Affordable and sustainable homes for the middle-income group in Dutch cities.

Research Plan

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Personal Information

Name: David Grünewald
Student number: 5397685

Studio

Name of studio: AR3AE100 Architectural Engineering Graduation Studio Design
tutor: Mauro Parravicini
Research tutor: Pieter Stoutjesdijk

Argumentations of choice of the studio

I am convinced that digital design and manufacturing, and the implementation of the circular economy in the construction industry, can contribute to solving climate change and the lack of affordable housing. The Architectural Engineering Graduation Studio allows me to expand my knowledge of the latest developments in these fields, and to develop an approach that helps tackling the challenges that we are facing. For me, the studio presents a unique opportunity to learn from experts who are pioneers in the new fields of digital and circular architecture. Moreover, I want to use my graduation project to solidify my position in this transitioning industry, whilst being independent from real world constraints such as hierarchy, cost coverage, and common practice. This is important to me since architects in my generation will take a central role in shaping a more sustainable future.

Keywords
#affordable housing, #value retention, #open building, #open systems, #digital production, #circularity, #sustainability, #collective private commissioning, #participation

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Content

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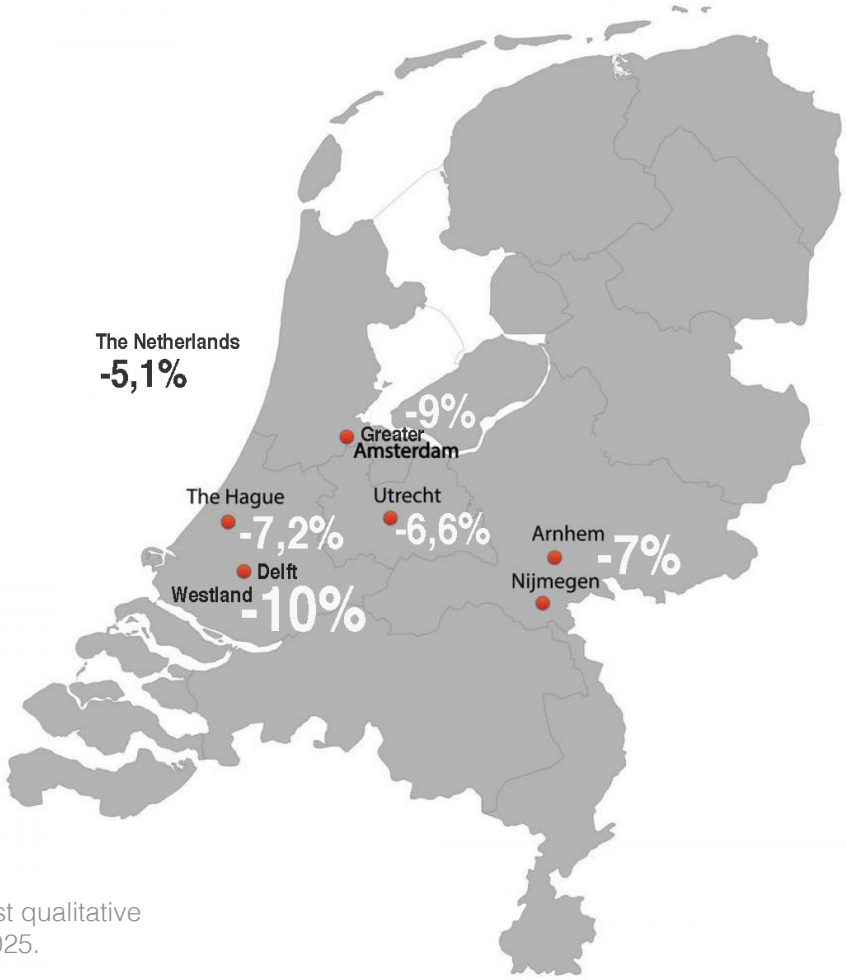
1 Introduction

This graduation project explores strategies to create affordable and sustainable residential projects. The goal is to provide approaches that tackle this issue in response to the ongoing Dutch housing crisis.
As of 2020 the Netherlands recorded a housing shortage of 331,000 homes. This tendency is estimated to rise to a shortage of 415.000 homes in 2024 and causes rental prices on the open market to skyrocket. (Capital Value, 2020) In 2021 alone, housing prices in the Netherlands rose by 18% in comparison with the previous year. (Statista, 2021) The high rental costs already left an estimated 800,000 households „financially stuck“ in 2019, meaning that it is virtually impossible for them to balance income and expenditure. (Metten, 2021) This problem is particularly visible among the 37.6% of Dutch renters who earn between 18,000 and 26,000 annually. (CBS, 2021) Members of this middle-income group often end up at the back of long waiting lists for social housing, which currently average at 9 years. (Moeys, 2021) Because of this, they are forced to look to the free market and especially in larger cities, they have difficulty finding affordable housing that meets their needs. (Rijksoverheid, a2021), (Numbeo, 2021) For this reason, it is regarded by many as indispensable that the production of houses in the price range between 750€ and 1200€ must be drastically increased. (Savills, 2021a)



Regions with the highest qualitative housing shortage by 2025.

Fig. 1

2 Problem Statement

Nevertheless, the much-demanded increase in housing production presents only a small part of the solution. The goal must be to tackle not only this crisis, but also future crises.
In recent years, one could witness a growing awareness for the importance of sustainability in the construction sector. In a 2021 survey by Savills, 55% of polled investment companies stated that they have placed significantly more emphasis on their ESG (Environment, Social, Governance) strategy in the past five years. (Savills, 2021b) In response to the ESG factors, it is anticipated that newly built housing projects are environmentally friendly and healthy, provide social cohesion and inclusivity, and follow a sustainable economic model. (Snoo, 2021) This expectation is underscored through the formulation of ambitious sustainable development goals by the Dutch government in 2015. (EEA, 2020)
In practice, however, sustainable buildings are on average still up to 10% more expensive during construction than their linear counterparts. (Rajabi, Sardrout, Kheyroddin, 2020) As the market is geared towards quick profit maximization, it is not a surprise that developers of residential projects quickly resort to cheap materials such as concrete to minimize construction costs. Additionally, floor plans are predominantly designed to be most economical whereby the individual needs of residents are secondary. Because of their seemingly unbeatable low price, drywall partitioning systems with gypsum boards are also still one of the most popular systems to divide flats. For the fact that they are difficult to dismantle without damage, they usually end up in landfills. Here they contribute significant levels of toxicity and eutrophication to the water, as well as toxicity to land. (Green Spec, 2021)
With regard to tackling the housing crisis in a future oriented way, it becomes apparent that solutions that reconcile affordability and sustainability are urgently needed. To achieve this, the price of construction (A) and disassembly (C) must be brought down, and the lifespan of the building must be increased (B) in order to alleviate the rental price as a direct consequence.

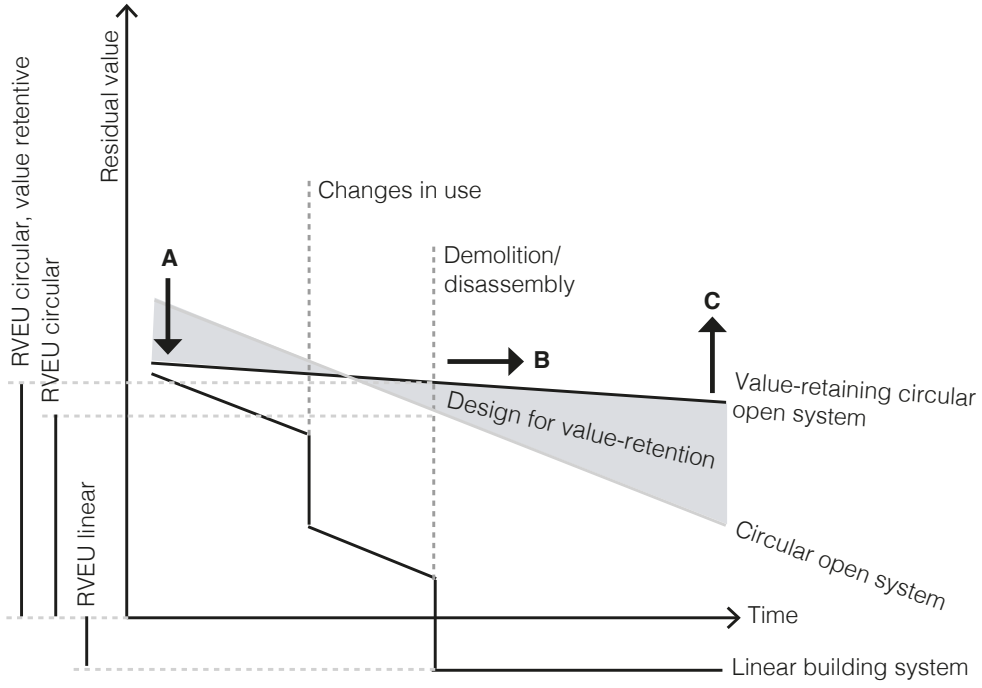


Fig. 2

Fig. 3
A schematic comparison between the value development of a linear building system, circular open system, and a value retaining circular open system.

To make a system value-retentive, different strategies can be implemented:

A Pushing the construction price down
-Reducing material-use
-Reduction of elements in components
-Easy assembly
-Communitization of functions

B Increasing the residual value of systems
-Use of high-quality materials
-Reduction of complexity
-Design for disassembly
-R-strategies

C Extend the end-of-use backwards
-Open building - resilient support structure + skin
-Adaptive, durable infill components

3 Objective

The objective of this thesis is to develop a sustainable mixed-use housing concept for the Merwedeterrein Arnhem, whose rents are affordable for middle-income earners. The design framework consists of open systems whose components can be disassembled without wear.
A robust structure and climatic envelope withstand the forces of nature and are use-open enough to host adaptive infill and installation systems. This framework will contribute to an extended lifespan, cost-efficient repairs, and the accessibility of the residual value of materials at the end-of-life of the building.
Within the economic model of cooperative private commissioning, adaptive and durable infill components such as partitioning walls and intermediate ceilings can be leased from the producer through the users. In this way, waste can be reduced and both parties benefit financially from the use of high quality components in the long term. This topic is explored further in the thematic research by mapping out design strategies for value retaining infill components.
To meet circularity goals, a database of all building elements is used, which can be accessed via QR-codes during construction and dismantling. For each element, a post-use scenario is worked out with the help of the circular R-strategies. (Ellen McArthur Foundation, 2019)
In the specific case of Arnhem, around 5% of the population is currently over 75 years old. This percentage is estimated to increase to 8% by 2026 and to 14% by 2050. (Gemeente Arnhem, 2021) Therefore, special emphasis must be placed on the inclusiveness of older people. In addition to an increased attention to accessibility and soundproofing, areas such as a vegetable garden, an open workshop or hamam must be created, where communication with other residents can take place, thus strengthening the entire house community.
Some of these functions could even support the project financially. Either directly through revenue from business, or by communitizing spaces like kitchens or dining rooms, with spacious, light filled communal areas that can host these functions instead of the private apartment.
To create a healthy building, the focus is on bright, spacious rooms that invite residents to adapt them to their own needs. A pleasant indoor climate must be created by using high-quality materials and avoiding the use of adhesives. The air quality should be excellent, thanks to lots of greenery and a passive climate concept.

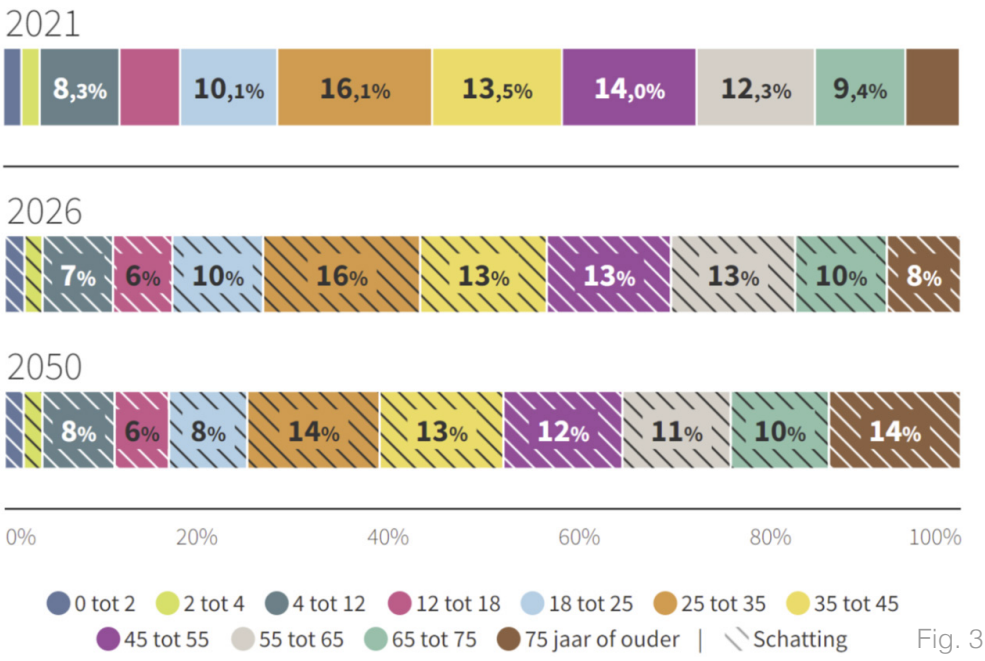


Fig. 3

4 Design Question

» *How could the design reconcile affordable rents with the desire of middle-income earners for sustainable living within an environmentally friendly, socially inclusive, healthy, and aesthetically pleasing architecture in the central city location of Arnhem Merwedeterrein?* «

D1 What are the spatial requirements of the users? What changes may occur in their lives that affect their spatial requirements?

D2 How can social cohesion and inclusivity be strenghtened through the communitization of functions? What functions can be communitized?

D3 What measures have to be taken to assure a vital living environment through the project, despite high density? How many people can live in my building?

D4 How can (CPC) collective private comissioning be applied as a sustainable economic business model to the project?

D5 What spatial developments will take place in the sourrounding area in the coming years? How can the open systems respond to them?

D6 Which mixed-use applications make sense in relation to public functions in the surrounding infrastructure? What additional uses can be integrated into the building in the context of mixed use with regard to users?

D7 What are the most sustainable, durable, healthy, and affordable building materials that can be used for structure, skin, and infill?

D8 Which open systems for the skin and structure are already on the (Dutch) market and how can they be integrated? Can these systems be improved?

D9 How could a value-retaining open system in the infill of an open building look like?

D10 How can the building be designed to aesthetically fit into its environment?

5 Relevance

As outlined in the Problem Statement, solutions that reconcile affordability and sustainability are urgently needed, in order to respond to the current housing crisis in a future oriented way.The graduation project as a whole will showcase a possible approach to bringing those two points together.

The focal point lies on waste reduction through design for disassembly in circular infill systems. Even in ambitious open buildings such as ‚Stories' by Olaf Gipser Architects in Amsterdam Buiksloterham, drywall partitioning systems from gypsum boards are still used today. This supposedly flexible solution cannot be disassembled without wear and is usually landfilled. In the thematic research paper design strategies for high quality, sustainable and affordable infill systems, will be explored.

5 Thematic research question

» *What design strategies can be implemented to create circular infill components that retain value?* «

The result of this examination is a catalog of design strategies for value-retaining circular infill components in open systems in a Dutch context. These can be partitioning walls and intermediate ceilings. By designing high quality infill components that can be easily disassembled, the inherent value of products is made accessible. This would create an incentive not to demolish, but to reuse products instead, and could ultimately lead to a reduction in waste and carbon emissions.

R1 What is the current state of the art in design strategies for circular and reversible buildings? What are design strategies for circular infill components?

R2 How can residual value models of other industries be applied to circular infill systems.

R3 What are the parameters that influence the residual value of infill components? What are parameters that can be influenced by the design?

R4 What requirements are posed to infill components in a Dutch context?

R5 How can a tool for designers be created, that helps them to design for residual value retention?

7 Methodologies

Computerized design and manufacturing is used to make sure the design is data-informed, the construction costs are reduced, and the planning time for future adaptations of the same design framework is reduced.
Through the parametrization of the design process, changes can be iteratively made at all scales.
To increase the durability of the building, a data-informed climatic optimization is performed in the first design stage at macro level. For this, the Grasshopper plugins Ladybug Tools and Galapagos are used. The LEED framework serves as the basis for the analyses. In addition, the zoning tool Space Syntax is used to simulate different usage scenarios. In this way, LCC (Life Cycle Costs) can be reduced during early planning and a sick buiding syndrome can be prevented.
At the meso and micro levels the focus is on material savings and design for disassembly. In order to make construction and disassembly cheaper and more sustainable, one can draw inspiration from traditional European or Japanese plug-in timber connections. The potential lies in the fact that today, cnc milling can produce complex shapes fast and precisely. These can have the same quality as Elements from timber buildings that have aged hundreds of years. This saves human labour and reduces the number of elements in components. It also eliminates the need for any glue or screw connections, which reduces wear and tear on materials.

	Method	Field research/ prototy-ping	Literature/ data ana-lysis	Interviews	Reference projects/ products
D1	User group analysis of the middle-income group in Arnhem.	■	■	■	
D2	Analysis of projects that explore new forms of living together. Reading into inclusivity in residential buildings.		■		■
D3	Studying the perceived qualitative vitality of Arnhems districts.What exterior factors lead to an aesthetically and socially welcoming place?	■		■	
D4	How can CPC be used as a business model to withdraw property from the free sector and keep rental prices stable?		■	■	■
D5	Analyzing the cities vision for the location. Analyzing open systems and how they can provide the most flexibility.		■		■
D6	Doing field research and data analysis on what functions already exist in the sourrounding area. Finding out what mixed-use functions would make sense for the users by means of interviews, data analysis, and reference projects.	■	■	■	■
D7	Analysis of building material properties and requirements.	■	■		■
D8	Which open systems are already on the (Dutch) market and how can they be integrated? Can these systems be improved?	■	■	■	■
D9	Drawing conclusions from the thematic research. Designing an infill system.	■	■		■
D10	Analyzing the appearance of the built environment at Arnhem Merwe-deterrein. Drawing conclusions for the aesthetics of the building.	■	■		
R1	Literature research on design strategies for circular and reversible building, and design strategies for circular infill components.		■		
R2	Literature research on residual value models across industries.		■		
R3	Defining parameters that influence the residual value of infill compo-nents. For example raw material price, production costs, quality of connections, demountability/ releasability, transport, maintenance, and repair costs. Defining parameters that can be influenced by the design of products.		■		■
R4	Analyzing the requirements of infill components in a Dutch context (sound insulation, thermal insulation, fire resistance, load capacity,...) and defining what the specific infill components are.		■		
R5	Finding case studies. Critically analyzing circular building products (infill) with the factors for residual value retainment in mind. Determin-ing positive and negative points. Creating a “matrix of design solu-tions” that shows aspects in the design of circular infill products that lead to high residual value retention.	■	■		■

7 Planning

Week	Date	Phase	Important	Design	Thematic research
1.10	1-7 Nov			D1 D2 D3 D5 D8 D6 D10 Concept design (**Macro**: Urban context, volumetric)	R2 R1 R3 R4 R6 R5 Developing the research paper
2.1	8-14				
2.2	15-21		Registration P2		
2.3	22-28				
2.4	29-5 Dec				
2.5	6-12	P2			
2.6	13-19			D7	RP draft
2.7	20-26		Research paper draft		
2.8	10-16 Jan			D8	Finalizing RP
2.9	17-23			P2 preparation	
2.10	24-30		P2 presentation Research paper		
3.1	07-13 Feb			Integrating open-systems	Meso: Open systems, users
3.2	14-20			D9	
3.3	21-27			**DESIGN Methods**: Models (physical, , virtual, parametric), drawings, diagrams, etc.	
3.4	28-6 Mar			D10	
3.5	7-13	P3		Design of a value-retaining infill system	
3.6	14-20				
3.7	21-27				
3.8	28-3 Apr				
3.9	4-10			P3 prep.	
3.10	11-17		P3 presentation		
4.1	18-24			Final drawings,visuali-zations,reflection paper	Micro: Details, production
4.2	25-1 May				
4.3	2-8	P4		Detailing	
4.4	9-15				
4.5	16-22			P4 prep. Physical prototyping	
4.6	23-29		P4 presentation		
4.7	30-5 Jun				
4.8	6-12				
4.9	13-19	P5		P5 prep.	
4.10	20-26		P5 presentation		

* Creating a plan for the weekly research every Thursday afternoon after the design tutoring.
* Record all research results of the design sub-questions in a design logbook as source of inspiration for the design.

8 Literature

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- This list will be extended during research -