing

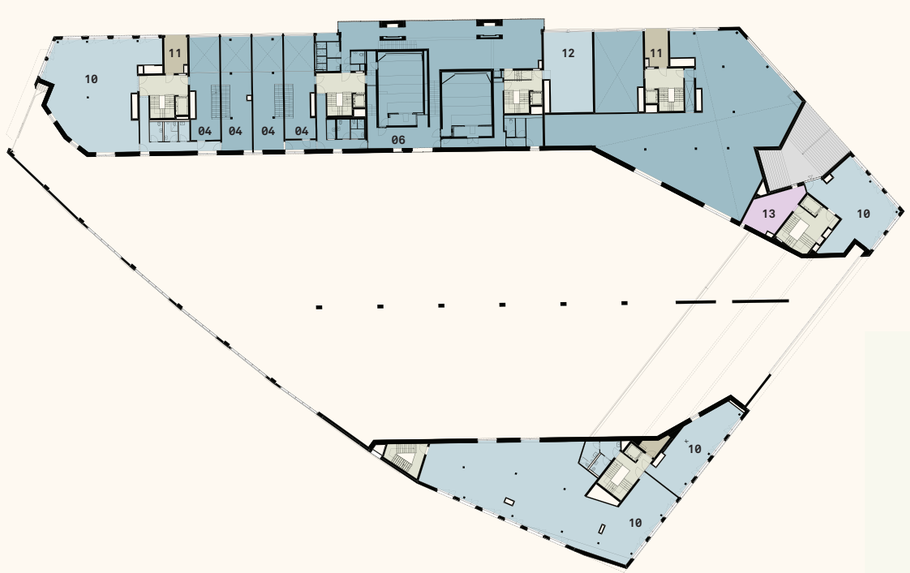
+ 2



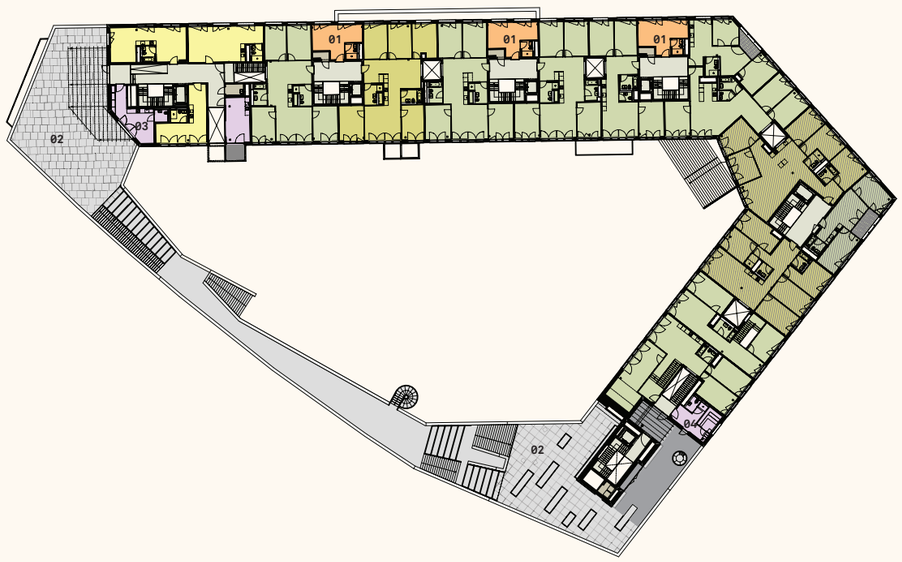
01 Parking
02 Paper recycling
03 Bike storage
04 Store
05 Entrance hall
06 Cinema
07 Grocery store
08 Restaurant
09 Tram depot
10 Office
11 Technical room
12 Atelier
13 Music studio
14 Birthing centre
15 Storage box
16 Postnatal room
17 Daycare nursery
18 Joker office
19 Multipurpose space
20 Café
21 Foyer
22 Hall
23 Laundry
24 Guest bedroom
25 Communal dining room and kitchen
26 Courtyard

Passage
Storage box
Technical room
Office
Store
Communal space
Communal space within cluster housing
Joker flat
Studio
1-4 Bedroom flat
5-6 Bedroom flat
7-8 Bedroom flat
Cluster housing

+ 0,5



+ 5



PROJECT THE CITY DUNE

Location	Copenhagen, Denmark
Program	Public space, bank
Year	2010
Architect	SLA
Client	SEB Bank and Pension
CFA	7300 m²



3.1 Project context
The harbour front of Copenhagen along Kalvebod Brygge had been criticised for years as a strip of low-quality offices, introverted shopping malls, poor cycling and pedestrian infrastructure, and almost no usable public space (SLA, n.d.; Land8, 2014). This is the same as the exteriorless industrial neighbourhoods. When the Swedish bank SEB chose to build its Scandinavian headquarters at the most traffic-heavy corner of the area, the project included an 7,300 m² outdoor area above an underground car park between two new office buildings designed by Lundgaard & Tranberg. SLA was commissioned to design this space. The design problem was almost archetypal: how to mediate between a hard, technical, infrastructural edge (a multi-lane road, a parking garage roof, an office façade) and the everyday human scale of pedestrians, cyclists, lunch breaks and informal use. The challenge in Between Shed and Polder is structurally similar: how to mediate between the hard edge of an industrial logistics shed and the soft, cultivated polder landscape of Midden-Delfland, on top of an elevated deck that is itself a piece of infrastructure.

3.2 The dune as a gradient
SLA's design strategy was to read the entire area as one continuous topographic gesture rather than as a flat plaza divided into zones (SLA, n.d.; Mooool, n.d.; Landezine, n.d.). The terrain rises from street level to second-floor height, covering the side and the roof of the bank's parking garage (a 7-metre level change). The folding movement of the white concrete surface is inspired by the sand dunes of northern Denmark and the snow dunes of Scandinavian winters. Three hundred metres of winding ramps thread through the



topography, providing pedestrian and cyclist routes from the harbour, past the Danish National Archives, to the Tivoli Congress Center.

Crucially, the dune does not impose a binary distinction between "building" and "ground"; it produces a gradient. At the lowest level it merges with the public street; at the highest it touches the upper floors of the SEB offices. Inside the buildings, the ground-floor plane rises in a series of stepped seating elements that extend through the curtain wall into the landscape outside, dissolving the boundary between interior and exterior (E-architect, 2021). The result is a single terrain in which it is unclear where the office ends and the city begins.

This gradient principle was directly adopted in Between Shed and Polder. The public deck transitions materially from concrete near the JoyLogistics shed to greener, planted surfaces near Midden-Delfland; the buildings step down in height along the same axis; and 'holes' in the landscape show (frame) the driving trucks underneath. The lifted gradient does not only serve as a park and playground, it also keeps people save from the industry without hiding it.

3.3 Privately financed public space and integrated water management
The City Dune is privately owned (it sits on the SEB plot), but under Danish law it functions as publicly accessible space. SEB itself has stated that the branding value of the space is roughly five times what an equivalent budget spent on a regular branding campaign would have produced (Høltermand, in SLA, n.d.). This demonstrates that a privately financed but publicly used space is not a charitable gesture; it is a calculable investment in identity and presence. This casestudy serves as prove towards logistic sheds that optimising the landscape around the shed is a very promising investment.

3.4 Integrated water management
In addition to its spatial function, the City Dune is Copenhagen's first 100 % climate-adapted urban space (SLA, n.d.; Danske Ark, n.d.). Rainwater is collected by line drains hidden in the folds of the terrain, transported through channels to plant beds, recirculated by a pumping system to irrigate the trees, and only discharged into the harbour as overflow. One hundred and ten water sprays cool the air on hot days. The water management is therefore not added on top of the design but folded into its formal logic: the same shape that creates public routes also handles drainage. This is the precedent for the visible water flow integrated into the deck of Between Shed and Polder, where stormwater is routed across the gradient toward the ZUS water buffer in Midden-Delfland, making the project's water and energy systems legible to residents and visitors (Section 3.3 of the main report).

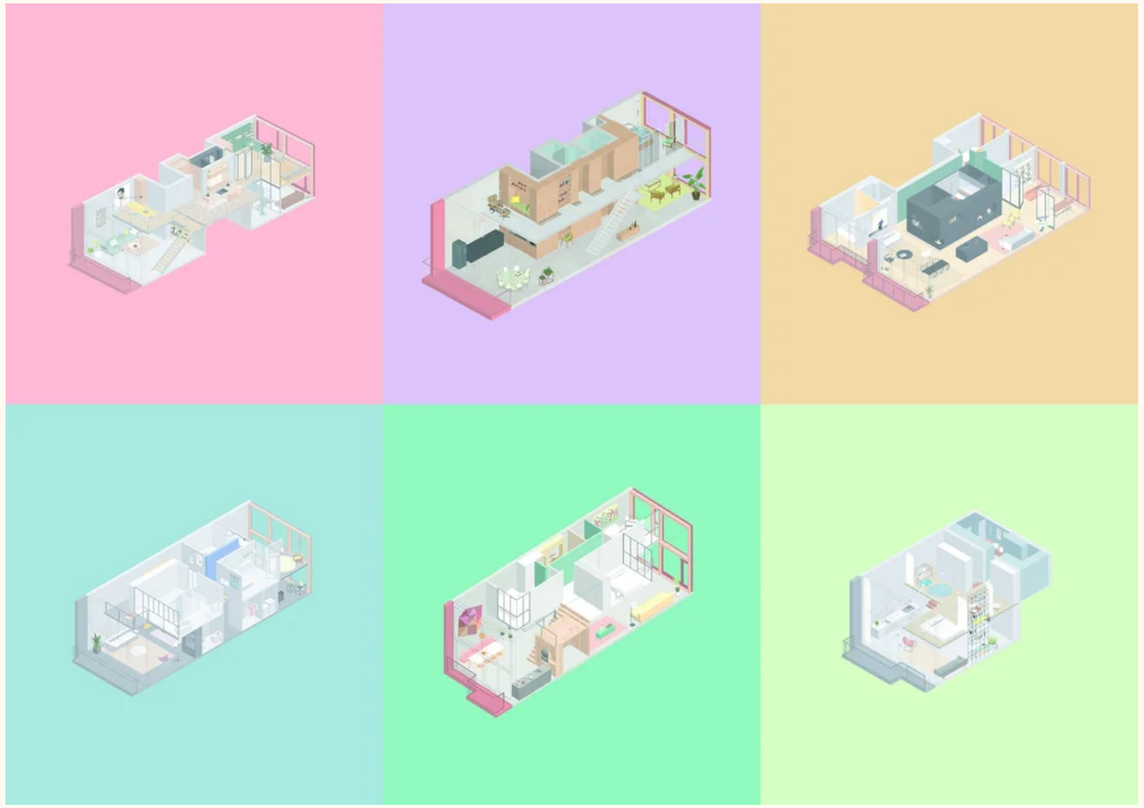
Design decisions:
- Designed the plane between industry and landscape as a single continuous gradient, materially transitioning from concrete near the shed to planted surfaces near Midden-Delfland.
- Used topography (the elevated deck, openings down to the truck level) to mediate between heavy infrastructure below and human-scale public space above, rather than separating them with fences or walls.
- Made water flow visible as part of the public space, integrating drainage from the buildings and deck into a designed gradient that connects to the ZUS water buffer.
- Treat the public deck as an investment in identity and presence: an open foyer that benefits the logistics company, the residents and the wider neighbourhood simultaneously.





PROJECT: SUPERLOFTS

Location: Amsterdam, Utrecht, Delft, Groningen
Program: Dwelling
Architect: Marc Koehler Architects (MKA)
Approach: Open Building applied at the building scale, with resident co-creation
Structure: Prefabricated concrete frame with 3–6 m wide and tall modules; central “Supercore” service shaft



4.1 The shell delivery model

Superlofts is a series of cooperative housing projects developed by Marc Koehler Architects since around 2015, beginning with Casco Lofts and continuing through several plots in Amsterdam’s Houthavens and Buiksloterham, then to Blok Y in Utrecht and further locations (Marc Koehler Associates, n.d.; ArchDaily, 2018). The series is the most consistent contemporary attempt to apply Habraken’s Open Building principles in a commercially viable Dutch context. The architectural system is direct: a prefabricated concrete base structure (the support) provides a framework of three- to six-metre-high and three- to six-metre-wide modules, which can be combined into housing blocks, slabs, towers, or townhouses. A centrally placed services shaft, which MKA calls the Supercore, allows kitchens and bathrooms to be placed almost anywhere on the floor. Owners or residents then add their interior fit-out (the infill) into these raw, double-height volumes, with complete freedom over the layout, materials, and even the inclusion of an internal mezzanine. Façades are designed by the architect but include selectable openings so each loft has its own daylight character. The result is delivery at casco (shell) stage: the building is structurally complete, weatherproof and connected to services, but the interior is empty. Residents complete the dwelling either themselves, with a contractor of their choice, or with the architect. Blok Y in Utrecht (2018) houses thirty lofts ranging from 70 m² (XS) to 145 m² (family) within one structural framework; no two apartments are alike (ArchDaily, 2018; Designboom, 2018).

4.2 Affordability through self-build and gradual investment
Casco delivery has two affordability consequences that are particularly relevant to Between Shed and Polder. First, the cost of finishing is decoupled from the construction loan: residents pay for the shell upfront and then complete the interior at their own pace, on their own budget, choosing their own level of finish (Marc Koehler Associates, n.d.). Second, the framework allows residents to "grow into" their space: a young couple may initially finish only half of a double-height loft, adding a mezzanine or a second bedroom later when their household expands or their budget allows. This converts the dwelling from a static product into a long-term project that the resident invests in over time.

This logic is directly adopted in Between Shed and Polder, but rephrased through a modular rather than a single-loft strategy. In Superlofts, residents customise within a single loft. In Between Shed and Polder, residents add or release rentable modules attached to a base unit as their household grows or shrinks. In both cases, the dwelling adapts without the resident having to relocate, and the cost of the dwelling is paid in stages rather than as a single fixed lump sum but with the strategy from Between Shed and Polder: no space goes to waste when not used (see appendix: Modules).

4.3 Customisation as a driver of place attachment
Superlofts was the case study where the connection between adaptability and staying in place became most explicit. Residents who design and self-build their own dwellings have invested significant time, choice and (often) physical labour in the place. This investment is qualitatively different from buying a finished apartment off the shelf. Marc Koehler Architects have observed that residents in Superlofts projects develop strong ties to the building and to the cooperative community even before construction begins, because they have already spent years co-creating the project (Marc Koehler Associates, n.d.).

Read through the lens of the place attachment literature (Lewicka, 2011; see Appendix 02 Social Cohesion), this means that Superlofts residents are predisposed to stay longer, because a customised space cannot be replicated by simply renting another apartment elsewhere. The mechanism of attachment is the inverse of standard rental housing: instead of attachment forming slowly over years of residence, it is partly front-loaded into the construction process, then deepened through residence. Between Shed and Polder uses a softer version of the same principle: residents do not co-design the structure, but they configure their own modular dwelling, and the modules they release re-enter circulation as collective space rather than disappearing.

4.4 Two governance variants: ownership and rental
Superlofts has been delivered in two financial variants, which directly inform the dual tenure strategy of Between Shed and Polder:

1. Cooperative purchase (CPO): the original Superlofts projects (Casco Lofts, Houthavens, Blok Y) are Collectief Particulier Opdrachtgeverschap (Collective Private Commissioning) developments. A group of future residents collectively commission the building, finance their share, and form a Vereniging van Eigenaren (homeowners' association) afterwards. The price stays low because the units are delivered casco. Members hold individual ownership of their loft and shared ownership of common spaces.
2. Cooperative rental (Superwood/ next generation): more recent Superlofts projects are delivered by a developer for the rental market, including for housing corporations. The developer builds the framework, residents rent the casco loft, and they retain the freedom to fit out the interior themselves. This converts the Superlofts logic into a model that can be applied at scale by social housing providers (Marc Koehler Associates, n.d.).

These two variants confirm that Open Building is not restricted to one tenure model, and that the support–infill separation can be combined with either ownership or rental. Between Shed and Polder uses both: the rental tower next to the shed operates in a corporation-led rental logic; the tower closer to Midden-Delfland operates as a pension-fund-backed cooperative purchase model, in which residents buy a cooperative membership and rent additional modules (see Appendix 07 Governance).

Design decisions:

- Deliver the dwelling as a base unit + attachable modules, with residents choosing their configuration and adapting it over time, rather than as a fixed apartment.
- Use casco / shell logic to keep entry costs low and let residents complete the interior at their own pace. Locate the service shaft (kitchens, bathrooms, sewage) in a fixed core/ fixed cores so the rest of the floor plan is free of constraints.
- Combine rental and cooperative purchase in two or more parallel towers, both operating on the same modular logic, so residents can move between tenure forms over a lifetime without leaving the neighbourhood. (Creating symbiosis over time, see Appendix 2 social cohesion)
- Treat resident customisation as a deliberate driver of place attachment, ensuring that residents are predisposed to stay long enough for the symbiosis with the industry to develop (Appendix 02 Social Cohesion).

APPENDIX. 07 FUNCTION ANALYSIS

Facility		Standard in m² GFA	Standard in m² GFA per 250 dwellings
Healthcare	Pharmacy	49 m² GFA per 1,000 dwellings	12,25 m² GFA per 250 dwellings
	General practitioner	300 m² GFA per 1,000 dwellings	75 m² GFA per 250 dwellings
	Physiotherapist	m² GFA per 1,000 dwellings	m² GFA per 250 dwellings
Special housing types	Assisted living	241 m² GFA per 1,000 dwellings	60,25 m² GFA per 250 dwellings
	Protected/supported living	119 m² GFA per 1,000 dwellings	29,75 m² GFA per 250 dwellings
Education	Daycare	1529 m² GFA per 1,000 dwellings	382,25 m² GFA per 250 dwellings
	After-school care	28 m² GFA per 1,000 dwellings	7 m² GFA per 250 dwellings
	Primary education	462 m² GFA per 1,000 dwellings	115,5 m² GFA per 250 dwellings
Community welfare	Community centres	93 m² GFA per 1,000 dwellings	23,25 m² GFA per 250 dwellings
Arts and culture	Cultural facilities	220 m² GFA per 1,000 dwellings	55 m² GFA per 250 dwellings
Sports	Sports hall/ room / gymnasium	240 m² GFA per 1,000 dwellings	60 m² GFA per 250 dwellings
	Sportsfield	5800 m² GFA per 1,000 dwellings	1450 m² GFA per 250 dwellings
	Swimming pool	132 m² GFA per 1,000 dwellings	33 m² GFA per 250 dwellings
	Scouting	3000 m² GFA per 3000 youths aged 4–17	-
Public space	Playground	Every 300 m, and every 200 m in high-density areas	-
	Playable sidewalk	3–5 m wide and at least on one side of the street	-

Calculated based on Rotterdam standards.

The area in question consists of 250 dwellings. The table shows that general practitioners, daycare, primary education, sports fields, assisted living, and sports halls require the largest floor areas and are therefore the most spatially demanding functions. With the exception of the sports field, which can be located in Midden-Delfland, and assisted living, which is already present in the area, these functions have been incorporated into the masterplan.

APPENDIX. 08 GOVERNANCE, STAKEHOLDER ANALYSIS AND AFFORDABILITY

This appendix describes the governance structure and stakeholder configuration that make the project financially and organisationally feasible.

The central challenge is not a shortage of technical solutions but the absence of a proven model for building housing on active industrial land. The risks that comes with building on such lands are big and the investments are high. The first section explains why the modular housing system and the symbiosis between residents and industry are not optional design features but preconditions for the financial viability of the project. The argument follows a causal chain that connects each step to the next.

The next section proposes a model financing model. It identifies four principal stakeholders, defines two distinct tenure tracks (rental and cooperative purchase), introduces a Neighbourhood Operator to manage shared and vacant modules, and presents a cross-financing logic that distributes costs and revenues so that each party gains more than it risks.

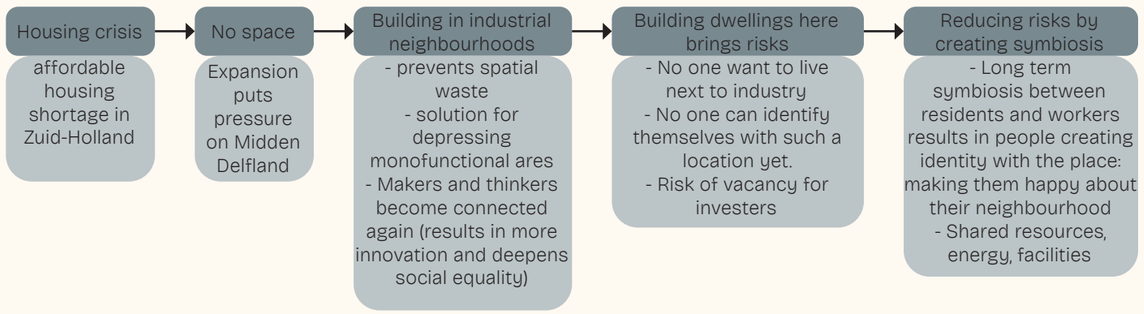
The governance model is inseparable from the spatial design. The modular grid (4.2 × 4.2 m), the rentable modules, and the shared energy system all require organisational agreements that go beyond a standard development contract. Architecture and governance must be designed together.

1.1 The causal chain

The starting point is the housing crisis. South Holland faces a deficit of approximately 400,000 homes, and nearly one million homes must be added nationally by 2030 (ABF Research, 2024). At the same time, there is almost no space left to build: Midden-Delfland is a protected Special Provincial Landscape, and further expansion into the polder threatens to turn the southern Randstad into one continuous urban fabric. The only available land is industrial: monofunctional estates along the urban–polder edge that occupy large amounts of space while contributing little to urban quality.

Building on this industrial land solves the spatial problem but creates a social one. Housing next to a logistics shed is not a self-evident proposition. The area has no image, no amenities, no community, and no reason for anyone to come, so let alone stay. For the investment to succeed, the neighbourhood must develop a form of social resilience that can withstand the initial discomfort and grow into genuine attachment over time.

This is where symbiosis becomes essential. A symbiotic relationship between residents and industry (in which the two groups share energy, space, and resources) transforms the industrial context from a liability into an asset. Residents benefit from near-zero energy costs (PV on the shed roof), from shared facilities (the productive school, the workshop, the café), and from the identity of living in a place where making and thinking coexist. The industry benefits from improved parking, a stable energy partner, and a neighbourhood that advocates for its continued operation rather than complaining about trucks. But this symbiosis does not happen overnight. It needs time (see Appendix Social Cohesion and Target Group).

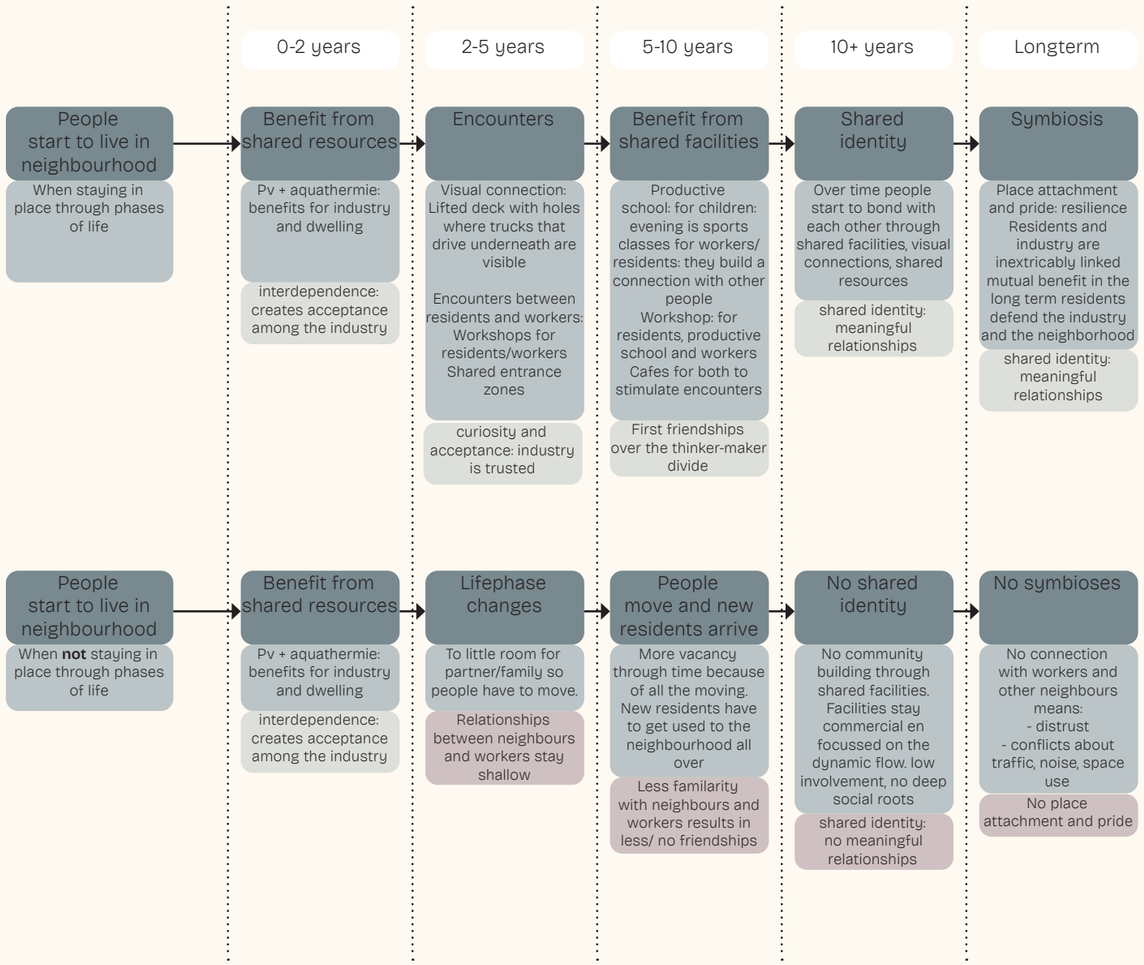


1.2 Symbiosis needs time, and time needs staying

Place attachment research consistently shows that the single strongest predictor of whether people develop emotional bonds with a neighbourhood is how long they have lived there (Lewicka, 2011; Brown et al., 2003). The process unfolds over years, not months.

- In the first years, residents benefit from shared resources (energy, parking) and begin to encounter industry workers in shared spaces.
- After two to five years, the productive school, workshops, and cafés generate routine interactions that produce the first friendships across the thinker–maker divide.
- After five to ten years, shared identity begins to form through collective decision-making in the energy cooperative and through children who have grown up with the productive school.
- After ten years and beyond, the neighbourhood reaches genuine place attachment and pride: residents and industry are inextricably linked, and residents defend the neighbourhood and its industrial character rather than seeking to leave.

But this entire trajectory depends on one condition: people must stay. If residents are forced to move every time their household changes (from starter to couple, from couple to family, from family to empty nest) the attachment clock resets with every relocation. New residents arrive and must start the process from zero. Relationships between neighbours remain shallow. No shared identity forms. No symbiosis develops. The result is not a community but a revolving door: a transient population with no investment in the place, no connection to the industry, and no resilience against the inevitable tensions of living next to a truck operation.



1.3 The modular system prevents relocation

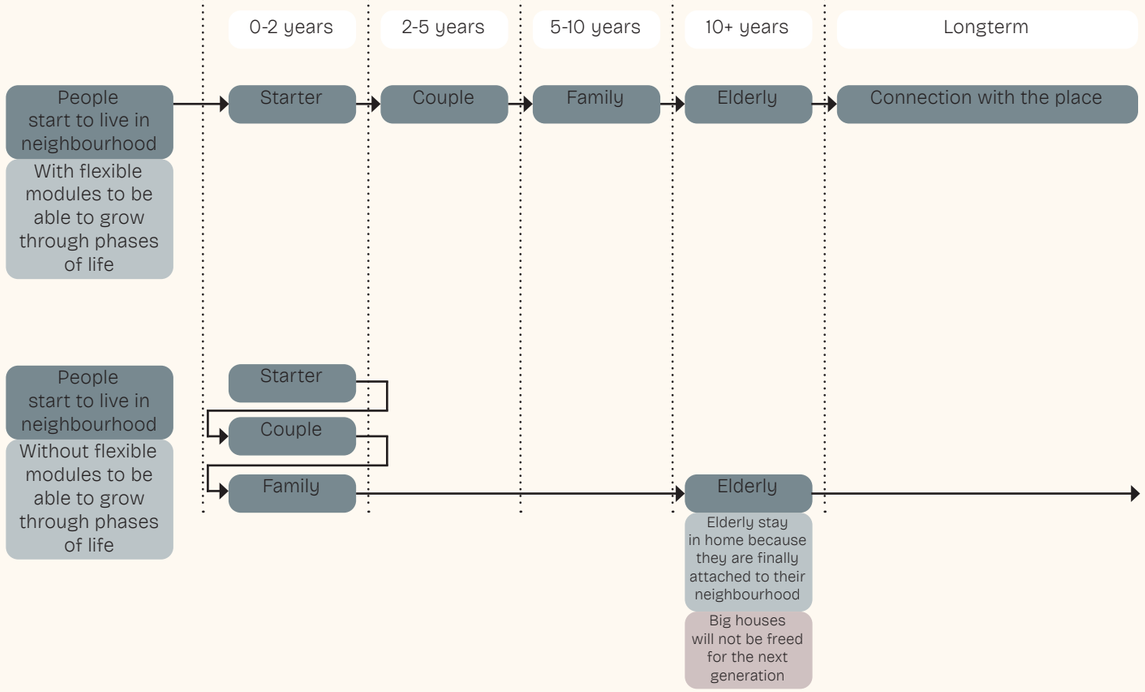
The modular system is designed to break this cycle. Residents rent or buy a base unit of 32–64 m² and can rent additional modules of approximately 16 m² each as their household grows. When a starter becomes a couple, they rent an extra module with no moving required. When a child is born, another module is added. When children leave, the module is released and re-enters the pool. When the module is not rented as part of a dwelling, it does not stand vacant: it is activated as a co-working space, guest room, yoga studio, or other shared function. The result is no moving and no vacancy.

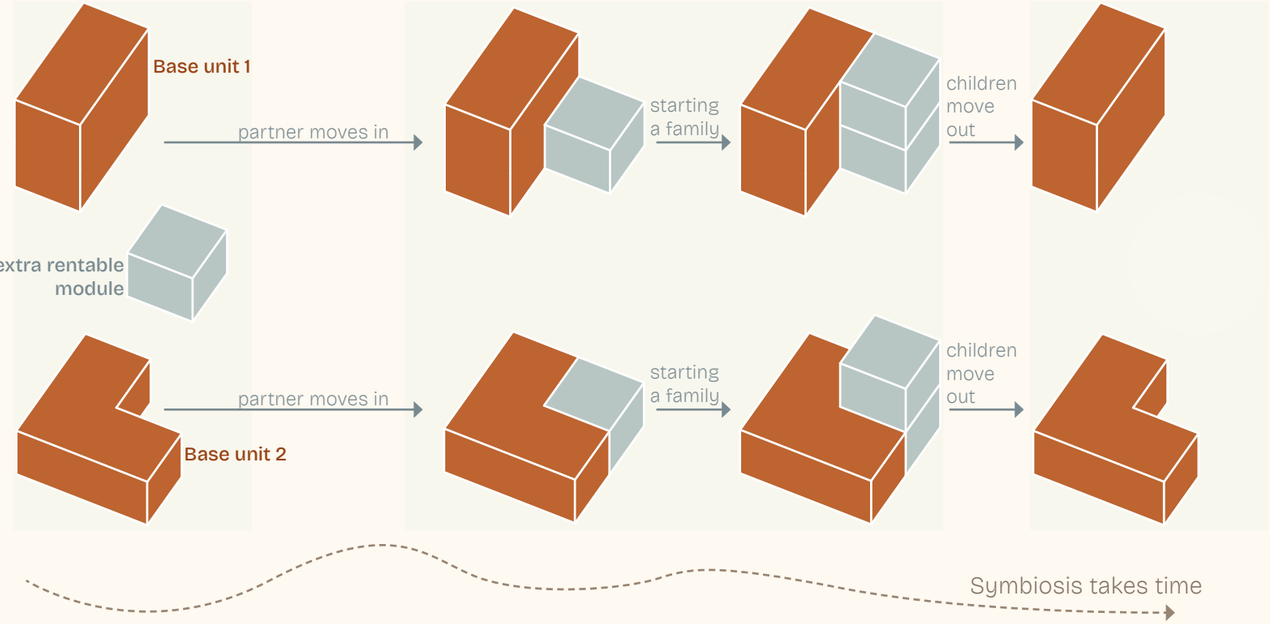
Affordability is built into this system from the start. Because residents begin with a small base unit and expand incrementally, the entry cost is low. Shell delivery keeps construction costs down. And because the modules are rented rather than purchased, residents pay only for the space they actually use at any given moment. This makes middle-segment rent (middenhuur) achievable on a site that requires significant structural investment (the elevated deck), which would otherwise push rents into the free sector.

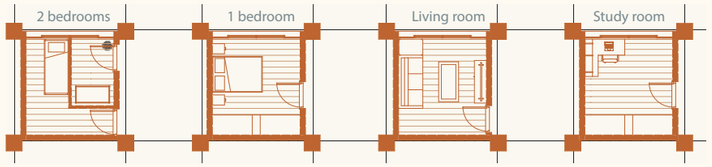
1.4 What happens without modules: the conventional scenario

Without the modular system, the neighbourhood follows a conventional trajectory. Residents arrive as starters, benefit initially from cheap energy, but quickly outgrow their apartment when household composition changes. They move to a larger home which is most likely in a different neighbourhood, because the fixed apartments on site do not match their new needs. New residents arrive and must start the attachment process from zero. Over time, vacancy increases as mismatched apartments fail to find tenants. Facilities that were designed for a stable community (the productive school, the workshop, the energy cooperative) lose participation and become commercially oriented or close. No shared identity forms. Conflicts about traffic, noise, and space use (which a bonded community would resolve informally) escalate into formal complaints and regulatory pressure. The logistics company faces operational restrictions. The investment depreciates.

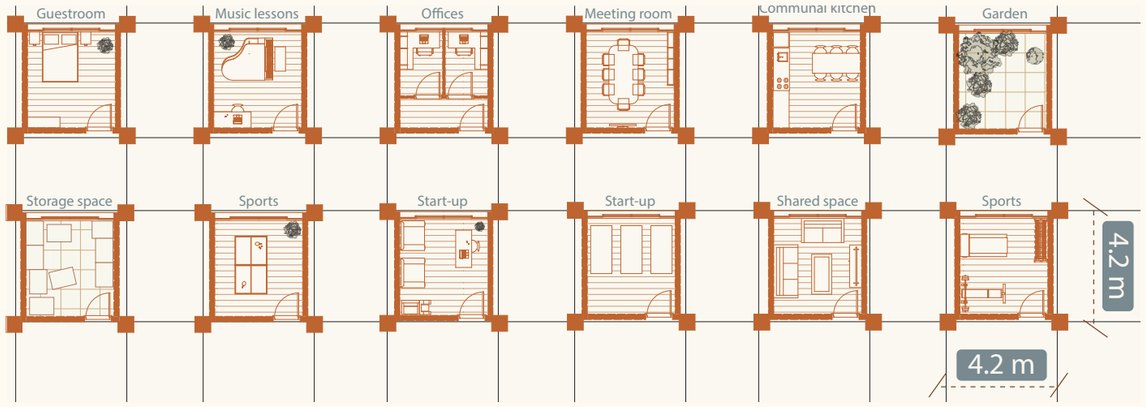
The worst paradox occurs at the end of the cycle: elderly residents who have finally developed attachment after decades of living in one place refuse to leave, even though their large apartment could house a young family. The dwelling that was too rigid to adapt when the household shrank now blocks the next generation from entering the neighbourhood. This is not a hypothetical scenario; it is a well-documented pattern in Dutch housing that contributes directly to the housing crisis (doorstroming problem).







Module rented



Module not rented

2 Risk and long-term resilience: why investors benefit from adaptivity

Adding modules to create symbiosis and thus, resilience is not only a social one; it is a financial one. Every stakeholder in this project (the logistics company, the municipality, the housing corporation, and the pension fund)faces specific risks. The modular system and the symbiotic relationship between residents and industry mitigate each of these risks in ways that a conventional development cannot.

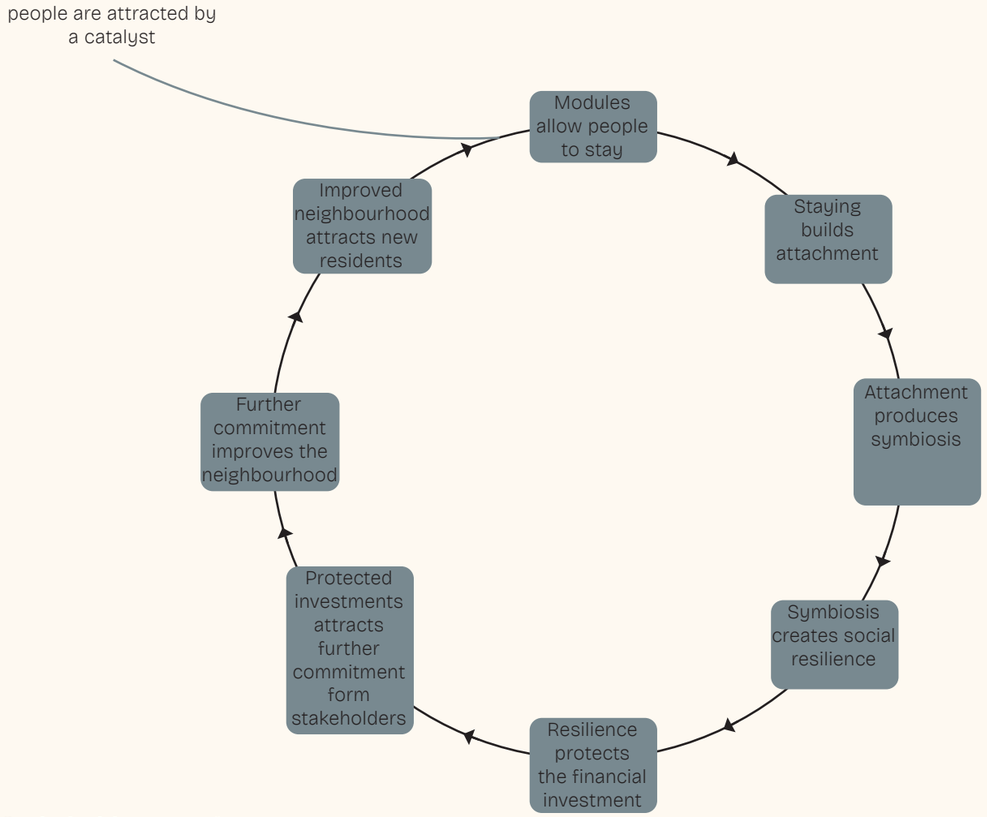
Logistics company (JoyLogistics)	Municipality (Lansingerland)	Housing corporation (rental)	Housing corporation (purchase)
Risks: Nuisance complaints from residents leading to operational restrictions on truck movements.	Risks: Zoning change is legally challenged; neighbourhood fails and becomes a political liability.	Risks: Vacancy due to mismatched apartment sizes as household compositions change over decades.	Risks: Building becomes obsolete in 20–30 years as household types, work patterns, and care needs change.
How modules + symbiosis mitigate: Symbiosis turns residents into advocates: they defend the industry because their energy, school, and identity depend on it. Elevated deck separates traffic flows physically.	How modules + symbiosis mitigate: Modular system reduces vacancy risk; symbiosis produces a self-sustaining community that does not require ongoing public intervention. Housing delivered without consuming Midden Delfland landscape.	How modules + symbiosis mitigate: Modules circulate rather than stand empty: when not part of a dwelling, they generate alternative income as collective spaces. Fewer moves = stable rental income.	How modules + symbiosis mitigate: Adaptable structure (4.2 m grid, 4.0 m floor height) accommodates any function without modification. Modules adapt to every life phase. Asset never becomes obsolete.
Long-term resilience: Land value increases; parking revenue is inflation-indexed; long-term partner relationship with neighbourhood.	Long-term resilience: Replicable model for other industrial edges in South Holland; tax base expansion.	Long-term resilience: Building remains relevant across demographic shifts; no costly renovation needed when household types change.	Design life >200 years; stable returns from module circulation and membership transfers. The safest long-term real estate investment is one that can change.

2.1 The pension fund question

A pension fund considering this investment asks five questions. How will people live in 30 years? We do not know but the building can adjust. How do buildings retain value? By remaining useful. Which dwellings become obsolete? Those that cannot change. How do we prevent vacancy? By circulating space rather than fixing it. How do we prevent costly renovations? By separating structure from infill and designing the structure for the longest possible life. The modular building answers all five questions with the same mechanism: adaptivity. For a pension fund, this makes the project not a speculative bet on one demographic scenario but a structural investment in flexible space, which is a much safer long-term proposition than a building full of fixed 80 m² three-bedroom apartments that may not match demand in 2056.

2.2 From risk to resilience: the feedback loop

The relationship between modules, symbiosis, and resilience forms a self-reinforcing feedback loop. Modules allow people to stay. Staying builds attachment. Attachment produces symbiosis with the industry. Symbiosis creates social resilience (residents defend the neighbourhood rather than abandon it). Resilience protects the financial investment. Protected investment attracts further commitment from stakeholders. Further commitment improves the neighbourhood. An improved neighbourhood attracts new residents. And the cycle continues.



3. Stakeholder overview

With this foundation, the following sections describe how the governance structure distributes costs and revenues across the four principal stakeholders. For a detailed description of each stakeholder's role, investment, and return, see the sections below.

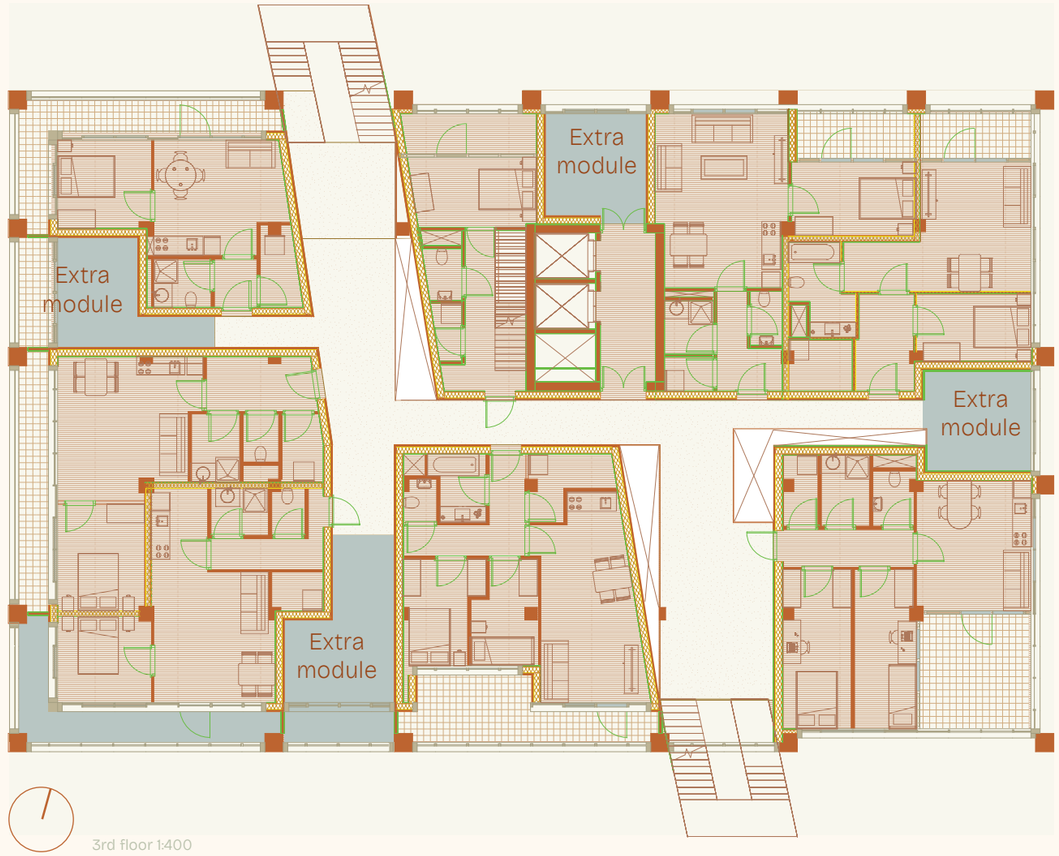
Logistics company (JoyLogistics)	Municipality (Lansingerland)	Housing corporation	Housing corporation
Retains land ownership; sells air rights and development rights to municipality; invests in structured parking below the deck.	Changes zoning plan; partially finances the structural deck as public infrastructure; coordinates sale of building plots/air rights; acts as client for public space.	Develops and manages the rental tower adjacent to the shed; delivers mid-segment rental housing (middenhuur); manages base units and rentable modules.	Finances and owns the purchase tower closer to Midden-Delfland; residents buy a cooperative membership; modules are rented from the cooperative.
Investment: Parking structure (columns, slabs, ramps) below the elevated deck.	Investment: Deck structure (shared with logistics company); public space; zoning and permitting process.	Investment: Construction of rental tower; module fit-out; long-term building management.	Investment: Construction of purchase tower; long-term capital commitment (pension fund); cooperative start-up costs.
Return: Recurring income from rented car parking spaces; improved parking quality; long-term land value uplift	Return: Housing delivery without consuming Midden-Delfland; infrastructure reuse; tax base expansion.	Return: Stable, long-term rental income; reduced vacancy through modular flexibility; social mandate fulfilment.	Return: Long-term asset value retention through adaptability; stable income from module rentals; inflation-protected returns.

4. The rental model: housing corporation towers

The rental tower is positioned directly adjacent to the logistics shed. It is developed and owned by a housing corporation, delivering mid-segment rental housing. The target is approximately 60% middenhuur (regulated middle-segment rent) and 40% of free-sector units within the rental tower.

Each dwelling starts as a base unit of approximately 32–55 m² (three to four grid modules of 4.2 × 4.2 m). This base unit contains the essential wet core (kitchen, bathroom, toilet) and is delivered as a finished dwelling. Affordable rent is achieved because of the small size of the base units. Adjacent to the base unit, along the facade, are rentable modules of approximately 16 m² each. A resident can rent one or more additional modules from the housing corporation when their household grows (partner moves in, child is born, home office is needed). When the need decreases (child moves out, downsizing), the resident releases the module, and it returns to the corporation's pool.

Because the resident pays monthly rent for both the base unit and the additional modules, there is a direct financial incentive to release modules that are no longer needed. This is different from a traditional apartment where the resident occupies a fixed floor area regardless of household size. The result is a continuous circulation of space: modules are released and re-rented, keeping the building's occupancy aligned with actual household sizes rather than with the original floor plan.



3rd floor 1:400

5 The purchase model: housing cooperative and pension fund

The purchase tower is positioned closer to Midden-Delfland, in the quieter, greener part of the site. It serves families, couples, and elderly households who want a form of ownership that combines long-term security with the flexibility of the modular system. The model proposed here is a wooncoöperatie (housing cooperative) backed by a pension fund as long-term capital partner.

Why a cooperative, not traditional homeownership

Traditional homeownership (appartementsrecht) creates a rigid relationship between resident and floor area: the owner buys a fixed apartment and bears all risks of over- or under-sizing. If the household shrinks, the owner sits in a home that is too large; if it grows, the only option is to sell and move. This rigidity is precisely what the modular system is designed to overcome.

In the cooperative model, the resident does not buy an apartment but a membership in the housing cooperative. This membership grants the exclusive right to occupy a base unit and the right to rent additional modules from the cooperative at cost price. The cooperative itself owns the building. When a resident leaves, they sell their membership (either back to the cooperative or to a new member)at a price that reflects the value of the base unit plus any improvements, but not the modules (which are cooperative property and re-enter the pool).

This structure has three advantages:

1. The entry price for new members is significantly lower than buying a full-sized apartment, because the resident only purchases the right to a base unit rather than the largest configuration they might ever need. A starter buys a membership for a 48 m² unit and rents modules as life evolves, rather than buying an 80 m² apartment in anticipation of future needs.
2. The financial incentive to release unused modules is preserved: because modules are rented monthly, a resident whose children have moved out naturally returns the extra module rather than holding onto unused space.
3. The cooperative can reinvest module rental income in building maintenance, collective amenities, and energy infrastructure, creating a self-sustaining financial cycle

The pension fund as long-term capital partner

The wooncoöperatie needs a large initial capital investment for construction. A pension fund is the ideal partner for this type of project, for reasons that go beyond generic real estate investment.

Pension funds seek assets that retain value over decades and generate stable, inflation-protected returns. Traditional residential buildings carry a structural risk: they become obsolete. Household compositions change (single-person households are growing rapidly, families are shrinking, elderly households are increasing), working patterns shift (the rise of remote work since 2020 has made home offices essential), and care needs evolve (ageing in place requires adapted floor plans). A conventional apartment building designed for a specific household type in 2026 may no longer match demand in 2046. The result is declining occupancy, costly renovation, and ultimately depreciation.

The modular building avoids this because dwellings can grow and shrink within the same structure, the building continuously adjusts to changing demand without physical renovation. A two-bedroom apartment can become a three-bedroom family home by renting a module, then return to a two-bedroom unit when the household shrinks, all without touching the structure. If residential demand weakens in a future scenario, the same floors can absorb office, care, co-working, or educational functions, because the 4.2 metre grid and 4.0 metre floor height accommodate all of these (see Appendix Grid Study).

6 Cross-financing: how the pieces fit together

The financial viability of the project depends on a cross-financing logic in which costs and revenues are distributed across four investment domains: the structural deck, the buildings, parking, and energy. Each domain has a different primary investor, and the revenues from one domain help finance another.

6.1 The structural deck

The elevated deck is the most expensive single element, because it must span the truck zone and carry buildings, public space, and landscape above it. The cost is shared between two parties: the logistics company finances the parking structure below the deck (columns, slabs, and ramps for truck and car parking), because this replaces and improves its existing surface parking. They get parking rent income in return. The municipality finances the remainder of the deck as an investment in public infrastructure, comparable to building a new street or square in a conventional housing development. The municipality recoups this investment through the sale of building plots (air rights) on top of the deck to the housing corporation and the cooperative.

6.2 The buildings

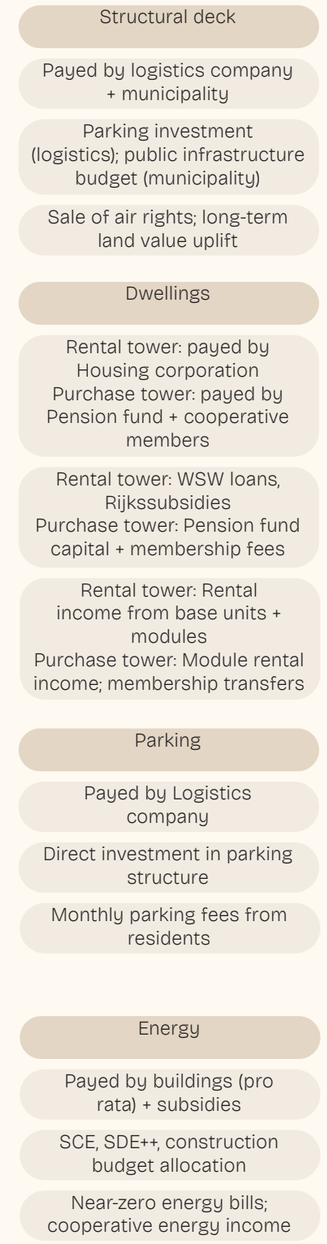
The housing corporation builds the rental tower using its standard financing instruments (WSW-guaranteed loans, Rijkssubsidies for middenhuur). The cooperative tower is financed through a combination of pension fund capital (for the structure and common areas) and membership contributions from residents (for the base units). Because both towers are built on existing industrial land with existing infrastructure (roads, sewers, water, electricity), the land preparation and infrastructure costs are substantially lower than in a greenfield development. In the Dutch context, land and infrastructure typically account for 20–40% of total housing costs; reusing industrial land can reduce this share significantly, which directly improves affordability.

6.3 Parking

The logistics company invests in the parking structure below the deck. In return, it gains improved, covered parking for its own trucks (replacing the current open-air surface parking) and a new revenue stream: residential car parking spaces rented to residents on a monthly basis. This creates a direct financial link between industry and residents. The logistics company's parking investment is partially offset by the rental income from residential spaces, making the business case attractive without requiring subsidy.

6.4 Energy

The shared energy system (PV on the shed roof, aquathermal heat from the water buffer, neighbourhood battery, and low-temperature heat network) is financed partly from each building's construction budget (each tower contributes a proportional share of the solar panel and heat network costs) and partly through sustainability subsidies (SCE for cooperative energy generation, SDE++ for aquathermal heat). After the initial investment, residents receive a near-zero energy bill. This near-zero energy cost is the decisive argument for attracting pioneer residents to an area adjacent to industry: it provides financial security in an uncertain economy and creates a tangible bond between residents and the industrial infrastructure on which their energy depends (see Appendix Energy System).

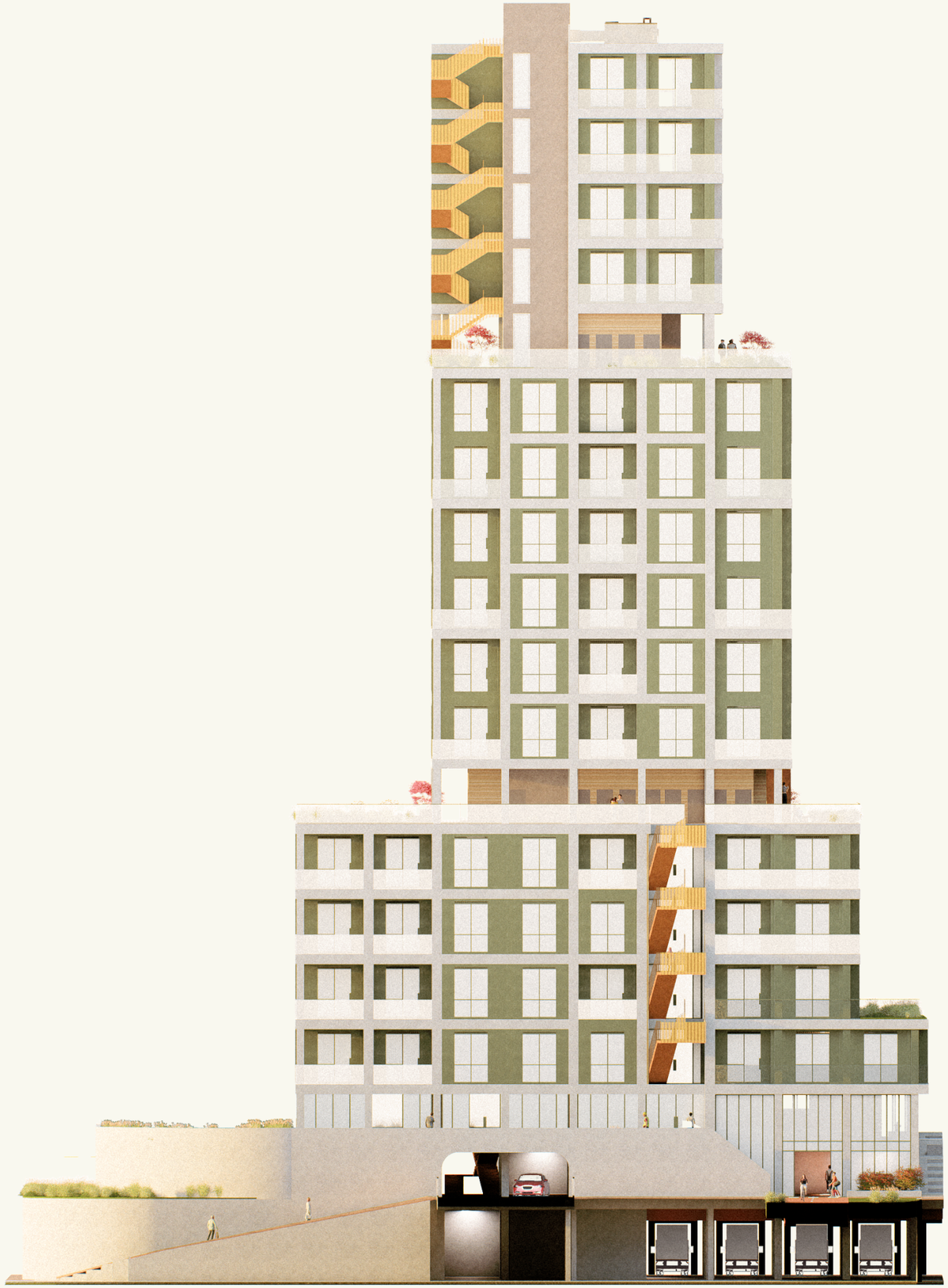


7 Conclusion

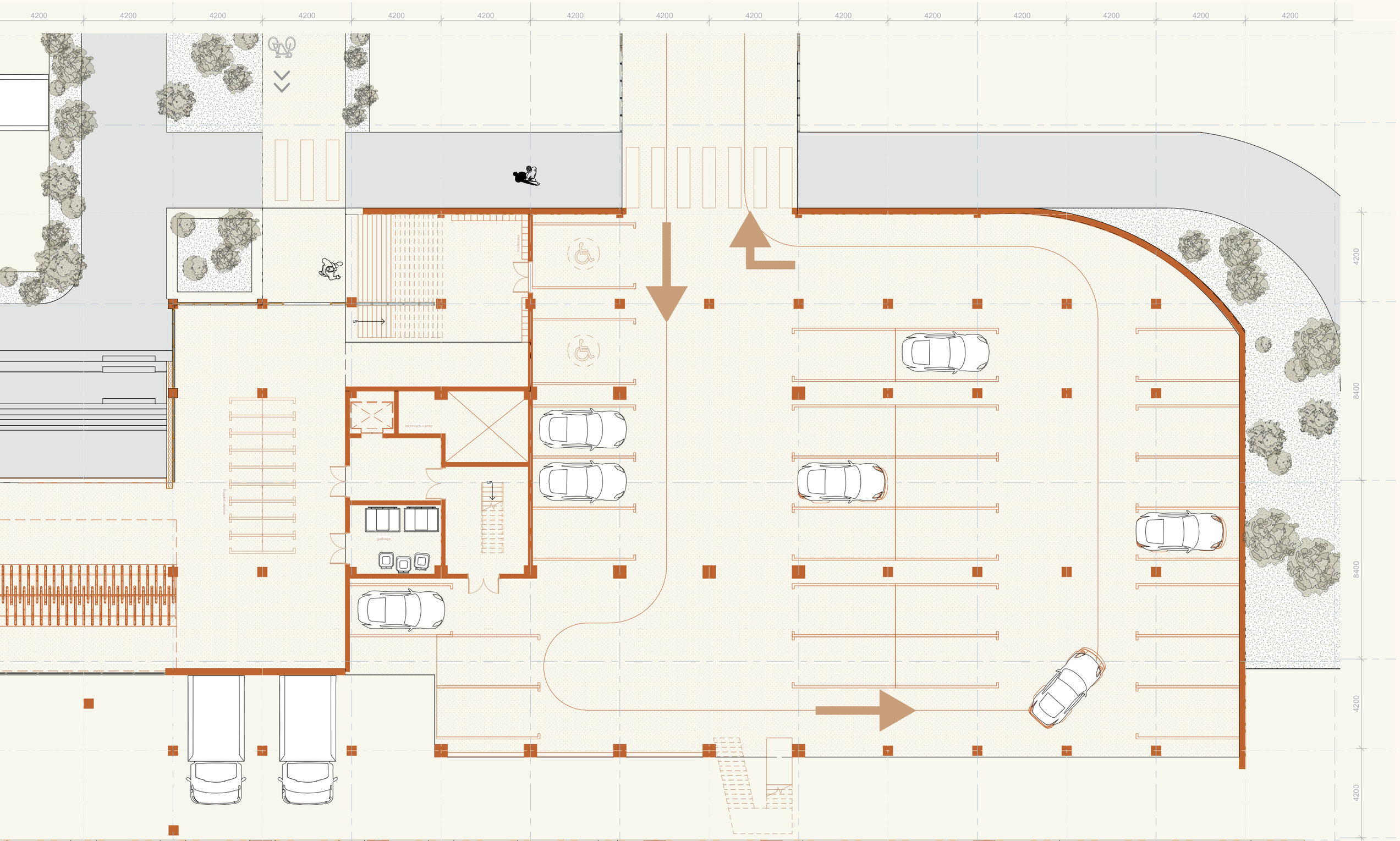
The governance model presented in this appendix is not a result of cheaper construction but built on affordability through existing infrastruture and resilience. Resilience is achieved through a system in which residents want to stay and create identity with the place. The modular module system eliminates the relocation cycle that destroys place attachment. The symbiosis between residents and industry transforms the industrial context from a risk into an asset. The cross-financing model distributes costs and revenues so that each stakeholder gains more than it risks. And the adaptive building ensures that the investment retains its value across decades of demographic, economic, and technological change.

The feedback loop: modules -> staying -> attachment -> symbiosis -> resilience -> protected investment, is the engine of the entire project. For a detailed analysis of how social cohesion develops through this process, see Appendix Social Cohesion and Target Group.

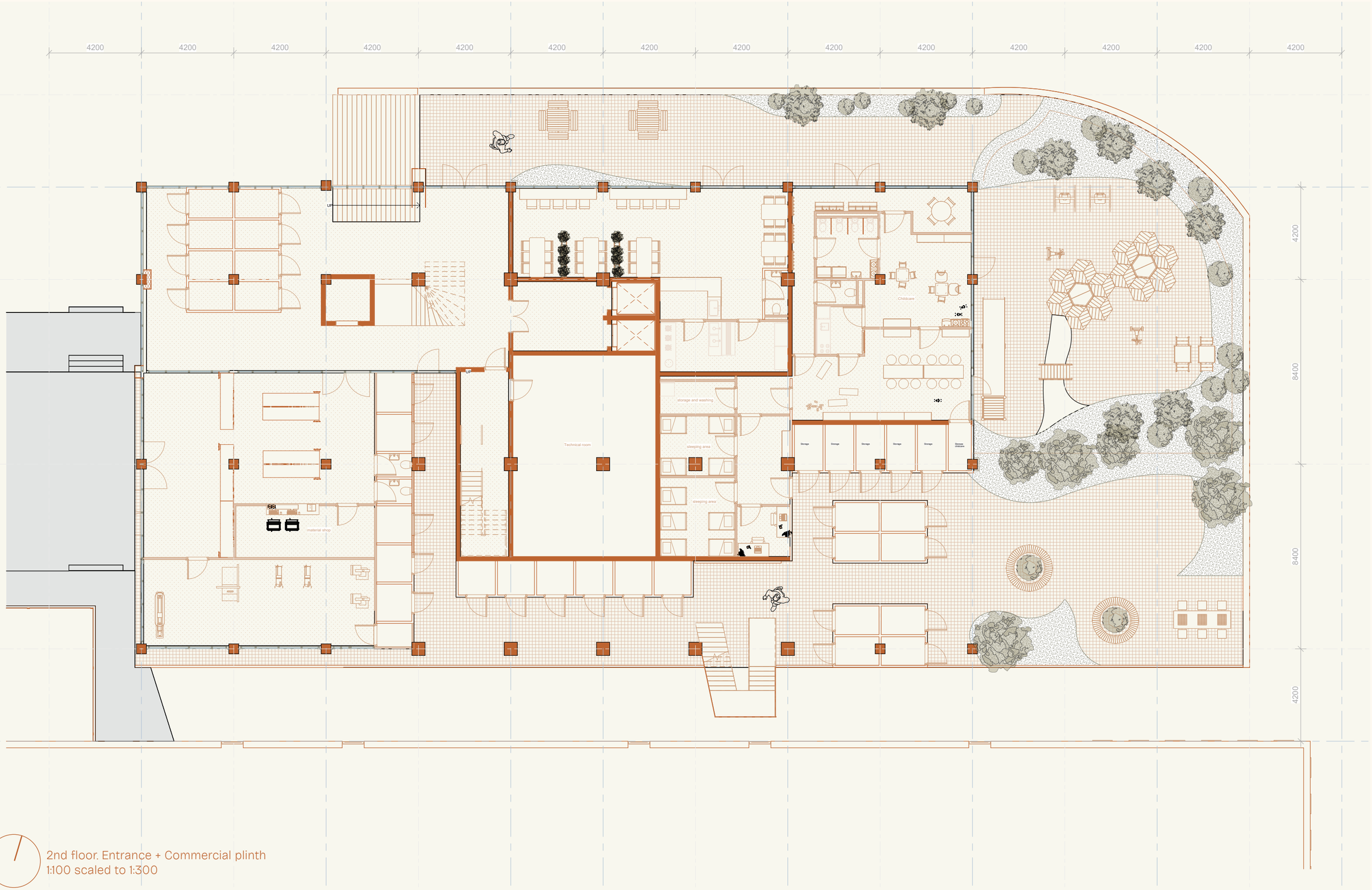
APPENDIX. 9 ARCHITECTURAL DRAWINGS



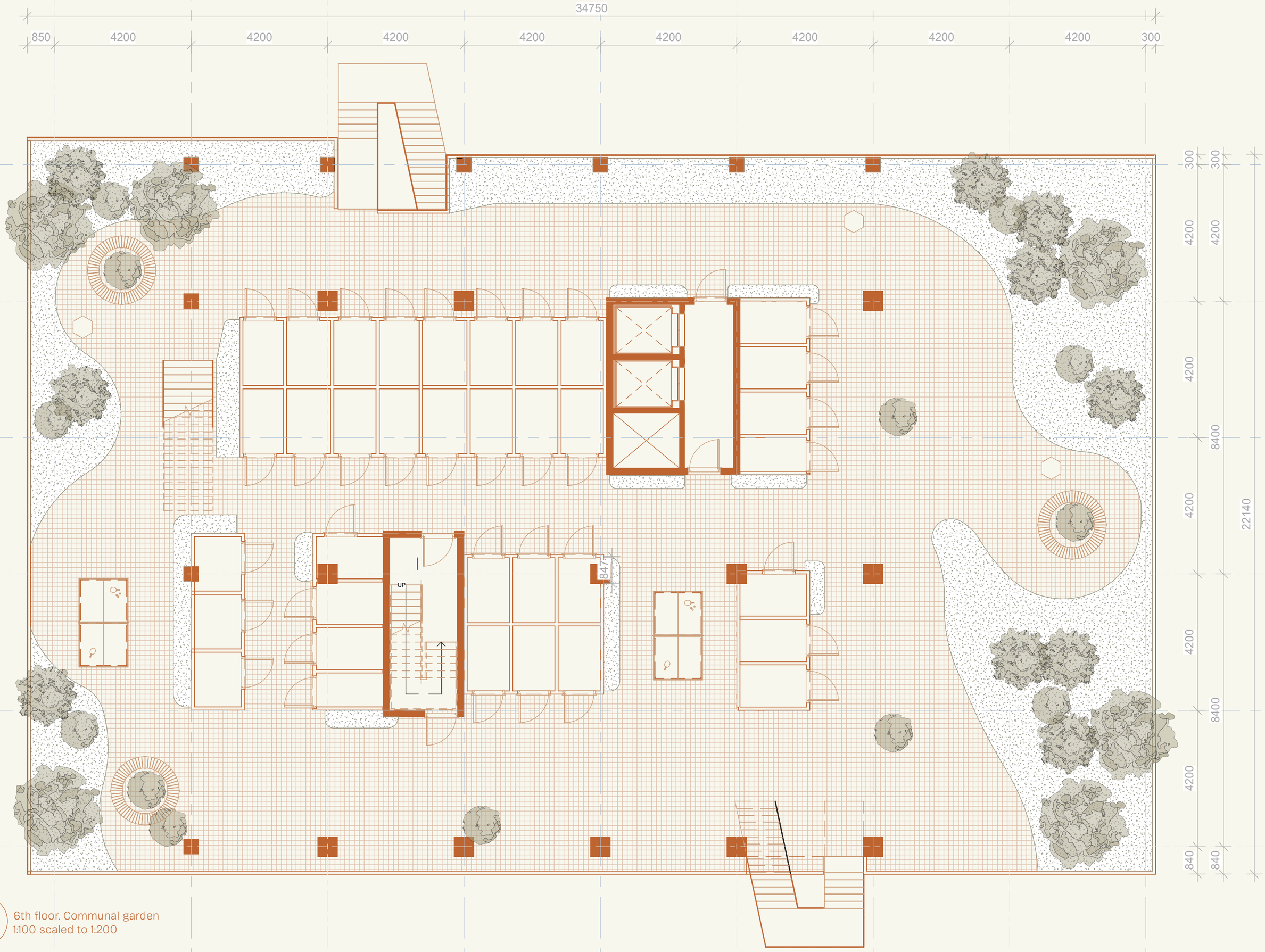




1st floor. Parking
1:100 scaled to 1:300



2nd floor. Entrance + Commercial plinth
1:100 scaled to 1:300



6th floor. Communal garden
1:100 scaled to 1:200

34740

840 4200 4200 4200 4200 4200 4200 4200 4200 4200 300

37.87 m²
128.86 m³

Extra rentable module
20.72 m²
69.20 m³

mk

44.75 m²
152.05 m³

mk

mk

52.88 m²
179.84 m³

Extra rentable module
15.42 m²
51.45 m³

59.93 m²
200.68 m³

mk

up

52 m2
168 m3
24.95 m²
84.72 m³

Extra rentable module
15.90 m²
53.60 m³

44.39 m²
148.73 m³

mk

mk

52.35 m²
175.44 m³

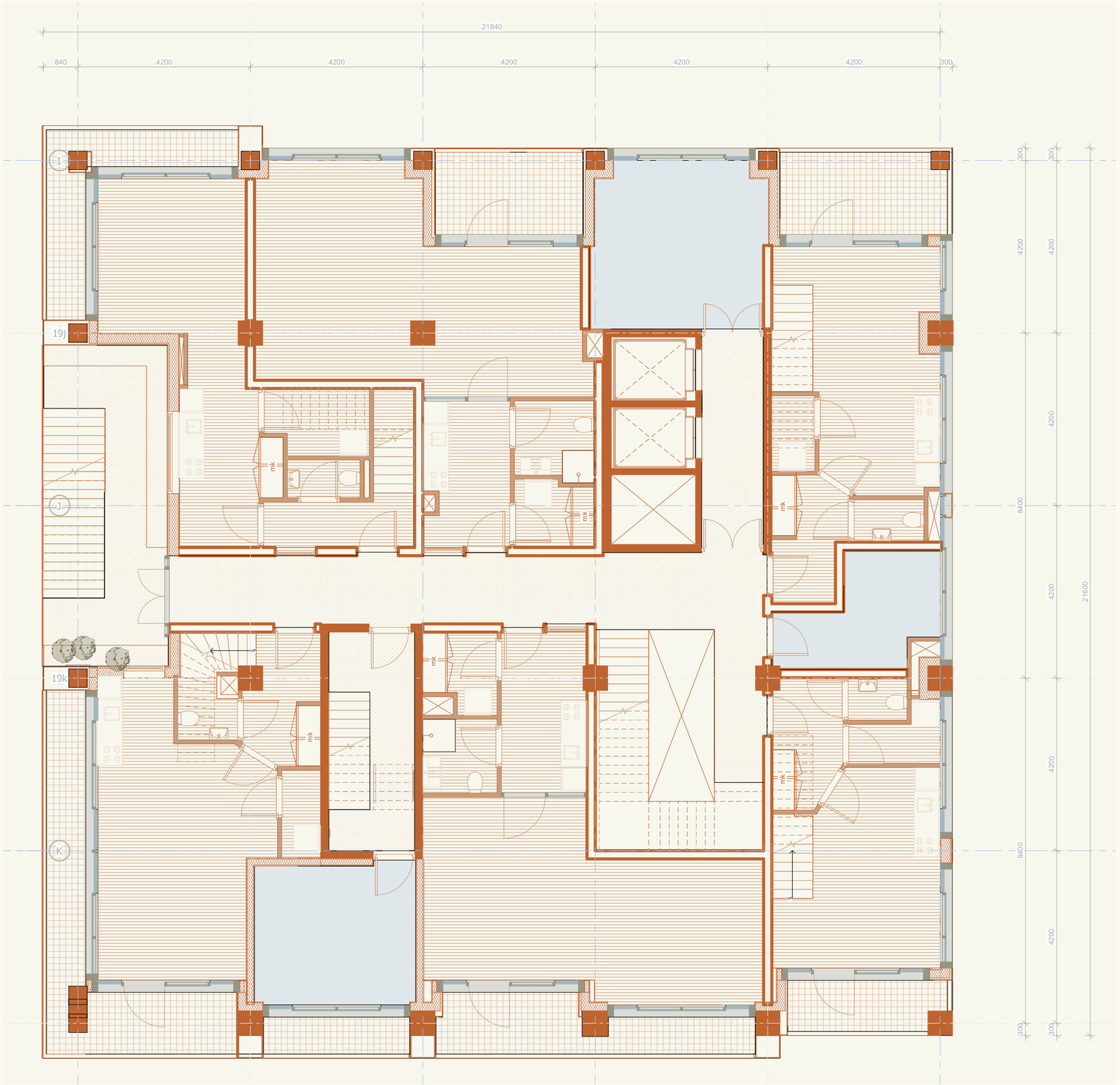
Extra rentable module
17.05 m²
56.98 m³

mk

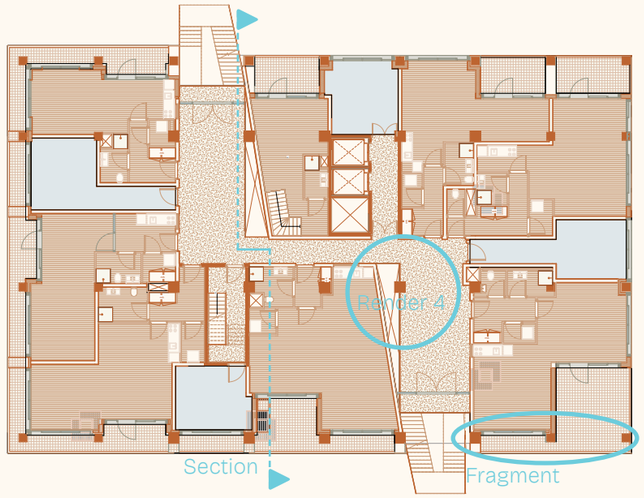
56.96 m²
190.88 m³

300 300 4200 4200 4200 9400 4200 4200 2140 840 840 8400

5th floor. Apartments
1:100 scaled to 1:200



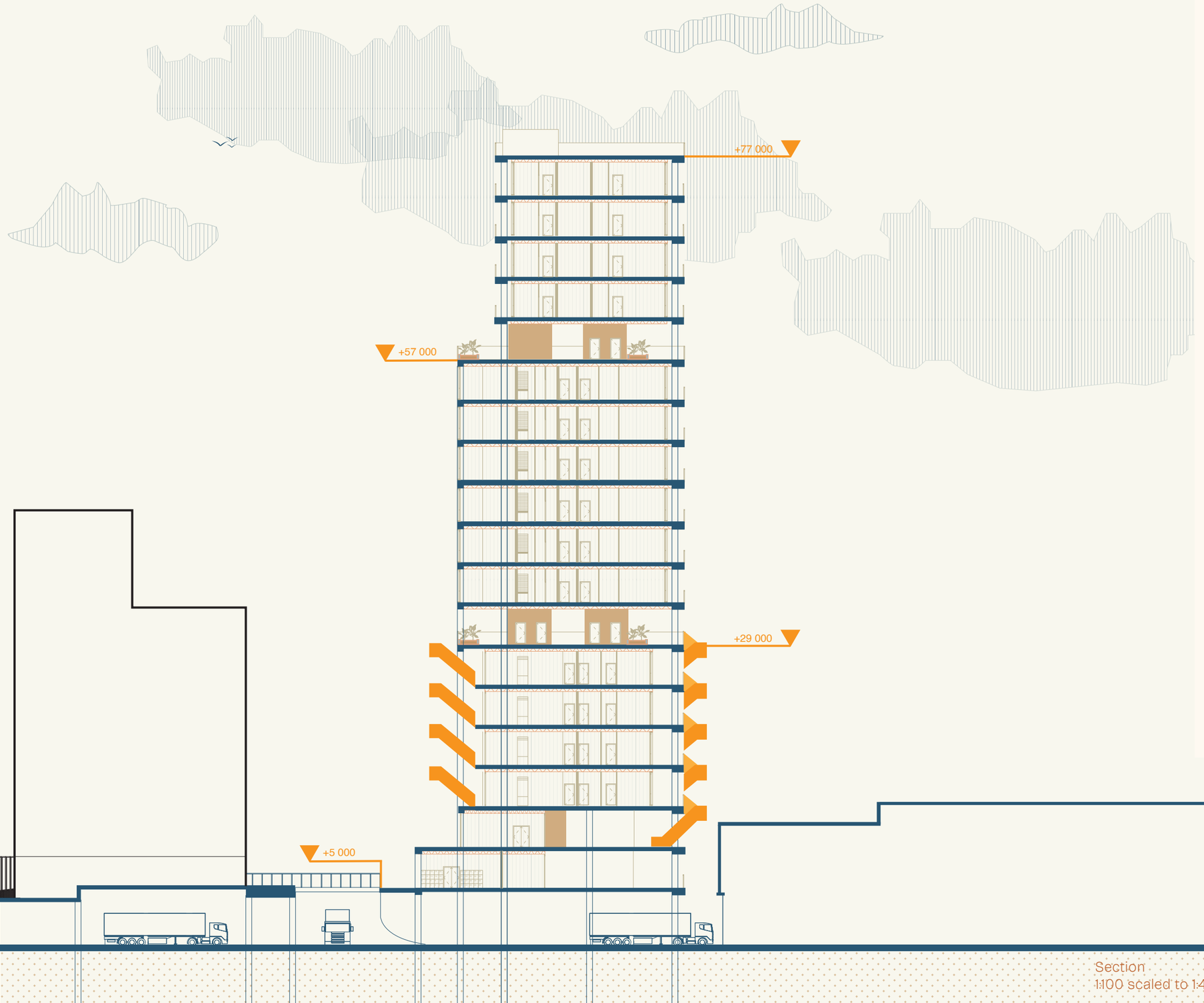
9th floor. Apartments
1:100 scaled to 1:200



Render 3

Render 2

Render 1



Section
1:100 scaled to 1:400



Render 1

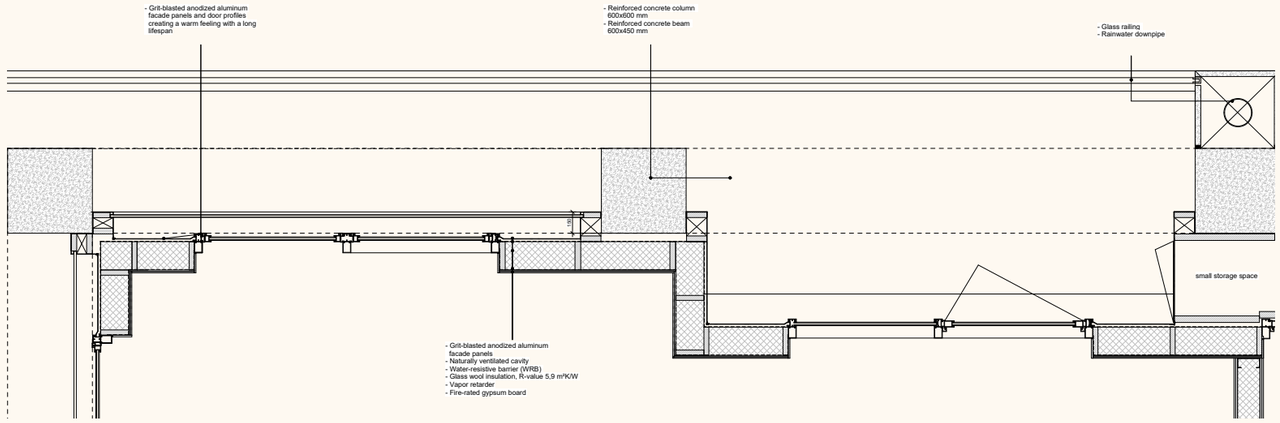
Render 2

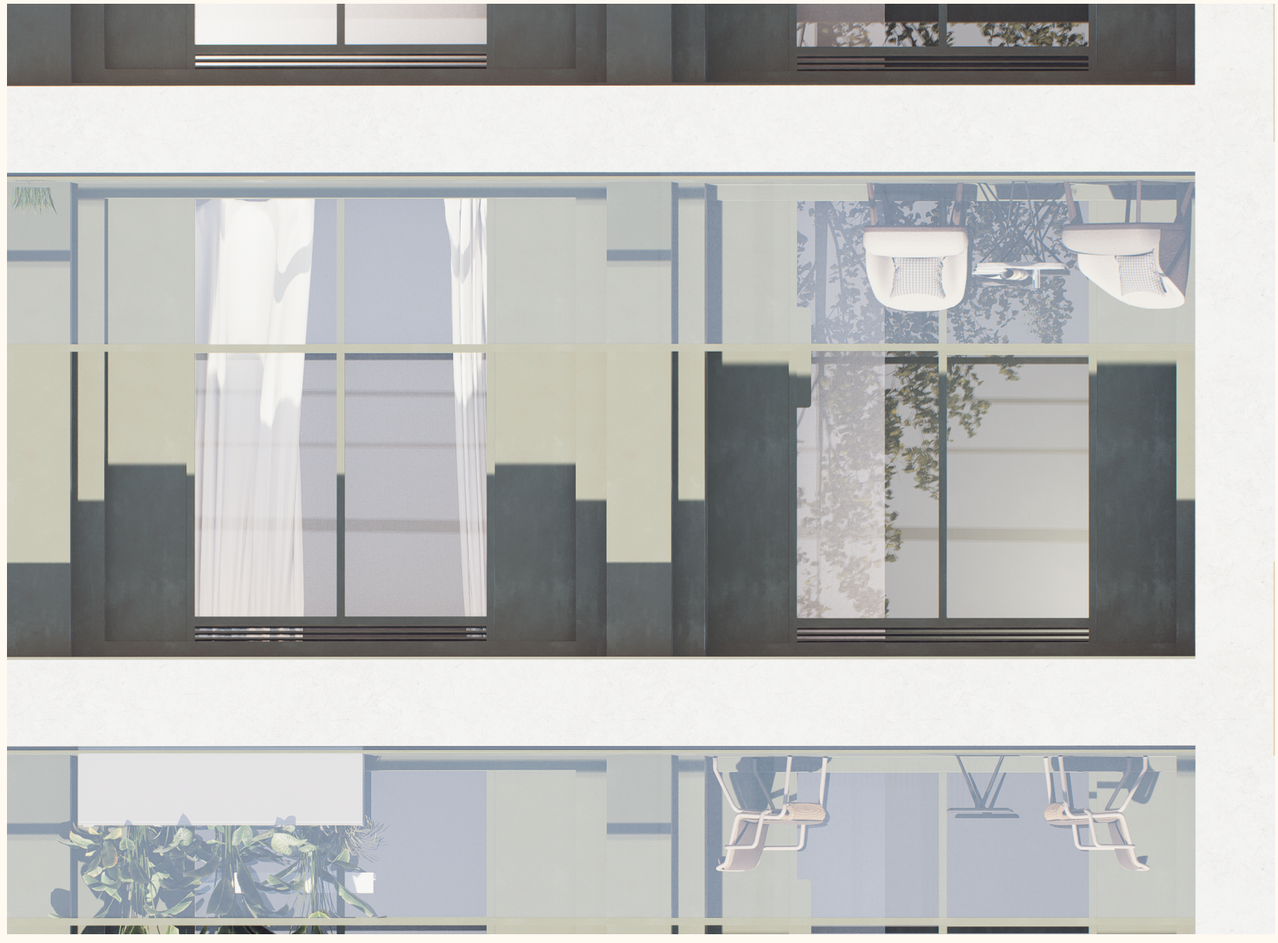


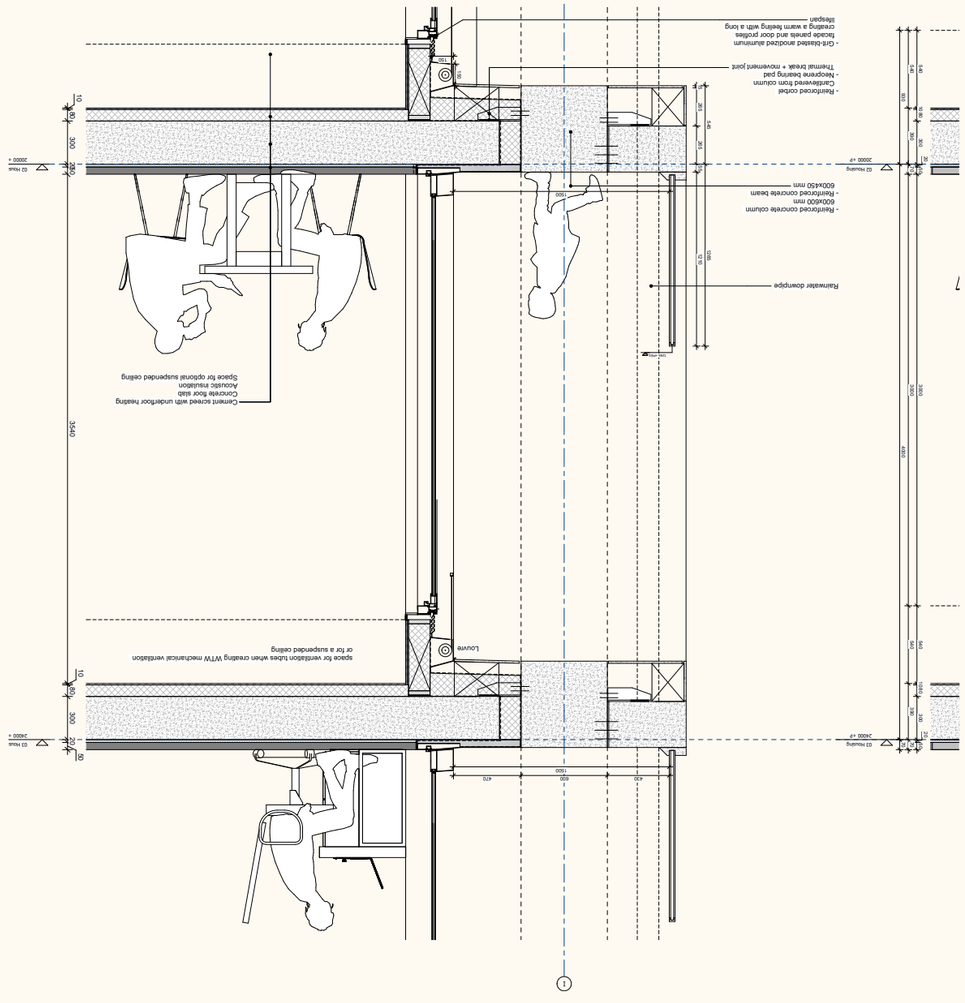
Render 3



Render 4


- Grit-blasted anodized aluminum facade panels and door profiles creating a warm feeling with a long lifespan
- Reinforced concrete column 600x600 mm
- Reinforced concrete beam 600x450 mm
- Glass railing
- Rainwater downpipe
small storage space
- Grit-blasted anodized aluminum facade panels
- Naturally ventilated cavity
- Water-resistive barrier (WRB)
- Glass wool insulation, R-value 5,9 m²K/W
- Vapor retarder
- Fire-rated gypsum board




- Reinforced corbel
Cantilevered floor column
- Neoprene bearing pad
Thermal break + movement joint
- Grit-blasted anodized aluminum facade panels and door profiles creating a warm feeling with a long lifespan
- Reinforced concrete column 600x600 mm
- Reinforced concrete beam 600x450 mm
Rainwater downpipe
Louvre
space for ventilation tubes when creating WTW mechanicsal ventilation or for a suspended ceiling
Cement screed with underfloor heating
Concrete floor slab
Acoustic insulation
Space for optional suspended ceiling

APPENDIX. 10 DATA MANAGEMENT CHECKLIST

Section A. General considerations	yes	no
1. Is the graduation project conducted as part of an internship (at a company), or as part of a research project at TU Delft? If a student's graduation project is conducted at a company or as part of a research project at the university, questions of data ownership and intellectual property rights need to be addressed in a written graduation or internship agreement before the project begins. Student and supervisor should consult the Intellectual Property Rights of Students webpage. Additional information can also be found in the Extended Personal Research Data Workflow. If applicable, complete the Confidentiality Agreement.		X
2. Does the project involve conducting (part of) the research outside the Netherlands? Students who intend to travel abroad (even to other EU countries) for study, exchange, research, internship, or graduation project purposes need to follow the Travel Safety Protocol. This includes attending a mandatory Travel Safety Training Session: see the Disclaimer.		X
3. Will the research involve processing data from humans, such as running a survey, conducting interviews or workshops, collecting data through social media or internet forums, or re-using existing datasets about humans provided by a third party? (If 'yes', see follow-up questions 4 to 13 in Checklist B.) Students who work with data from human participants must complete the next section and apply for and receive ethical approval from the Human Research Ethics Committee (HREC) before conducting the research.		X