# Housing after Housing

*Design strategies for resilient housing, focusing on adaptability concepts in modern architecture in wooden buildings*


CHALMERS
UNIVERSITY OF TECHNOLOGY

**Raquel Domingues**

Chalmers University of Technology
Department of Architecture and Civil Engineering
Gothenburg
Sweden
Examiner: Ola Nylander
Supervisor: Anna Braide

# Housing after Housing

***Design strategies for resilient housing, focusing on adaptability concepts in modern architecture in wooden buildings***


CHALMERS
UNIVERSITY OF TECHNOLOGY

**Raquel Domingues**
raquelafonsodomingues@gmail.com

Chalmers University of Technology
Department of Architecture and Civil Engineering
Master's thesis in Architecture and Planning Beyond Sustainability (MPDSD)

Examiner: Ola Nylander
Supervisor: Anna Braide

Housing Direction
June 2022

# Acknowledgements

Those who contributed to this Master Thesis are acknowledged as follows:

Thanks to Anna Braide for immense support and determination and for providing profound knowledge and experience in helping develop ideas and write this thesis.

Thanks to Ola Nylander for critical thinking and valued critique throughout the process.

Thanks to Peter Selberg and Tim Jonsson from Riksbyggen for supporting this thesis, sharing information, and inspiring my tenacity to achieve the best for this research.

Thanks to Kaj Granath for providing clarity of thought, curiosity, and guidance in preparing the first ideas.

Thanks to Kajsa Crona for sparking my interest in the case study project and for guidance in the first questions.

Thanks to Elina Scharn and Catrine Andersson from Sweco architects for being open to my ideas and sharing their expertise.

Thanks to Tabita Nilsson and Per Lundström for helping me turn my ideas into an actual model in the Workshop.

Thanks to my colleagues and friends for being supportive and listening in times of need. Appreciation to Claudia, who wrote her master's thesis simultaneously and formed our "non-official group work".

Thanks to my family for believing in me always, especially Bruno and my dear children, Henrique and João.

To all above and those who helped contribute to this thesis, thank you for showing again and again that, with (infinite) kindness, (shared) knowledge, (immense) support, and (loving) care, anyone can accomplish anything they set out to do!

*Obrigada.*



# Student Background

**Raquel Domingues, Arkitekt SAR/MSA**
**raquelafonsodomingues@gmail.com**
**+46 793395233**
**Gothenburg, Sweden**

Portuguese architect from Lisbon; in 2018 moved to Gothenburg.

Master's in architecture, with specialization in Interior Architecture and Rehabilitation of Buildings from the Technical University of Lisbon. With several years of experience working on all scales and on international projects.

I am currently attending the Master's in Architecture and Planning Beyond Sustainability at Chalmers University. With this Master's, I am looking to improve my skillset and architectural practice into a more inclusive and conscious approach to sustainability. I also want to learn more about Swedish architecture.

**Previous relevant courses:**

Design and Planning for Social Inclusion
Beyond Sustainability
Emergent Media & Representation
Sustainable Architectural Design
Social Ecological Urbanism (Spatial Morphology)

# Housing after Housing

***Design strategies for resilient housing, focusing on adaptability concepts in modern architecture in wooden buildings***

***"Dwelling: a volatile, continuous and temporal employment of a certain space that we call home."***
***(Braide, 2019)***


**Figure 01.** Mapping the Preconditions for this Masther thesis.

## Abstract


Today, demographic changes require that the apartments we design need to be able to meet changing living requirements, both for today's dwelling families and for those to come. With adaptable housing, a dwelling can respond to changing needs and enable families to remain in their apartments when such circumstances arise.

In line with the building industry's current direction toward sustainable solutions with wooden construction, this master thesis explores wooden architecture as a precondition for qualitative and adaptable dwellings in multi-family residential buildings.

As part of a collaboration with housing developer Riksbyggen and Sweco architects, alternative apartment floor plans are being explored in *"Gibraltarvallen"* to assess how wooden architecture and design strategies for adaptable space can be combined to create qualitative and valuable apartment spaces.

The current thesis examines the following research questions against this background:

*- How can adaptability strategies develop and create spatially optimal living environments that are resilient and best serve people?*
*- In what way can apartments in a multifamily residential building be constructed using cross-laminated wood and designed to meet the requirements of adaptable space?*

The research methods and processes involve *Research For* and *Through Design*. *Research for Design* began as a theoretical investigation and was vital to gain empiric knowledge and get closer to actual design applications. *Research Through Design* used the theories reflected in *Research For Design* as part of the design process to link theory to practice and develop knowledge of design practices.

The case study *"Gibraltarvallen"* will serve as a starting point for investigating the adaptability concepts most suitable for wooden structures.

The preconditions for this thesis are the theoretical framework based on adaptability concepts, the prerequisites for design in wooden construction and the qualities of both the housing developer and household/ user, focusing on the spatial capacity and use (time).

The results will define a set of guidelines for creating a typologies concept model, emphasizing the adaptability in wooden construction and how to create an adaptive concept to be used in future wooden housing projects.

This thesis demonstrates that implementing adaptability strategies can affect the spatial qualities of the dwelling and the social attributes of the household. This will lead to increased autonomy and resilience in overcoming challenges that only time will inform.



**Keywords: Dwelling, Adaptability, Usability, Resilient Living Solutions, Multi-family Housing, Modern Wooden Houses.**

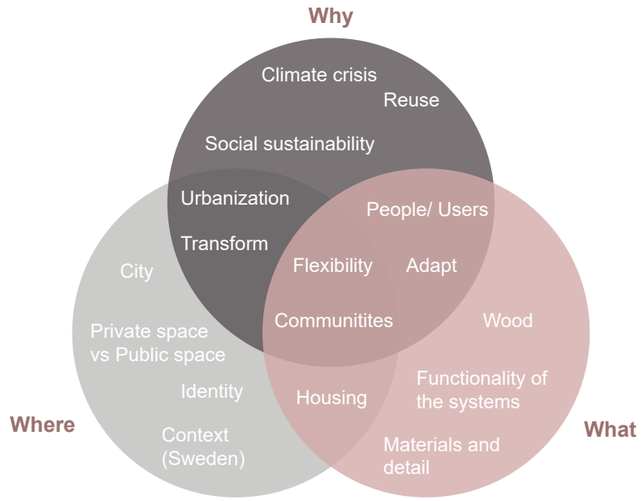




**Figure 02.** Venn diagram showing the relationship of "Topic Hierarchy" sets.

# Glossary

**Adaptability vs Flexibility**
Different authors define Flexibility and Adaptability in different ways, leading to confusion.
Adaptability considers when buildings are capable of different social uses, and Flexibility is when buildings are capable of physical arrangements. (Groák, 1992)
This thesis will use the term adaptable housing instead of flexible housing.

**BIM**
Building information modelling (BIM) involves the generation and management of digital representations of the physical and functional characteristics of places with the aid of various tools and technologies.
By developing an intelligent model, BIM integrates structured, multi-disciplinary data, permitting a digital representation during its lifecycle, from design and planning through construction and operation.

**Bostadsrätt**
Tenant owned apartment.

**CAD**
The term computer-assisted design (CAD) refers to the use of computers to create graphical representations of physical objects to facilitate the design process.
CAD makes it is possible to produce 2D or 3D representations and animations and other presentational materials and add additional information such as dimensions, descriptions of components, and references to specifications.

**Carbon dioxide**
Carbon dioxide ($CO_2$) is emitted by all aerobic organisms (plants, animals, fungi, and most microorganisms) during respiration. Carbon dioxide leaves the body in exhaled air, a waste product formed during cellular respiration. The process of photosynthesis enables plants to convert carbon dioxide and water into sugars, which are used in their metabolism or stored in their cells, most commonly converting into cellulose, starch or fat. (https://www.swedishwood.com/wood-facts/about-wood/glossary)

**CLT (KLT)**
In Cross Laminated Timber, wood boards are glued together in layers perpendicular to each other. (Gustafsson, Eriksson, Engström, Wik, & Serrano, 2012)
Panels are constructed by stacking and glueing layers of lumber (usually three, five, or seven) at 90-degree angles, which offers structural rigidity across both directions.
(Mass Timber Design Manual, 2022)

**Construction timber**
Wood intended for carrying loads within a building. Construction timber is commonly spruce, and pine is used only when pressure-treated construction timbers are required, as spruce timber is difficult to impregnate.

**Creative Dweller**
Based on the notion that people can design their ways of living using typologically flexible buildings with self-organizing characteristics depending on their needs or economic circumstances. As a result, they can accomplish so much more than is possible in ordinary housing today. (Krokfors, 2017)

**Dwelling**
In the Oxford Advanced Learner's Dictionary:
Dwelling noun
A house, flat, where a person lives.

**Glued-Laminated Timber (Glulam)**
Glulam consists of individual wood laminations (dimension lumber), selected, and positioned according to their performance characteristics, then bonded with a durable, moisture-resistant adhesive. It is common to arrange layers parallel to the length of members, which can be adapted to produce straight, curved, arched, or tapered elements.
Due to its long history and wide application, glulam is one of the oldest and most widely used mass timber products. In addition to buildings, it can be used to construct major load-bearing structures, such as bridges, canopies, and pavilions. It has applications for long-span structures and custom curvilinear shapes, and it combines well with hybrid assemblies. (Mass Timber Design Manual, 2022)

**Greenhouse gases**
Atmospheric greenhouse gases have been implicated in global warming and climatic change. Carbon dioxide ($CO_2$), methane ($CH_4$), and nitrous oxide ($N_2O$) are the primary greenhouse gases. Other potent but less prevalent GHGs are hydrofluorocarbons (HFCs), perfluorocarbons (PFCs), and sulfur hexafluoride ($SF_6$). (UNEP, 2021)

**Household**
A social unit is composed of those living together in the same dwelling. A group of people who lives together under the same roof, forming a family.



**Interchangeable**
In the Oxford Advanced Learner's Dictionary:
interchangeable adjective
that can be exchanged, especially without affecting the way in which something works.

**IPCC**
The Intergovernmental Panel on Climate Change (IPCC) is the United Nations body for assessing the science related to climate change. (https://www.ipcc.ch/, 2022)

**LVL**
Laminated veneer lumber typically consists of an odd number of veneers bonded together, with all veneers aligned in the grain's direction used for load-bearing beams. (https://www.swedishwood.com/wood-facts/about-wood/glossary)

**Modularity**
A feature of all living systems is their modularity. Resilience thinking and systems thinking both emphasize modularity. Multiple self-sufficient components function together as a system, and it is possible to separate and combine components of the system and replace non-functioning ones without disrupting the system as a whole. (Krokfors, 2017)

**Resilient vs Sustainable**
Sustainability and sustainable will not be used very often. The terms themselves imply that something needs to be sustained, so "resilient" is used instead.

**Resilience**
Resilience refers to a system's ability to cope with change.
In the Oxford Advanced Learner's Dictionary:
resilient adjective
able to recover quickly after something unpleasant such as shock, injury, etc.

**RISE**
Sweden's RISE Research Institutes of Sweden is a research institute and innovation partner that collaborates internationally with industry, academia, and the public sector.

**Room**
In space, a room is a divisible unit divided into parts.

**Space Syntax**
Space syntax is the theory and methodology for studying space and spatial configurations. Describes how to arrange spatial elements within a spatial configuration.

**Self-organizing**
Adapting to a changing environment is the nature of any self-organizing complex system. Consequently, they are relatively insensitive to perturbations or errors and have a solid ability to restore themselves, unlike most human-designed systems. (Krokfors 2017)

**Type**
Type is a holistic understanding of an architectural entity in the context of architecture; it illustrates a particular configuration and architecture, and the meanings people associate with it. The parts of a type cannot dismantle to understand it and comprise continual renewal as part of the concept. (Krokfors, 2017)

**Typological flexibility**
A characteristic that permits unpredictable use of a building in a self-organizing manner and promotes the emergence of new socio-spatial contexts. It refers to the idea of a building and its spatial configuration in terms of the concept of type. (Krokfors, 2017)

**Typology**
Typology is the study of types, and this defines how a dwelling or building creates from a specific type and its spatial arrangement in architectural discourse.

**Wooden Houses (Trähus)**
A wooden house is defined as having most of the structural system made of wood, regardless of the material of the facade, it is still considered a wooden house. (Gustafsson, Eriksson, Engström, Wik, & Serrano, 2012)

# Reading Instructions

**Chapter 1** introduces the background, subject and purpose of this Master's thesis and outlines its relevance to the profession of architecture and resilience. The chapter presents the research questions and completes them by presenting a diagram of the research methodological approach.

**Chapter 2** discusses the theoretical framework that supports this thesis, explaining why it is vital to rethink our notions of projects and present a new perspective when designing dwellings for the future, looking for a more resilient and long-term perspective. Outlines the prerequisites for wood construction and presents reference projects that have already been challenging notions of adaptability concepts and theories.

**Chapter 3** presents the case study and the context for the design proposal, analyses the existing proposal and a revised proposal focusing on adaptable space through design and space syntax analysis. Develop and present the final design proposal and test the time-space model proposing different scenarios for different typologies (typologies concept model).

Finally, **Chapter 4** reflects on the research, theory, and design conclusions drawn. It summarises what was concluded and the findings from this thesis.



# Content

# Chapter 1 - Introduction

***"The underlying hypothesis is that the climate emergency presents a threat to some of the principles on which architecture has been founded, and so any response to the emergency may affect reformulations of the role, practices, and values of the profession. The title 'Architecture after Architecture', is knowingly provocative, suggesting as it does that the climate emergency makes current notions and values of architecture at best fragile, at worst unviable and so redundant. The provocation is meant to reflect the urgency of the environmental crisis, and with it the pressing need to consider radical alternatives to architectural practice as it is presently constituted. If, as many argue, the emergency demands systemic changes to dominant economic models, social structures and behaviours, then what are the implications of these changes for the architectural profession?"***
***(Till, 2020)***

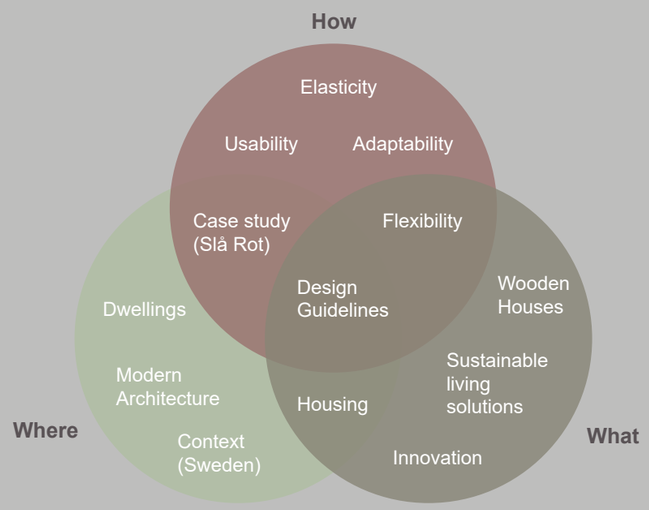



**Figure 03.** Venn diagram showing the "Master Thesis scope" relation of sets.



## Background

Housing after Housing is based on the provocative title "architecture after architecture" from a lecture by Jeremy Till in 2020. The author reflects on how modern notions of architecture are vulnerable and outdated due to climate emergencies. He discusses the argument that climate changes disrupt some of the fundamental ideas underlying modern architecture, regarding the need for changing architectural practice and production in response to the environmental crisis.

Adaptive housing can help families stay in their apartments even when different needs change over time. Providing them with alternatives so they can use the space they have available, in the way that suits them the most and that only they know how to use their space best. For this thesis, the household design takes into consideration long-term perspectives.

In a dramatically changing world, we see an increase in people living in cities. In the 20th century, 10% of the world's population lived in cities and continuing at this pace, it is expected to become 75% in 2050. Furthermore, with limited natural resources, the world is looking for environmental solutions for the construction sector, representing a significant part of greenhouse gas emissions globally (30-40%). (https://www.un.org/sustainabledevelopment/cities) (UNEP, 2021)

The Intergovernmental Panel on Climate Change (IPCC) report in 2022 states that between 2010 and 2019, greenhouse gas emissions reached their highest levels in human history. Limiting global warming to 1.5 degrees Celsius is not achievable unless there is a radical and immediate reduction in emissions across all sectors. Moreover, there are numerous options available now in all sectors that could at least halve greenhouse gas emissions by 2030, and "Buildings" are one of the seven sectors cited. (IPCC, 2022)

Architects face a significant challenge and need to change how architecture approaches Housing. Dealing with diversity and changes in searching for new and different uses is necessary. A housing project should not be built only for a specific purpose or for a specific time but instead to meet the different needs of future residents unknown to us.

As houses continue to develop and produce, they will be more rational and compact, disregarding social aspects. Moreover, the amount of space is reduced in exterior and interior dwellings, especially in urban areas. (https://www.scb.se)

There is a low or no chance of making a dwelling adaptable when an owner's life situation or family composition changes. The alternative will be to move to another house.

Adaptability concepts, such as flexibility, are concepts that I want to explore in Housing, mainly how to design dwellings where the user's needs may change over time. In addition, it seems very interesting to learn more about wood as a primary building material and examine how wood can be used in future Housing. This study investigates the topic of replication through the design of different households.

In the case study project, the use of wooden construction and careful design of the floor plans allows for greater flexibility, since cross-laminated wood and glulam provide a much lighter construction than a concrete frame.

***"The evidence is clear: The time for action is now"***
***(IPCC, 2022)***

## Research Questions

**- How can adaptability strategies develop and create spatially optimal living environments that are resilient and best serve people?**

**- In what way can apartments in a multifamily residential building be constructed using cross-laminated wood and designed to meet the requirements of adaptable space?**

***"As Croxton (2003) points out: If a building doesn't support change and reuse, you have only an illusion of sustainability."***

***(Schmidt III, R., et al. 2010)***



## Purpose and Aim

Purpose: Why? and Aim: What?

The case study investigation aims to analyse the project's guidelines so that some results can be defined and replicated in the design proposal and, ultimately, in future projects. When testing and exploring the adaptability concepts in the proposal, the findings will serve as a starting point for investigating which are best suitable for use with wooden architecture.

An alternative apartment floor plan is designed for the ongoing housing project *"Gibraltarvallen"* to examine how wooden architecture and adaptable space strategies can be combined to achieve qualitative and valuable apartment space, collaborating with the housing developer Riksbyggen and Sweco architects.

Specifically, this master's thesis examines wood as a material for the construction of high-quality adaptable housing for multi-family residential buildings to find resilient housing solutions.

The precondition is that the design proposal should provide people with opportunities to live more sustainably throughout their lifetimes, challenging established patterns for housing.

## Audience

To the audience who will read this thesis statement and what do the thesis aims to accomplish is:
- Architecture students: to develop an interest in and inspiration for "other" ways of doing architecture rather than the "conventional" one. (Awan, Schneider, & Till, 2011)
- Chalmers University of Technology, the School of Architecture: to consider the relevance of resilient strategies such as adaptability concepts in long-term visions in design education.
- Master thesis Case study, Stakeholders: to contribute insights that could prove helpful in future projects.
- Architects and Professionals in the building sector: to demonstrate the advantages of working with adaptable spaces and building with wood concerning future needs, challenging our preconceived ideas about designing housing.
- Users: to identify and promote different conceptual approaches to enhancing people's ability to take control of their space.
(Groat & Wang, 2013)

## Delimitations

The case study project has wooden construction in its proposal, so one of the objectives would be to investigate what solutions the wooden material offers, to improve housing flexibility and qualities for residents.

This thesis will only investigate the performance of construction, materials, and technical solutions in a broad view.

The design strategies and proposal will focus more on urban settlements, which means the research is limited to a Swedish context, although that does not mean it cannot be helpful for other contexts. The research is limited to a particular area or scope according to the relevant context.


**Figure 04.** Illustration of the master's thesis process - Diagram of the methodological research approach.





## Method and Process

This thesis is divided into four main chapters:

**Chapter 1** - Introduction: review the background, research questions, purpose and aim, and methods and processes.

**Chapter 2** - Adaptable Space in Multi-family Residential Buildings and Wooden Construction: discusses the theoretical framework, prerequisites for wood construction, and reference projects concerning "Research For Design".

**Chapter 3** - Multi-family Residential Project for "Gibraltarvallen" - existing proposal and a revised proposal focusing on adaptable space: prioritise "Research Through Design", develop a design proposal, and test a "time-space model".

**Chapter 4** - Conclusion: highlight the discussion and the final reflections.

**How?**

Methods used were:

*Research For Design* - Literature reviews; Architectural references; Case studies investigation; Interviews/ Meetings, Collage (Graphical and Written Manifesto) were used.

*Research Thought Design* – Design proposal (typologies concept model) and applying the Time-space model to investigate adaptable space (Scenarios); Drawings and Model making (digital/physical).

*Research For Design* started as a theoretical study which was vital to gaining practical experience and getting closer to the actual application of Design.

*Research Through Design* is an approach that recognizes the design process as a legitimate research activity, examining tools and processes of design thinking and making as part of a design process, bridging theory and building knowledge about design practices. (Hanington & Martin, 2012)

This work researched adaptability concepts, wooden construction and spatial capacity and use (time), and extensive theory to create a knowledge base to analyse the case study and then conduct the design proposal.

Besides literature studies, this research investigated examples of architectural projects that tested adaptable concepts previously. The referenced projects in this thesis are also a source of inspiration.

Interviews/Meetings were held with stakeholders, regularly with Riksbyggen, and occasionally with case study architects Sweco.

*"Gibraltavallen"* project is selected for the case study due to its characteristics of being innovative and resilient and its goal to offer flexibility to its residents. The existing project is analysed to determine how it could guide the design proposal.

# Chapter 2 - Adaptable Space in Multi-family Residential Buildings and Wooden Construction

## 2.1 - Theoretical Framework

## 2.2 - Two Perspectives

## 2.3 - Architectural References

## 2.4 - Wood as a Building Material

***"Adaptability forces design to become an ongoing social process between designer and user over time. The designer must focus on enabling adaptation to take place; as opposed to attempting to control experiences and anticipate the future." (Schmidt III, Eguchi, & Austin, 2010)***

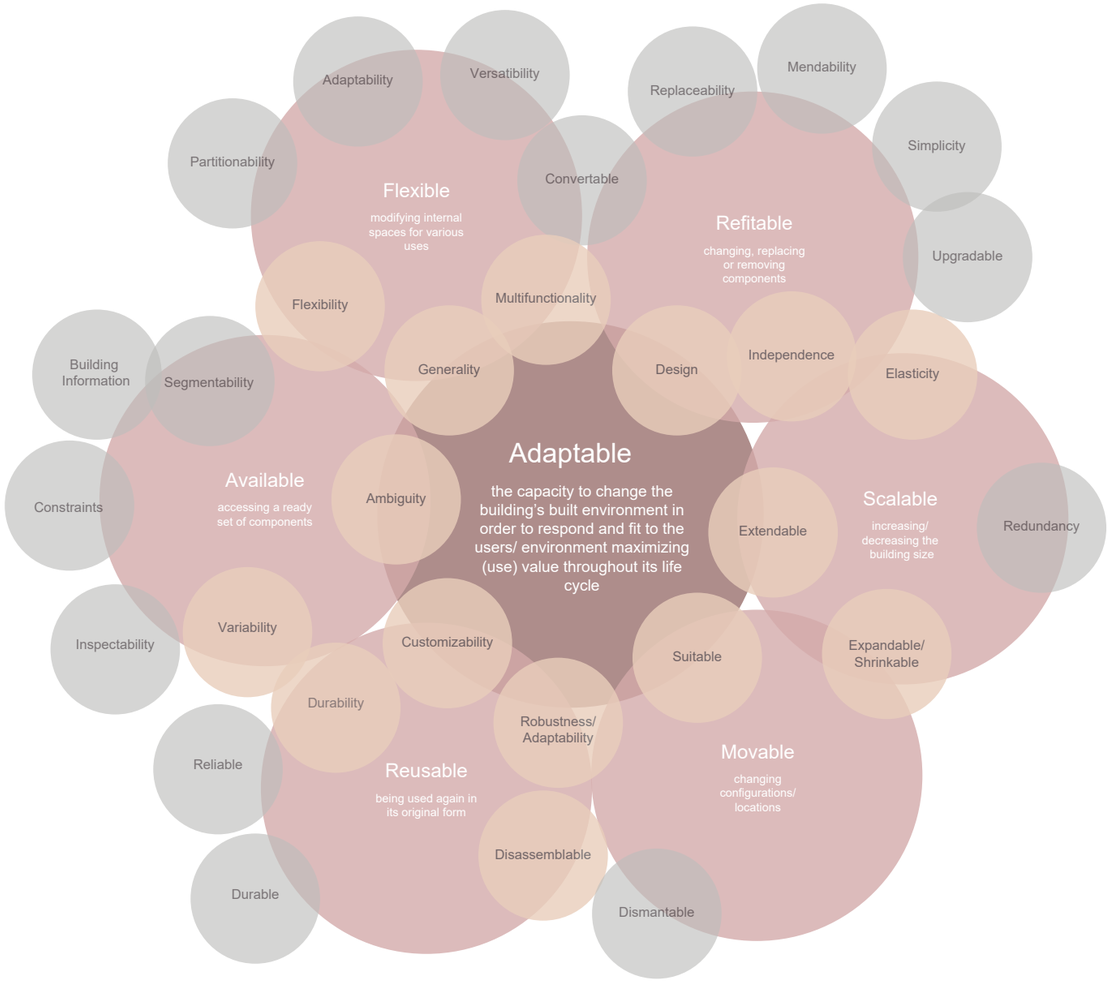



**Figure 05.** Diagram "Adaptable Design Strategies" adapted from Robert III Schmidt et al. (2010).

# 2.1 - Theoretical Framework

## A Framework for Adaptability

Research in adaptable housing has been closely related to architecture since the 1920s and is still under constant investigation today.

When Karin Krokfors considered the difference between Flexibility and Adaptability, she referred to Steven Groák (1992), offering the distinction. Adaptability has a social aspect, according to Groák, and according to him, it allows different social uses, while Flexibility refers to physical arrangements. Groák believes that adaptability is achieved by designing spaces so that people can use them in various ways. (Groák, 1992) (Krokfors, 2017)

However, adaptability is also a concept related to Schneider and Till's (2007) approach to flexible housing, as these authors see the apartment's ability to deal with volatility as an integral part of the residential project.

In this thesis, adaptable apartments refer to those that can adapt to changes in spatial requirements throughout the life of their residents use. Thus, the term adaptable housing will be used instead of flexible housing, including the meaning of social use of space, related to adaptability theory.

This thesis explores the concept of adaptability through the lens of Generality, Flexibility, Elasticity and Polyvalence (Fig. 06), as they provide spatial qualities that are not typically found in current housing projects. These theories will be explained later in this thesis (Fig. 08 p.26)

When analysing and investigating how housing can be adaptable under various theories, these can provide us with a greater understanding of its vast possibilities.

In the context of changing and unpredictable uses, implementing different adaptability strategies in housing could produce a new generation of housing with interesting spatial organisation and substantial resilience expectations.

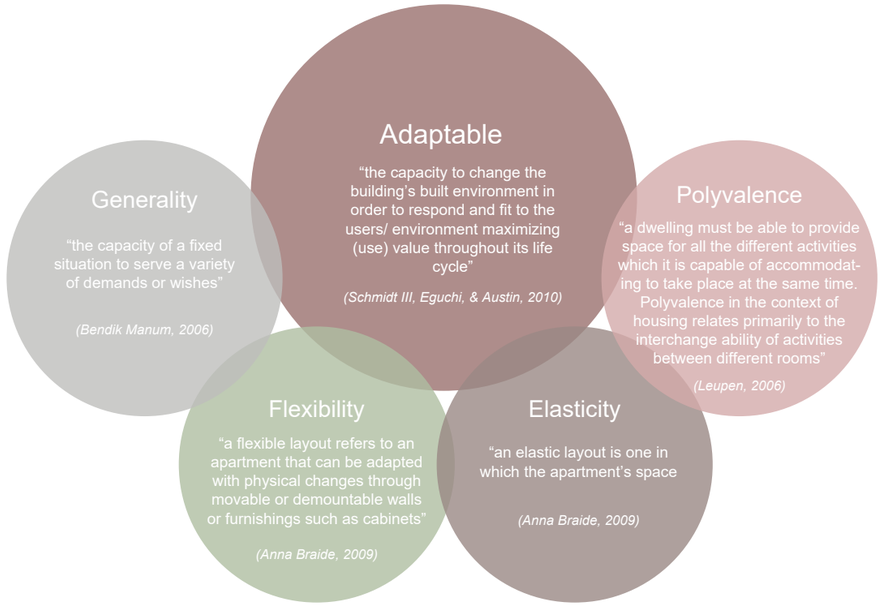



**Figure 06.** Diagram "Design Strategies" reinterpretation for this master thesis, adapted from Robert III Schmidt et al. (2010).

## Introduction

Past, present and future circumstances have always influenced the production of architectural design.

This thesis investigates the social qualities and the effect of time on the use of space. Krokfors (2017) emphasized that cultural aspects are crucial to understanding the different definitions of space, use and time.

Society is based on the past, which shapes the different paths it has taken. Consequently, a society's future is often determined by its historical perspective. Furthermore, the present tense is crucial because all decisions are made now, thus defining future characteristics. (Krokfors 2017)

This study seeks to analyze and approach design more strategically and systemically so that different typologies allow continuous change; this refers to the ability of a system to persist through adaptability, as seen in socioecological systems.

Modularity can be interpreted as spatial units in buildings, residences or the units that compose them. (Figure 09) The interaction between these units has a significant impact on adaptability. Thus, adaptable solutions designed for building construction rely on modularity.reconstruction will promote the unsustainable development of the built environment and societies.

Leupen (2006) emphasizes how spatial configurations are related to each other and how they can interact and significantly impact how adaptability works at the architectural level.

This thesis argues that the way space is produced today, particularly for housing, may not be sustainable in the long term, mainly because purpose-built buildings and how we design and build them today cannot quickly adapt to unpredictable social changes.

In the long term, housing is not necessarily adaptable enough to accommodate different needs and aspirations. In addition to wasting natural resources, continued reconstruction will promote the unsustainable development of the built environment and societies.





## The Creative Dweller

The idea is that people themselves can identify what they want from space, and they can create the spatial conditions they need. A creative dweller is a concept that refers to a way in which humans can define their way of living through typologically adaptable buildings with self-organizing features in a way that is profoundly different from what is possible with everyday dwellings nowadays. (Krokfors, 2017) (Figure 07)

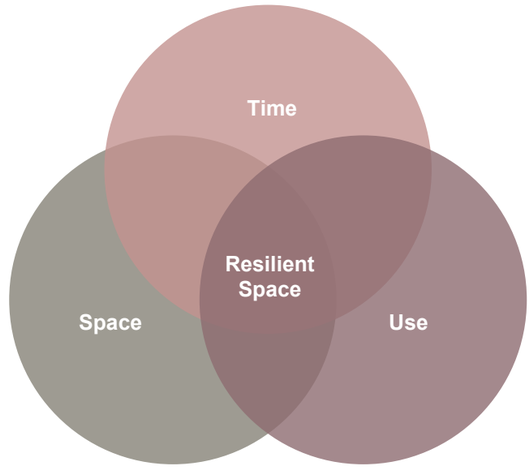



**Figure 07.** Three main properties define resilient spaces: time, space, and use. The interaction between these units greatly influences adaptability. Diagram adapted from Krokfors (2017).

## Interpretation of the Four Concepts: Generality, Flexibility, Elasticity, Polyvalence

When investigating different concepts and authors about the leading theories on adaptability, the research in this thesis focused on those who sought to include social notions and time in physical space and its use and those who sought to find actual examples where these theories could find some answers.

The research also sought to understand the theories that could favour the needs of building solutions in wood, namely in the modularity of different typologies and those theories that best respond to the resiliency challenges faced by people and, ultimately, the planet.

Interpreting the concepts based on the literature studies mainly from authors:

Anna Braide (2019);
Steven Groák (1992);
Herman Hertzberger (1991);
Karin Krokfors (2017);
Bernard Leupen (2006);
Bendik Manum (2006);
Robert Schmidt III; Toru Eguchi; Simon Austin & Alistar Gibb (2010);
Tatiana Schneider; Jeremy Till (2005);

Furthermore, others in the Reference list.

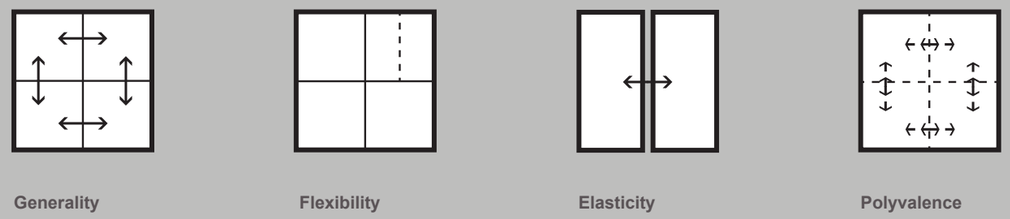



**Figure 08.** Diagrams representing the "Design Strategies" reinterpretation for this master thesis, adapted from Anna Braide (2019).

Chapter 2 - Adaptable Space in Multi-family Residential Buildings and Wood Construction

***Generality***

According to a general layout, each room does not have a specific function but allows a variety of uses without requiring physical modification of the space; thus, the rooms are interchangeable to a great extent. (Braide, 2019)

Generality can also be described as having physical fixed rooms with a layout that can adapt for social purposes.

Anna Braide refers to Generality as Bendik Manum defines as " the capacity of a fixed situation to serve a variety of demands or wishes".(Manum, 2006) (Braide, 2019)

***Specificity vs Generality***

The strategy of specificity is contrary to that of Generality in that its design satisfies a particular requirement out of the many possible ones; by definition, the specific strategy aims to meet precise, time-constrained needs or preferences. (Manum, 2006)

***Flexibility***

An apartment with a flexible layout refers to a space that can change with physical changes, such as through movable or demountable walls or movable furnishings such as cabinets. Flexibility allows modifying the room configuration, the number of rooms, and the room dimensions in the existing apartment, while maintaining its footprint. As part of the flexible design schema, open spaces are offered to the residents, which can be transformed into a preferred design and layout if they wish, using movable wall panels or constructed partitions. (Braide, 2019)

One good example provided by authors Anna Braide, Bendik Manum, Tatiana Schneider & Jeremy Till, and others is *"Järnbrottshus"*, designed by Tage and Anders William-Olsson in 1952, a structured housing project that was made flexible due to the use of lightweight internal walls with carefully planned positions for fixed elements, such as plumbing for kitchens and bathrooms. (Figure 12 and 13 p.38)

***Elasticity***

Elasticity is a characteristic of typological flexibility, and it refers to how much transformation is necessary to make a space multifunctional. Space exhibits elasticity when hardly any or no changes are needed when its purpose changes. The more transformations a building or dwelling needs for changes, the less elastic it is. (Krokfors, 2017)

Elastic layouts are ones in which the apartment space can expand or contract as needed, and this can frequently be achieved by exchanging space between adjacent apartments. (Braide, 2019)

Generality differs from Elasticity and Flexibility to achieve the same result in that it is permanent and does not depend upon physical changes. When comparing these three strategies, Bendik Manum (2006) points out that Generality is different from Elasticity and Flexibility in that it is permanent and does not require physical changes, and this alone is a reason to strive for Generality.

***Polyvalence***

Herman Hertzberger introduced the concept of Polyvalence to architecture, and this term derives from the French "salle polyvalence": a multipurpose hall. The idea behind Polyvalence is that space does not necessarily need to undergo any change to be flexible, but it is possible to use for multiple purposes due to its versatility. (Krokfors, 2017)

Tatiana Schneider & Jeremy Till ask: "How one does this is largely a question of design intelligence, projecting a series of questions against any proposed design, the first of which is: can this design respond to change?" The authors suggest that the minimum size of a functionally neutral room can be determined directly. Ideally, it should measure 3.6 m wide by 4.0 m deep to accommodate a variety of furniture layouts from bedrooms to living rooms; however, this can be reduced to 3.2 m wide by 3.8 m. (Schneider & Till, 2005)

Leupen (2006) applies a concept of time-based to the question of the sustainability of the building stock in Polyvalence, a concept for the resilient dwelling. According to him, Polyvalent spaces and spatial systems respond to diverse needs and different forms of habitation. To achieve better spatial usability, he emphasizes the need for a Hall that makes every room accessible from a central and neutral point.

Authors Bernard Leupen and Tatiana Schneider & Jeremy Till refer to *"Diagoon Houses"* by the architect Herman Hertzberger as a good example. (Figure 14 and 15 p.39)

## Spatial Logic: A Dwelling's Primary Activities

When identifying and categorising the different primary activities from a dwelling perspective, from Public to Private, the general functions of a dwelling provide for long-term usability.

While Heckmann, Schneider & Zapel (2017) divide floor plans into nine spatial logics: Corridor; The living room as circulation centre; Zoning; Neutral/ambiguous floor plan; Dividing elements floor plan; Continuous floor plan; Floor plan with circular path; Organic floor plan; Flexible floor plan.

Bendik Manum (2009), when using space syntax (justified connectivity graphs), represents the activities according to function/use: Red: bedroom, Green: living or kitchen, Yellow: transition space, Blue: WC/bath/washing, Brown: balcony, Pink: storage.

The Swedish Standard Regulations for Building Works (BBR, 2011) list eight general functions that a dwelling should be able to provide for long-term usability: personal hygiene, get together, sleeping, cooking, eating, storage, laundry, entrance and storage for outdoor clothes.

Bernard Leupen (2006) presents six basic activities that can be expressed in a graph: Sleeping, Get Together, Eating, Cooking, Bathing and Working.

This thesis proposes primary activities based on literature studies mainly from Leupen (2006) and according to the Swedish Standard Regulations for Building Works (BBR, 2011).

As a result, 11 activities are proposed. With the aim of, on the one hand, being able to use them to analyse the floorplans of the case study "Gibraltarvallen", where the activities are explicit and fixed, but on the other hand, also being able to identify a new activity here called just "Room", which could thus express also theoretical concepts of Generality and Polyvalence for the Design proposal. In some cases, when identified in the floorplan, some of these activities may appear together in the same space.

Generality and Polyvalence are particularly interesting because they offer meaningful solutions for the preconditions of this work.

***"The extent to which a dwelling is polyvalent could be said to depend on the number of possible arrangements or combinations of activities it permits." (Leupen, 2006)***

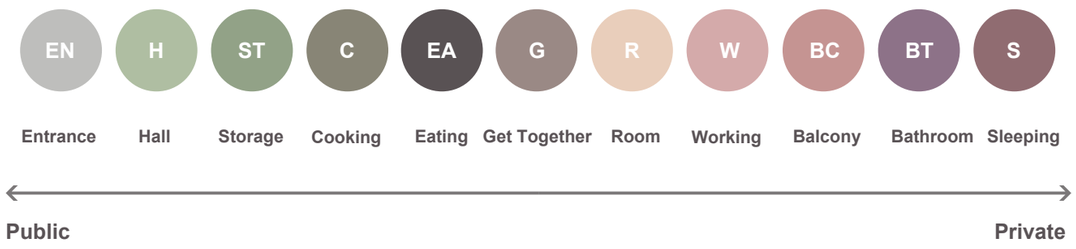



**Figure 09.** Primary activities identified for this master thesis, adapted from Bernard Leupen (2006) and BBR (2011).

***"3:52 The design of dwellings***
***Dwellings shall be designed, utilised, fitted out and equipped, with consideration taken to their long-term use." (BBR, 2011)***





## Space Syntax: Spatial Configurations and Connectivity Graphs Representations

The social logic of space (space syntax) will be analysed in the floorplans studies to understand the case study *"Gibraltarvallen"* and further design proposal.

Some authors use space syntax to organise the logic of space. A basis for space syntax is the work of Bill Hillier and Julienne Hanson. (Hillier & Hansson, 1984).

"Space Syntax" is a theoretical approach that focuses mainly on the configurational aspects of space. Describes a field of architectural research characterised by developing quickly applicable methods for observing spatial configurations based on a consistent theoretical framework. It helps to understand how spatial units relate to each other, how they relate to social life, and how to identify and analyse relationships between spatial units.

"Justified Graphs" are a way to visualise a configuration of elements from a particular point of view.

Bernard Leupen identifies five basic models for the spatial configuration: A - Chain, B - Star, C - Star with central room, D - Circle, and E - Grid (entrance = square + arrow). Explaining that the A - Chain model is the least Polyvalent since we must pass to one room when going to the other, he also clarifies some degrees of Polyvalence.

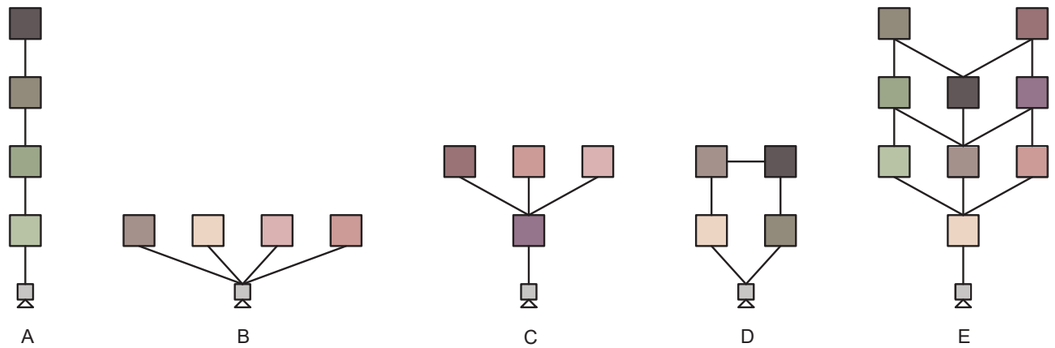
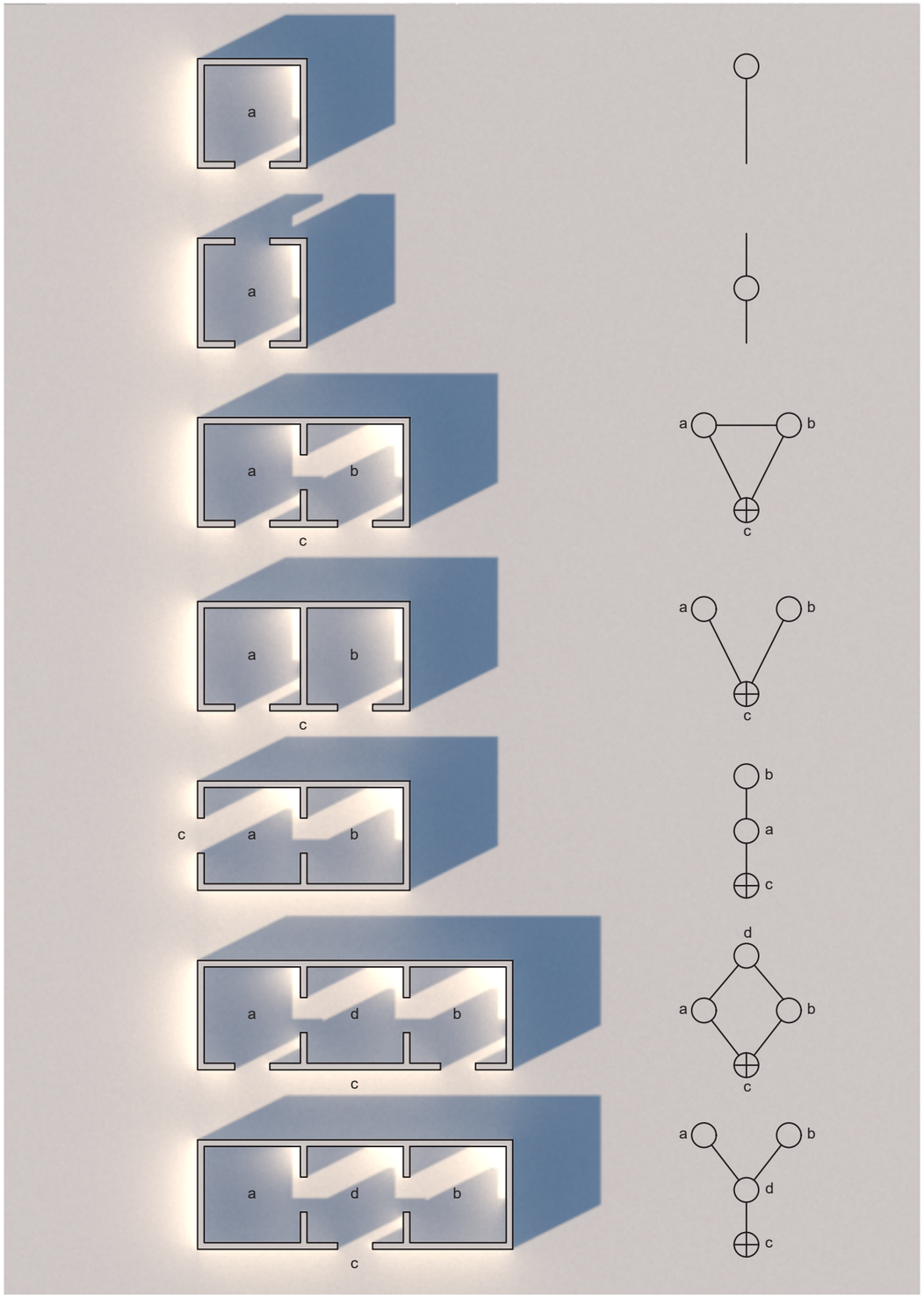



**Figure 10.** Graph models of spatial organization, adapted from Bernard Leupen (2006).








## Multipurpose “Room”

Leupen (2006) states that the number of large rooms and the size of the rooms plays an influential role; he starts by explaining that living/sleeping areas larger than 16m2 have the potential to accommodate any primary activity.

Perhaps this can be done in less than 12,5 m2 (Nylander, 2007), mainly when living areas in housing today are increasingly reduced. There is more freedom when we plan room space for more than 12,5 m2 or even 16 m2, from where it distributes other essential functions.

Ola Nylander studied the capacity for varied use in the size of 12.50 m2 in a multifunctional room, suggesting a square shape for the room (or almost square), which contributes to varied use. Nylander states that the size makes it possible for a person living in group housing to have a bed and a workplace and to be able to meet others in small social contexts. (Nylander, 2007)

In addition to offering residents a convenient and practical design solution, multifunctional rooms can also be used without causing any physical changes to the apartment. Research has also noted this as a significant advantage, mainly in the work of Anna Braide, Bernard Leupen and Bendik Manum.

Furthermore, rooms that do not have an alternative route to another room are less suitable for basic activities such as sleeping. Moreover, the relationship to rooms with fixed activities, such as the bathroom and kitchen, also influences Polyvalence.

According to Leupen, a star or circle structure has more potential than a chain. (Figure 10 p.29)

## Reflection

From knowledge-based research and analytical studies related to architectural practice as it is done today, it seems very relevant to understand usable spaces in housing. From a historical point of view, current practice is relatively distant from research studies.

Nylander’s research (1998) analyses seven “non-measurable attribute fields” in Swedish households. The goal is to conceptualise these “non-measurable” architectural attributes. He proposes seven “attribute fields”, these are “materials and detailing”, “axiality”, “enclosure”, “movement”, “spatial figure”, an “organization of spaces”.

It is interesting because Nylander intends to develop an original methodological framework for analysing architecture, one of the types of work in which architects work with theoretical approaches and methodologies specific to architecture.

A lack of engagement has been observed between research, analytical background knowledge and architectural design practice in Norway (Manum, 2006) and, in my experience, in other European countries as well.

That is why the theoretical framework for this thesis is based mainly on Generality and Polyvalence and focuses on the “Multipurpose Room”, together with the analysis of the spatial syntax and the space-time model, which can be valuable to serve as a guide for the design proposal for this thesis, since theoretical knowledge as such rarely constitutes a basis for architectural practice.

However, the architects did a great job advancing the theory and practice of adaptability, demonstrating the importance of design research and its variations before the concept emerged. (Krokfors, 2017)

In this thesis, considerations of key concepts include Hertzberger’s Polyvalence and Leupen’s framing as a generalist space (Generality) that tries to encompass both concepts within its theoretical framework.

This thesis also acknowledges the research done by Bendik Manum (2009) on the type of household, “Kind of Households”, which will be described in chapter 3, to develop the design proposal.

# 2.2 - Two Perspectives

## Introduction

***"The core issue of flexible housing is that of use. How might we design housing that is flexible enough to accommodate users' desires and needs, both before and after occupation? The answer to the question lies in both how one designs the layout of the housing and in the way that one constructs it." (Schneider & Till, 2007)***

In the master's thesis theoretical framework, the purpose was to highlight and explore two main perspectives when designing dwellings: the user and the housing developer. By focusing on two different questions and needs about adaptable spaces, we may be able to develop strategies that meet the interests of both parties, adding a bottom-up perspective not fully explored in dwelling design. (Braide, 2019)

The *"Gibraltarvallen"* case study is the first wood construction project that Sweco Architects are designing in Gothenburg, and it is also the first wood project that Riksbyggen is developing using wood construction as an innovation.

One of the housing developer's objectives with this project is to design a concept model that can be replicated in future projects. Thus, the concept of design adaptability makes even more sense. With this prerequisite, the analysis and further development of a design proposal are defined ahead.

Accordingly, one of the objectives of the final design proposal is to define a set of guidelines for the design of the concept model that emphasizes adaptability and wood construction. At the same time, designing an adaptive concept that will be used in the future and can unite the two perspectives to produce a design that is appealing to both parties.

***"Architecture should offer an incentive to its users to influence it wherever possible, not merely to reinforce its identity but more especially to enhance and affirm the identity of its users." (Hertzberg, 1991)***

Chapter 2 - Adaptable Space in Multi-family Residential Buildings and Wood Construction

## The User

In response to strategies that regard people as passive design objects, Jonathan Hill (2003) proposes a new understanding of architecture and design.

The "Passive user" is consistent and predictable and does not alter the use of space or its meaning, whether the user performs practical tasks under functionalist principles, following the sequence of spaces directed by the architect, or contemplates as an artwork. The "Reactive user" alters the physical characteristics of the space according to changing needs but is constrained by a narrow and predictable range of configurations that the architect has predetermined. "The Creative user" either creates a new space or changes the meanings and users of an existing space. Jonathan Hill (2003) states that the central concern of architecture should be "The Creative user".

According to Hill, the architect's conception of the user influences its design decisions. A new understanding of the architect's and the user's roles can serve to develop new architectural strategies that recognize the creative abilities of users (Hill 2003).

By applying Hill's idea of the "creative user", Karin Krokfors, however, aims to resign the concept of user altogether and replace it with the concept of the "dweller", thereby understanding that the creative user is the creative dweller; this is due to the concept of the user having the potential to suggest a rather one-sided view of people and living by suggesting consumption. (Krokfors, 2017) (Figure 07 p.25)

From the User's point of view, adaptability is seen as an enormous advantage not only by practical means but also by economic ones.

According to the RIBA report regarding space, a research that investigates the size of England's new homes (2011), a survey about perceptions toward newly built housing:
- 69% of people who would buy a new home said that energy efficiency was the essential reason;
- 60% of people who would not buy a new home said that the small size of the rooms was the most crucial reason;
- The top three things people look for when moving home are outside space (49%), the size of the rooms (42%), and proximity to local services (42%);
- 31% of people would not consider buying a home built in the last ten years or would only consider it a last resort. Of these, 60% said the rooms were too small, 46% said they lacked style, and 45% were concerned about the lack of outside space;
- People believe that newly built homes fail to provide two of the top three things they are looking for when moving home: adequate space inside and outside the home. (Roberts-Hughes, 2011)

These arguments confirm the current need to provide users with adaptable solutions.

***"The passive user is consistent, predictable and transforms neither use, space nor meaning, whether performing useful tasks according to functionalist principles, following the sequence of spaces directed by the architect or contemplating as an artwork. The reactive user modifies the physical characteristics of space as needs change but must choose from a narrow and predictable range of configurations largely defined by the architect. The passive and reactive users are dependent upon existing conditions, which they are unable to fundamentally transform. With a role as important as in the formulation of architecture as that of the architect, the creative user either creates a new space or gives a one meanings and users contrary to established behaviour." (Hill, 2003)***

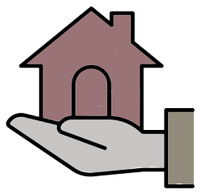
## The Housing Developer

Riksbyggen is one of Sweden's largest property developers in housing cooperatives.

Positive Footprint Housing is an interdisciplinary research for holistic thinking. Riksbyggen initiated the project in 2011, and the goal was to run Sweden's most innovative housing and urban development projects. The focus areas are:
- land use, animals and nature;
- design, choice of materials and construction methods;
- energy production, energy storage and energy use;
- security, well-being, community and collaboration with the environment;
- the economy;
- means of transport and mobility around the accommodation;
- property management.

*"What is Positive Footprint Housing?*
*Many people believe that a building is considered sustainable only if it is environmentally classified, but sustainability is more complicated than that. Positive Footprint Housing is a project where we want to find new ways to build and take care of housing that is good for people, the environment and the economy, both now and in the future. The project is as much a knowledge laboratory as it is a national and international demonstration project."*

*"Success factors*
*The goal is to run Sweden's most innovative housing and urban development projects. We have identified several success factors on how we can let different competencies work together to achieve our goal. The work is interdisciplinary and complex, and the key lies in cooperation and partnership. Therefore, we have linked several partners to the project, and through this network, we have received a broad exchange and a dynamic process." (https://www.riksbyggen.se/hallbarhet/bygga/positive-footprint-housing)*



## Positive Footprint Housing

*"A study on what it is like to live in a housing project from Positive Footprint Housing?"*

*"Brf Viva results from years of research on building, living, and living as sustainably as possible." (Positive Footprint Housing, s.d.)*

In order to evaluate the Positive Footprint Housing, Riksbyggen conducted a survey to learn more from the residents about their living experience in their first housing project, Brf Viva. By conducting further research, it is possible to evaluate the process, learn from it, and make improvements, which shows that the sustainability of a project does not end with the construction of the building. It is also valuable to continue evaluating the process, taking lessons and improving.

*"Bostadsrätt"* participants completed a survey in the fall of 2016 concerning their current situation, their expectations regarding life after moving, and their plans for the future.

The survey focused on understanding how participants view sustainability from a broad perspective. The topics included environmental sustainability, social sustainability, economic sustainability, travel habits, community development and consumption patterns. The survey consisted of a questionnaire and an interview. As part of the survey, questionnaires were sent to households who signed contracts in November 2016, and 66 respondents returned the questionnaires. In addition, nine households with 21 participants were interviewed from autumn 2016 to autumn 2017.

Some results from the survey:

*"Who moves in?"*
The most common household type in the survey consisted of 1-2 adults aged 50 years old. Families with children are few in Brf Viva, and the vast majority of those who live there have a university degree. Even though the residents look homogeneous in terms of education and age, there is considerable diversity regarding their country of origin and their perspectives on the community. Professional roles range from technical to humanities-based professions, and in between are self-employed and salespeople.

The proximity to several significant workplaces in the higher education sector has attracted some buyers who work in these facilities. The survey and the interviews indicate that apartment design and flexibility are essential when considering a new home.





One of the interviewees reported:
"The location was part of what decided the choice, close to nature and central. The whole concept, but also the apartment, that it would be bright and spacious and that you could save energy."

*"How will life in Brf Viva be?"*
Based on the interviews, the move to Brf Viva links to a significant change in life, such as moving away from home, separating and changing residential areas.

One of the interviewees said:
*"That is the way it is sometimes, and sometimes you have to make changes in your life."*

*"The sustainable life"*
Several of the interviewees pointed out that Brf Viva will be what the people who live in it make it, i.e. that the longevity of the house will be determined by who lives there, how committed they are, and what issues they pursue.

This study concludes that there are good opportunities to live a sustainable life after moving to Brf Viva. The house, the neighbours, and their own experience provide a solid foundation for sustainable choices. (Positive Footprint Housing, s.d.)

## Reflection

As a research method for this thesis, collaboration with housing developer Riksbyggen proved vital as it gave the author a clear perspective from the real estate developer's point of view. It also seems important to highlight their clear will to build responsibly and resiliently.

An essential part of this thesis is to try to combine the concepts of adaptability with wooden construction and the possible idea of being able to use and replicate concepts from the case study in the future. This research project intends to reinforce the developer's goals and overcome barriers and ideas. To make homes more resilient so that, as "creative dwellers" (Krokfors, 2017), the users have increased autonomy and choices, and housing can better withstand changes and future challenges that can still be widely unknown.

With regular meetings and conversations, collaboration has also proved to be very important when discussing the many possibilities that the thesis brings to light concerning adaptability and modularity.

There were some unanswered questions, but these questions, simply by being asked, bring about many reflections in themselves.

Chapter 2 - Adaptable Space in Multi-family Residential Buildings and Wood Construction

# 2.3 - Architectural References

## History: Sweden's housing development

In Sweden, social housing issues have been of great importance since the 1930s, especially when it comes to housing and residential areas that today serve as homes for most citizens. In addition, the direction and scope of social housing policy distinguish Sweden from other countries in many aspects regarding the standard and quality of housing.

Housing policy has as its primary objective to increase options for housing expansion, which has been a significant problem for over a century and was addressed through the Million Houses Program.*"Miljonprogrammet"* was a program that aimed to build one million new homes within ten years, from 1968 to 1970.

The Swedish government's housing policy focuses on quality, economy, and construction, and in a broader regulatory framework, quality objectives were outlined. Subsidized government loans could be used to manage housing construction actively. Public housing companies, which built non-profit housing, helped control construction processes. As a result, Sweden was able to build decent housing for all.

At the beginning of the 21st century, changes in housing policy began to take place. The recession that dominated the 1990s, with high unemployment, was replaced in the 2000s by a slightly rising and ever-improving economy.

At the turn of the century, a new Sweden emerged with low housing construction, low demand, low-interest rates, and low permanent unemployment. As a result of significant immigration, the population increased throughout the decade.

After a record low level of housing construction in 1994-1995, there was an increase in housing demand in the 2000s, mainly in metropolitan areas. Many rural municipalities in central and northern Sweden demolished vacant apartment buildings during the same period.

Construction of new homes increased during 1995-2000 and the boom of 2006-2008. In the wake of the financial crisis, housing construction fell sharply in 2009. There was an equal amount of new housing construction in the mid-2000s as in the mid-1980s. On an international scale, housing construction in Sweden was deficient, contributing to a housing shortage.

The low level of housing construction during the 1990s could be viewed as logical strictly from a market economy perspective. Offering spacious and luxuriously equipped apartments to attract customers was not a good idea. Housing prices rose in the 2000s.

Metropolitan areas experienced increased demand during the 2000s, specifically small dwellings and housing for young people. As household sizes decreased, singles and singles with children were the two collapsed household groups. In Sweden, the traditional family with small children has re-established itself as the third-largest household type.

A new housing policy program was implemented in 2015 that involved a takeover and a return to the classic housing policy of the middle of the 20th century. The state has invested heavily in supporting housing construction, and the number of new homes increased to 60,000 in 2017. (Nylander, Femenias, Andersson, Morichetto, & Braide, 2018)

## Two References: *"Järnbrott Experimental Housing" and "Diagoon Houses"*

The two examples presented next were chosen because they represent the interpretation of the concepts of "Generality", more in the first case and of "Polyvalence", more in the second case. Also, in both examples, the user's role is understood as active, defined as a "creative user" (Hill, 2003) (Krokfors, 2017), which has been reflected upon above.

Moreover, these examples illustrate how the two architecture projects changed over time and how the users reflected these changes. Additionally, research indicated how people who lived for long periods in their homes recognized the advantages that adaptability offered. These are examples of architecture that reflect the theories investigated in this thesis and provide challenges to pre-established assumptions about housing nowadays.

### *“Järnbrott Experimental Housing”*
### Tage + Anders Wiiliam- Olsson

“Experimenthus” is a housing building with 20 apartments framed in a rational concrete structure.

Residents themselves could decide the floor plan with the help of movable walls. Most apartments were 75 m2. When residents moved in, there was only a kitchen counter and a bathroom on the dividing wall of the apartment. The residents decided on the remaining areas. Removable walls provided great flexibility. All apartments became unique, and families could change their homes over time, an opportunity that many took advantage of.

*“As a result, the project in the early 1950s encouraged a debate about housing that is still relevant today: how to create housing that meets our diverse needs and wishes, that we can afford to live in, and that satisfies our need for good architecture?”* (Andersson, Jonasson, & Olsson, 1988)

### 1953
### Sweden

During 1950-51, the Gothenburg municipal housing company, “Bostadsbolaget”, organized a competition of ideas for new housing types, for which this experimental project was the winner.

The potential occupants were provided with suggestions for interior layout, which they could choose before moving in. Furthermore, modular partitioning allowed tenants to continue to change the layout of their houses over time. (Schneider & Till, 2005)

This example is interesting, as it shows that, as apartments can be so adaptable, this allows families to change their homes over time, so they can stay there for many years, with the average time of living there being 21 years.

**Figure 12. “**Experimenthus” in Järnbrott, Gothenburg (1955).
(photos by author: Sune Sundhal/ source: www.digitalmuseum.se).

**Figure 13. “**Experimenthus” in Järnbrott, Gothenburg (2022).





### *“Diagoon Houses”*
### Herman Hertzberger

The principle behind the project is based on an “incomplete building”, which means a basic framework leaves space for the user to express its interpretation of the space, function, and size.

Houses were designed as an alternative to how they are traditionally constructed to allow the occupants to control the design. Hertzberger refers to the structural skeleton used in design as a half-product, which anyone may complete according to personal preference.

The “Diagoon Houses” are not simply neutral structures that offer an infinite number of options, and they serve as a framework and indicate the possibilities of spatial arrangement. (Schneider & Till, 2005)

### 1971
### The Netherland

The plan is, to some extent, indeterminate so that occupants can decide how to divide space and live in it, as well as where they can sleep and eat. Houses may be adjusted and enlarged when a family’s composition changes; this represents an incomplete framework.

The house consists of two fixed cores with several different half-storey-high levels that constitute the living areas, which can be used for many purposes, including living, sleeping, studying, playing, relaxing, and dining. A part of each unit, i.e. level, can be partitioned off to create a room, while the remaining space can transform into an indoor balcony which runs the entire length of the living room (void). There is no clear separation between the living area and the sleeping area (though one is required to go upstairs). Each family member has his room as part of the ample communal living space.

Herman Hertzberger, when designing this plan, attempted to break away from some of the established stereotypes that still prevail in the housing industry today. (Hertzberger, s.d.)

In addition to its aesthetic value, this example reveals that adaptability solutions bring many advantages when considered in the initial design phase. Here, the concepts of Generality and Polyvalence are excellent examples of how they work in practice and increase the user’s control over the space.

**Figure 14 and 15. “**Diagoon” experimental housing, Delft. (1967-1970)
(photos by authors: Beton Verlag, Willem Diepraam and Johan van der Keuken / source: www.ahh.nl).

***"Cities are built in two materials: steel and concrete. They are the materials of the last century. But they are materials with very high energy and very high greenhouse gas emissions in their process. Steel represents 3% of man's greenhouse gas emissions, and concrete is over 5%. So, 8% of our contribution to greenhouse gases today comes from those two materials alone.***
***Our two solutions to climate are obviously to reduce our emissions and find storage. And wood is the only major building material that I can build with that does both those two things." (Green, M. 2013).***

***8%***
***of our contribution to green greenhouse gases today come from two materials alone:***
***3% steel + 5% concrete***
***(CO2 emissions)***

***wood is the only material that we can build that can reduce our emissions and store them:***
***1 cubic meter of wood will store***
***1 Tonne CO2***

### Timber Construction

Building a multi-story structure with wood has a number of advantages, according to a report (Gustafsson,A., Eriksson, P.E., Engström,S., Wik,T., Serrano, E., 2012):
- Competitive price;
- Quick assembly;
- Dry construction;
- Flexibility.

### Tall Timber Buildings

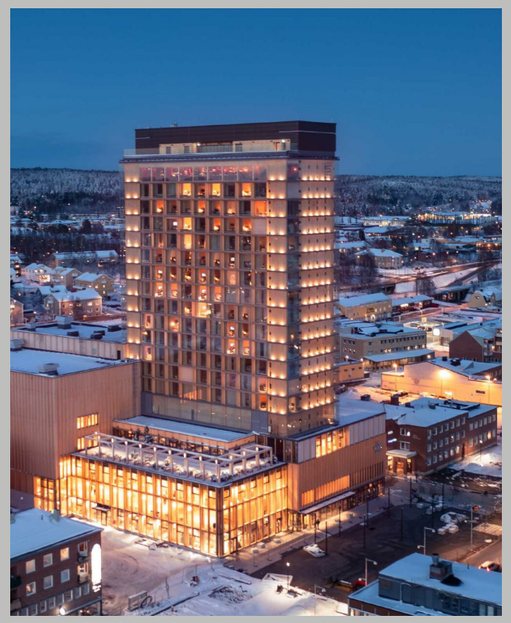


**Figure 16.** Sara Cultural Center. (source: whitearkitekter.com).

Sara Cultural Centre in Skellefteå, Sweden, with 20 storeys, was the tallest building to date (2022). The building is also one of the world's first carbon-neutral buildings, sequestering carbon and running entirely on renewable energy. It consists of prefabricated timber modules with a core of cross-laminated timber.

Chapter 2 - Adaptable Space in Multi-family Residential Buildings and Wood Construction

# 2.4 - Wood as a Building Material

### Building Systems and Wood-based Products

Most wood products for structural purposes are made from timber glued together, and it is possible to include other wood products or other materials, such as metal. Various adhesives and methods can be used to glue the wood together. Some elements of built-in wood construction are:
- Roof trusses;
- Glulam;
- Laminated Veneer Lumber (LVL);
- Lightweight joints and beams;
- Cross Laminated Timber (CLT);
- Tongue and groove sheathing panels.
(https://www.swedishwood.com)

### Structural Systems

In wood building systems, suitable for the extensive development of apartment buildings, massive load-bearing walls (in CLT), light frame (load-bearing walls of studs and joists) and post-beam structures are most appropriate.
The above mentioned are the established structural systems seen in residential developments regardless of construction material, and wood is the only material suitable for use in all of them. Due to the risk of shear buckling (deformation), steel should not be used for massive load-bearing walls, and concrete cannot be used for light frame structures for practical and structural reasons. (Gustafsson, Eriksson, Engström, Wik, & Serrano, 2012)

The common structural systems used in wood construction are:
- Post-Beam System;
- CLT-Slab System;
- Light Frame System.

A volume module cannot exceed a maximum size that will allow a truckload, which results in relatively small dimensions. Modules are not cut between apartments since the distance between their walls ensures acoustical insulation, and this is consistent with the plan of a module that encourages repetition to mass-produce it. A larger apartment can be made from more than one module; a one-room apartment is generally constructed from one module, and a two-room apartment from two modules. (Lindbäcks, 2020)

***"Yes, do everything possible to reduce carbon load in any work you do, but don't see this as the be all and end all. And no, don't believe that a technical solution alone will find our way out of the complexities of the climate emergency." (Till, 2020)***

## Study Trip

To better understand the systems and types of wood construction and the respective solutions available, I had the opportunity to go on a study trip and visit two of the largest producers and factories in Värö, Sweden: Derome and Södra. This was important for understanding wooden construction and its advantages, mainly in the use of modular construction.

### Derome Volumelementfabrik

**Figure 17.** Photo of the assembly of the modules in the factory. (source: https://www.derome.se/bostadsutveckling/husfabriker/varo).

### Södra KL Fabrik

**Figure 18.** Photo of elements in CLT.





## Case Study *"Gibraltarvallen"* Construction

This project uses construction building modularity, adapted to a flexible floor plan with moving interior walls. The building's load-bearing system is designed to efficiently make the best use of the strengths of each input material.

The residential building floors are built with cross-laminated wood and glulam modules, which entails a significantly lighter construction than the traditional concrete frame. The light residential floors have been used to allow ground-floor changes, which have thus been more open and given a freer division of premises.

Residential floors are supported by solid glulam pillars that give a steady yet light impression and effectively carry the load of overhead floors in combination with recycled brick at the entrances and stairwells. Cross-laminated book plywood and reinforcement of beech plywood will be used to join the wooden structure. On the ground floor, the building is stabilized with concentrated units of shear walls; this, together with the pillar-beam system, enables further freer floor plans as stabilizing crosses and walls can be avoided.

## Qualities and Limitations

The advantages of wooden buildings include their durability, ability to age gracefully, and ease of maintenance. For structural and construction purposes, wood can be used for cost-effective and environment-friendly reasons and realise a design idea that expresses the relationship between the structure and the architectural expression.

Sweden has a long tradition of building in wood. Wood offers the opportunity to reduce the use of finite raw materials and reduce carbon emissions from construction products.

With modern wood construction techniques, it is possible and often an advantage to build even larger structures from wood. Swedish Wood Building Council (https://trabyggnadskansliet.se) promotes wood in construction, focusing on multi-story buildings, public buildings, and large bridges over roads. (https://www.swedishwood.com)

Despite having been used as a building material for hundreds of years, the biophilic benefits of wood have only recently been understood. Wood has been found to contribute to the health and well-being of building occupants and be visually pleasing.
(https://www.swedishwood.com)

With the unique properties of wood, it is possible to achieve truly authentic and structurally expressive architecture. Nowadays, there is a large amount of production of wood-based housing, and the sector is being reoriented towards more wood-based construction.

From both perspectives of this thesis, there are many advantages to building in wood. Wood is easily used by the residents/user and adds quality to the construction for the housing developer.

However, despite many of the advantages, concerns are being raised regarding the impact of increasing wood usage, and recent reports reveal that it may not be a sustainable material concerning contemporary forestry practices.

In the current understanding of the planet's resources, recycling building materials does not solve the overconsumption of resources. In addition, it is crucial to recognise that buildings are not always "objects" that can be demolished at once.

# Chapter 3 - Multi-family Residential Project for "*Gibraltarvallen*"

## 3.1 - Existing Proposal (Sweco)

## 3.2 - Final Design Proposal (Master Thesis)

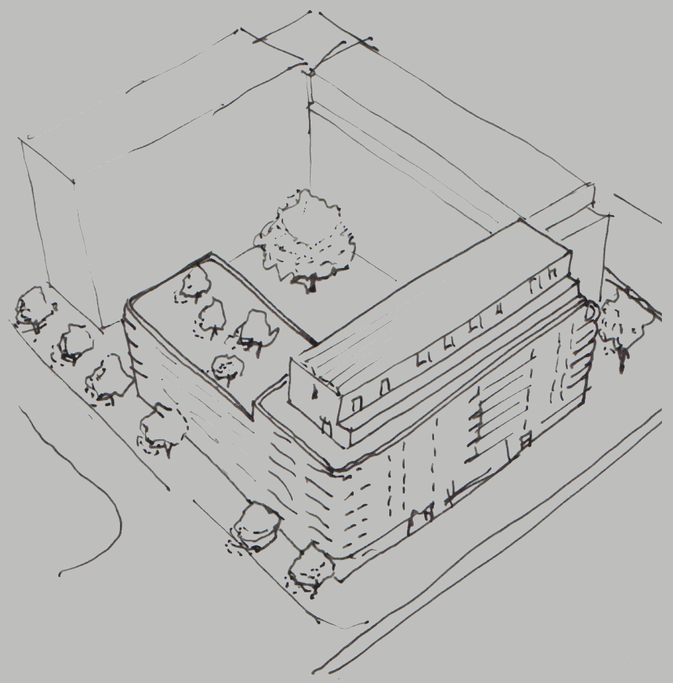


**Figure 19.** Hand drawing of the case study project *"Gibraltarvallen"*.


# 3.1 - Existing Proposal (Sweco)

## Case Study: *"Gibraltarvallen"*

This thesis will investigate the context of Gothenburg city: understanding the challenges that the housing market presents in Sweden, today and in the future.

Located in Johanneberg, Gothenburg, the case study for this thesis is *"Gibraltarvallen"* that is still under development. It is an excellent opportunity for learning and reflection, to analyse an actual project when it is still possible to bring knowledge and obtain results that can improve the final design proposal.

Riksbyggen sees this project as an innovative and sustainable concept house that can be standardized.

*"Very high flexibility in the ground floors provides the opportunity to build in places with different conditions while maintaining contact between street and local.*
*Building in wood is about equal parts tradition as innovation. Gothenburg has a long history of building wooden houses. Finding new solutions is part of the project.*
*We aim to be a strong driver in the development towards a more sustainable wooden house-production. Long-term thinking is crucial in this type of project. Our strength is that we are a long-term, knowledgeable partner for the residents even after moving in. For us, security, stability and well-being are not only about the living environment, but also a company with stable finances and positive growth."* (https://www.riksbyggen.se)

Together with Riksbyggen, Sweco's architects, with their design proposal, won the land allocation competition for the wooden house at "Gibraltarvallen" in Gothenburg.
From their perspective, this project is a "Wooden House" (built-in wood), and it will be a residential building that challenges and leads the way to sustainable housing construction from several aspects.

The environmental goals are high, and the building will accommodate mixed apartment types with movable walls, rooms on the ground floor, greenhouses on balconies, ecosystem services integrated on the yard and roof and an energy system with solar cells. There will also be pools for bicycles and cars to make it easier for the residents. The house will contain 45 apartments, including terraced houses on the roof. (https://www.sweco.se/projekt/brf-gibraltar)

**Figure 20.** Case study project *"Gibraltarvallen"*, (First Stage). (Sweco architects).

## Context

### Site and Surroundings

The area of Övre Johanneberg is of cultural national interest. Upper Johanneberg is Gothenburg's most distinctive "functional area" and the first area of the city that was built entirely according to the ideas of "Functionalism".
The surrounding area is very well preserved with a strictly "functionalist" urban plan with green areas. Housing buildings have around 6-8 floors and are uniformly designed. (Göteborg, 2020)

It is located on Engdahlsgatan/Gibraltarvallen and Gibraltargatan, close to the Chalmers University of Technology. Today on the site, Gibraltar Herrgård house will be relocated and not demolished due to its historical and cultural value.

**Figure 21.** Photo of the site and Gibraltar Herrgård, view from Engdahlsgatan street.

**Figure 22.** Photo of buildings in Gibraltagatan street.

**Figure 23.** Photo of the site and Gibraltar Herrgård, view from Engdahlsgatan/ Gibraltargatan streets.

**Figure 24.** Photo of the buildings near the site, in Lindströmsgatan street.





### Location

Johanneberg is an area and district located in the city centre (Centrum) of the municipality of Gotheburg and has a land area of approximately 75 hectares. Övre Johanneberg is where the case study is located, where 66.2% of dwellings were constructed before 1941, and there were 163 new dwellings built in 2019. (https://goteborg.se/wps/portal/enhetssida/statistik-och-analys/goteborgsbladet/hamta-statistik/faktablad/goteborgsbladet)

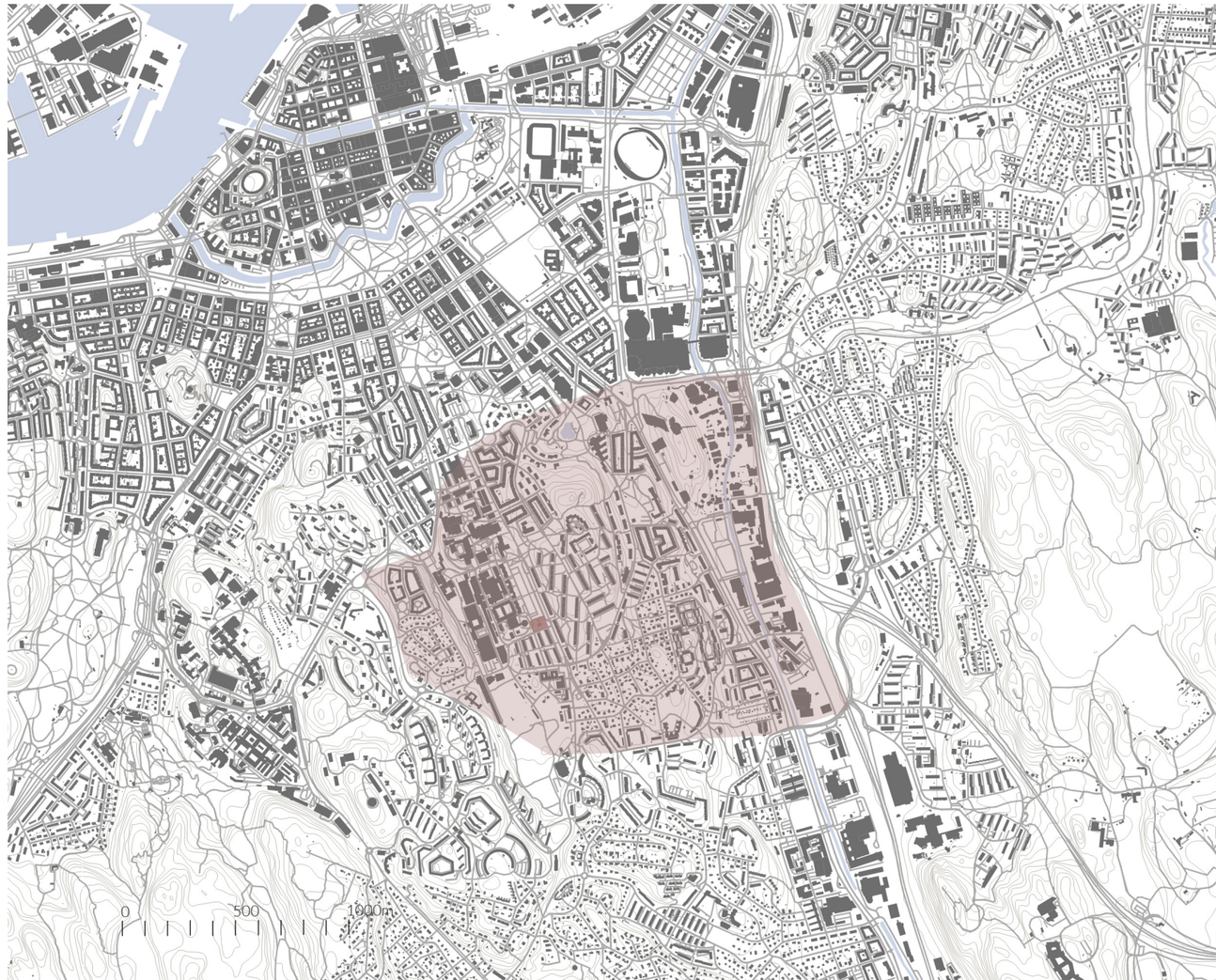



**Figure 25.** City map of Gothenburg, Johanneberg area, and case study location.

## Local Context: Johanneberg

**Figure 26.** Aerial photo of Johanneberg (2013).
(photos by author: unknown/ source: https://commons.wikimedia.org/wiki/File:Aerial_photo_of_Gothenburg_2013-10-27_164.jpg).

**Figure 27.** Aerial photo of Johanneberg (n.d.).
(photos by author: Oskar Bladh (1895-1973)/ source: www.digitalmuseum.se).

## Situation Plan


**Figure 28.** Situation Plan of the case study project *"Gibraltarvallen"*.





## Site analysis

The site analysis map (QGIS) made for this thesis, shows the built environment year of construction, indicating that only a small minority of buildings were built in recent years.

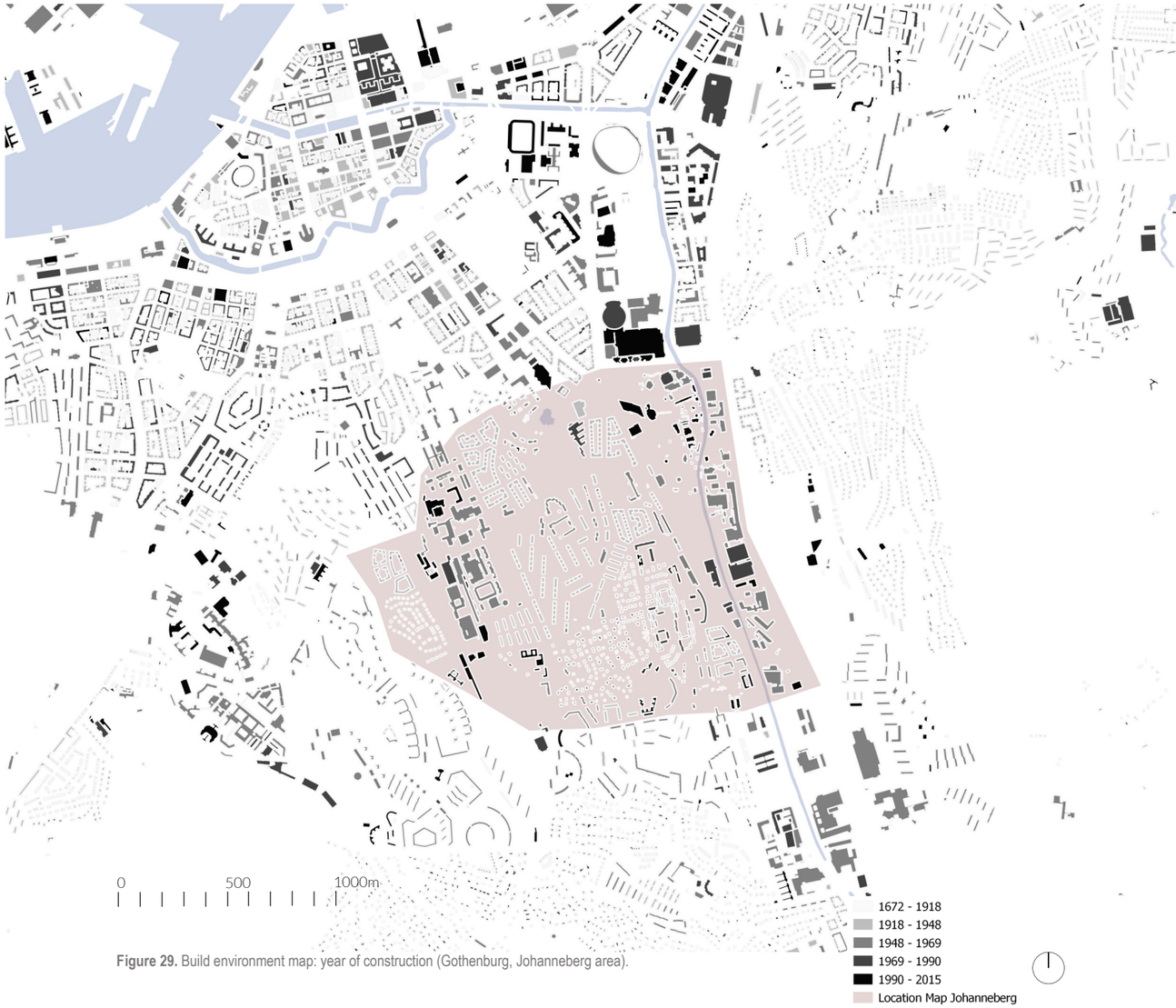



**Figure 29.** Build environment map: year of construction (Gothenburg, Johanneberg area).

## Ortophoto Map of Gothenburg Area

Chapter 3 - Multi-family Residential Project for *Gibraltarvallen*

**Figure 30 and 31.** Ortophoto maps of case study location (n.d).
(photos by author: unknown / source: https://geodata.chalmers.se/).

## Demographic Change

Regarding demography and residential design as ways to plan Housing, Sweden's regulations describe housing as a critical asset and a precondition for people's welfare, making housing production a major societal challenge and challenging the longevity of the stock of housing and its geographic mobility. (Boverket, 2016).

It is difficult to predict future demographic conditions, so we must assume they are unknown. One thing that can be forecasted is that the needs will be different for the next generation from today. (Schneider & Till, 2007).

Apartments with a variety of floor plans that can accommodate a variety of household configurations and accommodate a range of layouts within a limited space are more likely to be in demand due to unpredictable demand for housing. Modern apartment designs do not fully take this into account. (Braide, 2019).

## Sweden and Gothenburg Today

**population**
**10.38 million in 2020**

**these individuals living in**
**4.8 million households**

**population**
**estimated to increase**
**11.7 million in 2060**

**most common represents**
**40% households**
**single households without children**

source: www.statistica.com (Sweden 2020)

**population**
**SWE**
**87,6% live in urban areas**

**(Sweden) 2020**

**population**
**GBG**
**99,3% live in urban areas**

**(Gothenburg) 2020**

source: www.scb.se

Chapter 3 - Multi-family Residential Project for *Gibraltarvallen*

## Regarding Space

**living space per person**
**DK**
**53 sqm**

**(Denmark) 2021**

**living space per person**
**SWE**
**42 sqm**

**(Sweden) 2019**

source: www.stadbank.dk

**living space per person**
**GBG**
**36 sqm**

**(Gothenburg) 2019**

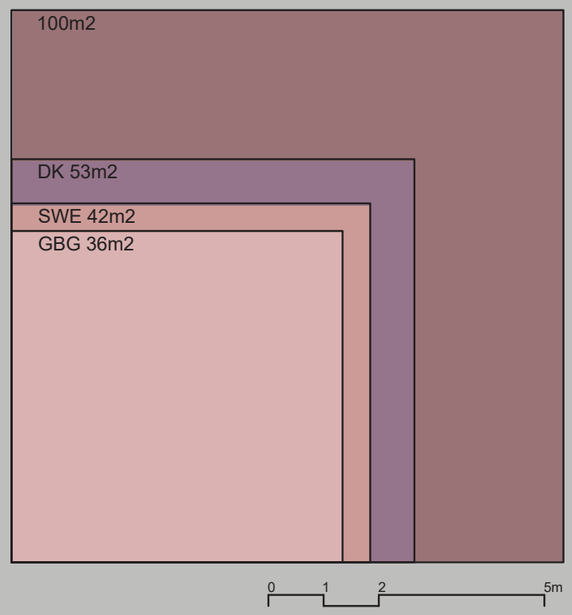



**Figure 32.** Representation of living space per person in sqm.

**most common dwelling**
**2 rooms and kitchen**
**with average living space**
**57 sqm**

**(Stockholm/Gothenburg/Malmö)**

**which represents**
**40% of dwellings**

**(Gothenburg) 2016**

**households type**
**52,1% single**
**38,8% living together**
**9,1% other households**

**(Gothenburg) 2020**

source: www.scb.se

## Households Type

In Anna Braide's (2019) research, she claims that apartment designs today are characterized by a top-down approach, neglecting housing social dimensions and longevity. She concludes that the spatial preferences and needs of individuals occupying the properties and their desire to coordinate and plan their own space are part of the family life course. As Braide (2019) notes, by observing contemporary apartment design, the designers are unwilling to acknowledge the manipulation of space by the families themselves as legitimate; instead, they view the use of space from a top-down perspective. Today, the design of residential buildings often presumes that relocation is the appropriate response to changing spatial requirements.

As part of the development and practice of current apartment design and research on adaptable apartments, the living process and life course situation are critical factors to consider.

Today the issue of the households' living process and life course is not taken into account, and the focus on rational and standardized housing in an attempt to produce qualitative and affordable homes has led to a top-down perspective that ignores this issue.

Research shows that the need for households to have the ability to rearrange their living space remains a concern. (Braide, 2019)

Households address the issue by taking steps to overcome the neglect of design practice. By not considering the processes of family life when designing apartments, housing production does not meet the spatial needs of the home, and consequently, this leads to the loss of social qualities that could have been developed, consequently compromising long-term housing availability.

In order to understand the user challenges and the complexity that each household faces today concerning rapid changes and the need to become more resilient, based on the identification of different types as more generic households, this thesis investigates and examines that, according to Bendik Manum (2009), to help determine the non-specific types of households that exist today.





## *"The Households in the New Dwellings" (Manum, 2009)*

Considering contemporary housing and the contexts in which it exists, Manum (2009) concludes that the recent trend in apartment design is notable in that the design criteria appear to be different from those related to daily domestic needs.

Since the late 1990s, the floor area of apartments and the size of individual rooms have decreased rapidly, and they are now much smaller than the recommendations of the Scandinavian housing research institutes.

Today's typical apartments with only one room for daytime living are well suited for some households. This category includes young couples and singles (a group that has been on the rise in recent years due to a later start to family life) and older couples (whose children moved) who prefer to sell their older home and garden area. Manum (2009) termed this type of household "Uniform", where daily life can be conducted in one room without causing conflict.

Likewise, the new apartments do not meet the needs of other households involved in many "not easily coexisting activities". There are many types of these households, and Manum referred to them as "Less uniform".

One of these households is for those who prefer separate spaces, either men or women, based on their cultural heritage. Another is the typical but unconventional family (such as families with young children in which one parent also has teenagers at home), and a third is a different type named "Several-adult-households" (such as students living together in one apartment).

The households above termed "Uniform" constitute the majority of the population of customers purchasing new apartments. Since the profits gained from building and selling four or five apartments of 20 m2 exceed those gained from selling one apartment of 100 m2, most new apartments are small. It is important to note that these "Uniform" households influence the size of new apartments, becoming smaller and impacting the layout of the larger apartments. In larger apartments, the "living-and-kitchen-room" tends to become bigger, while the bedrooms become smaller.

Although new apartments tend to be relatively small, they tend not to have extra-large bedrooms or other living spaces other than the 'living-kitchen-dining room'. New apartments tend to have just one living space, regardless of their size.

Accordingly, the new larger apartments are not intended for a different type of household than the new small apartments, but rather for the more wealthy members of the same kind of household. (Manum, 2009)

Several types of households were determined as "Kinds of Households" according to Bendik Manum's research in order to investigate the distribution of households within different apartments:

"Uniform Household"
"Less Uniform Household"
"Several-Adult Household"

According to Manum's (2009) definitions, this thesis seeks to identify a variety of households that exist today, thus highlighting their wide variety. (Figure 33)


**Figure 33.** Many Households Type.

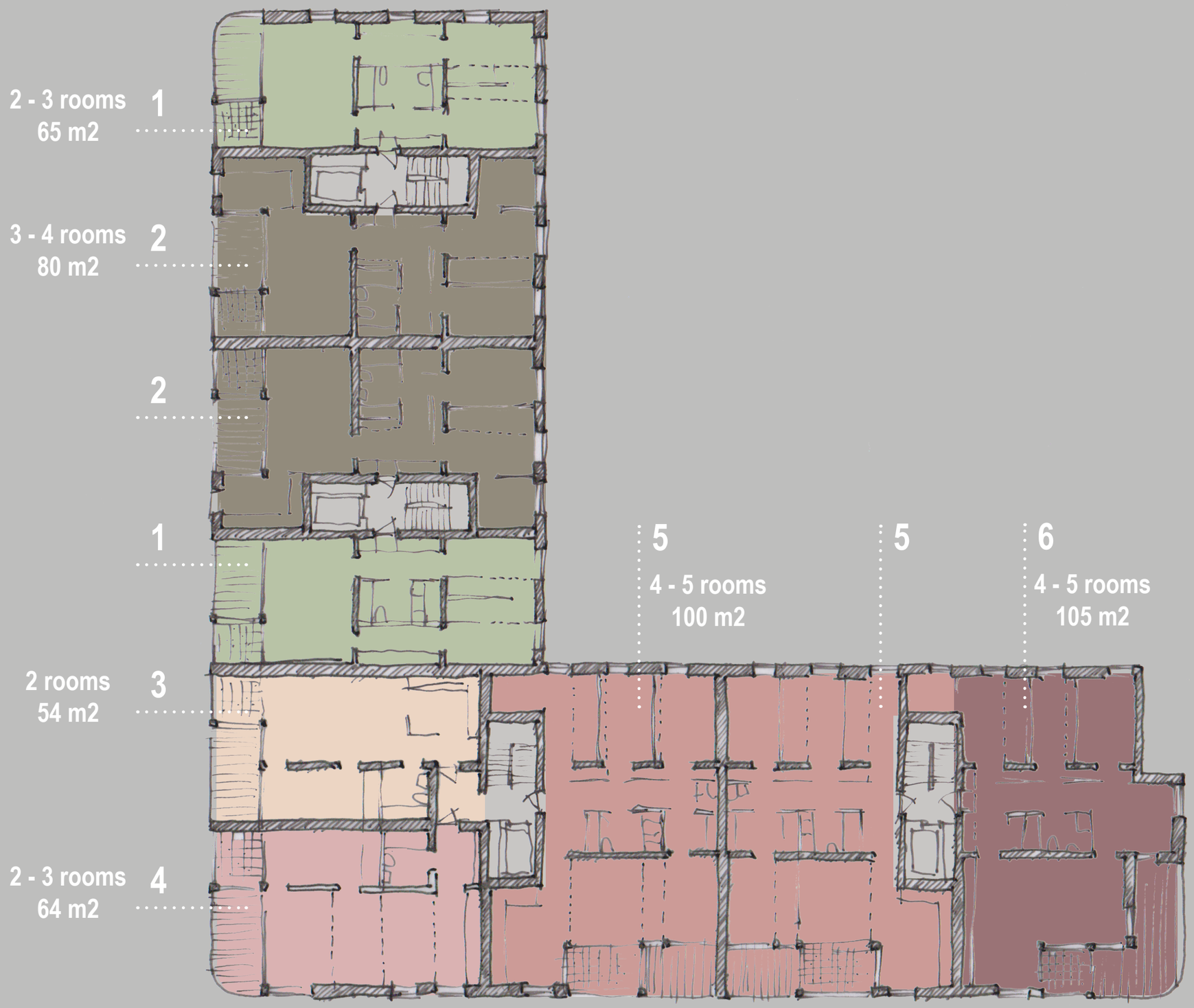



**Figure 34.** Floor plans typologies from case study project, (First Stage).

Chapter 3 - Multi-family Residential Project for *Gibraltarvallen*

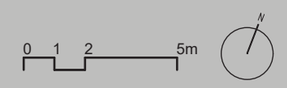
# Existing Proposal (Sweco)

## Typologies Study - First Stage

On working with different strategies of adaptability concepts concerning the usability of the apartments, the findings would include and develop theories on what type of adaptability could be practical regarding wooden architecture, considering design factors. In the end, it aims to suggest a system or principle for how wooden architecture can provide adaptable spaces.

The concept should provide people with opportunities to live more resiliently throughout their lifetimes, challenging established patterns for housing.

The case study analysed has had two stages of development so far. The first stage was the Competition phase (Markanvisningstävling), and the second was the Design development phase (Programhandling), where the project is today.



Chapter 3 - Multi-family Residential Project for *Gibraltarvallen*

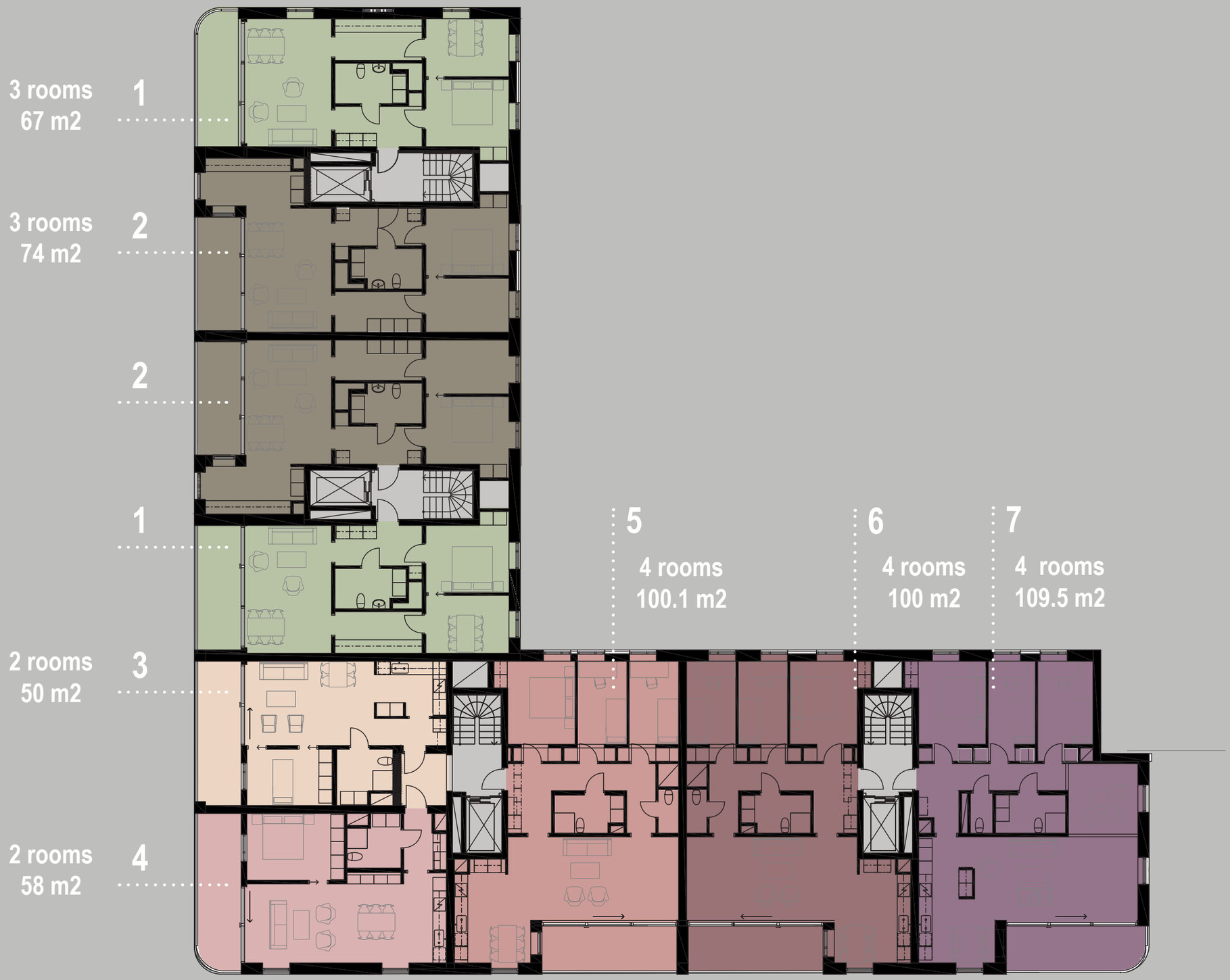



**Figure 35.** Floor plans typologies from case study project, (Second Stage).

# Existing Proposal (Sweco)

## Typologies Study - Second Stage

Some changes occurred from one phase to the other, as sometimes happens in the development of architectural projects. In the second phase, the main changes were that the project proposal reduced some areas, removed the greenhouses, and fixed the flexible walls in the floor plan. These changes do not mean that these intentions will not be implemented or be forgotten; it somewhat means that they are not present at this stage and may not continue in future development.

From meetings and interviews with the housing developer and the architects responsible, all these first ideas were exciting, but this was set aside for some technical challenges not fully solved.

This thesis proposal aims to bring light to these design solutions, often so attractive in the first ideas but sometimes set aside.


**Figure 36.** Floor plans typologies from Master thesis Final Design Proposal V06 A.

Chapter 3 - Multi-family Residential Project for *Gibraltarvallen*

# 3.2 - Final Design Proposal (Master Thesis)

## Typologies Study - V06 A

When starting from the case study, the design proposal of this thesis divides the project's implantation area (limit) to standardize dimensions and create possible configurations from the definition of modules, thus creating a more uniform typology and facilitating the future production of the prefabrication in wooden modules.

The proposal tested six versions.

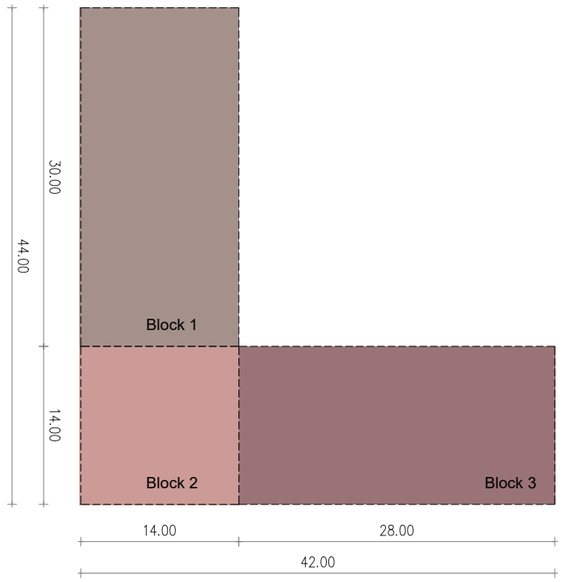
This is the Final Design Proposal V06 A, and this one presents a larger version in terms of typology areas than the first versions, as the dimensions of the case study are more restricted than V06 A. This decision was a conscious choice regarding the proposed design presented as optimal, reassuring that the quality of the housing space is a relevant factor for the user and for the possibility of implementing the concepts of Generality and Polyvalence. As a result, the larger the size of the "room", the greater its adaptability.

A more simplified variation, V06 B, will also be presented later. (Figure 41 p.70 and 71)

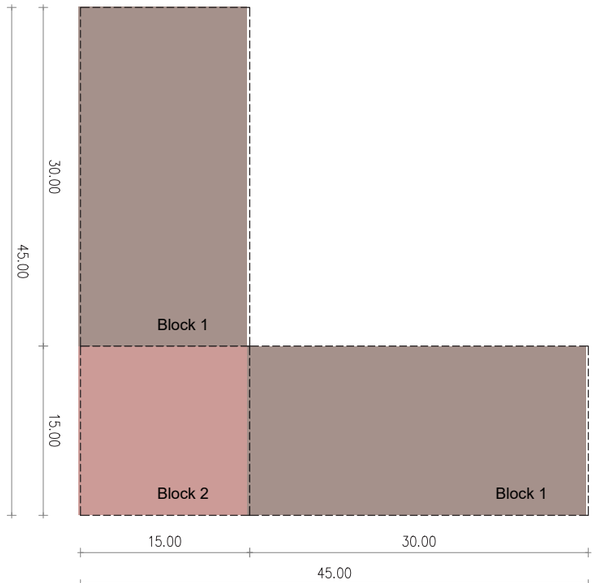
# Final Design Proposal (Master Thesis)

## Typologies Concept Model - Previous Studies Versions V01, V02, V03 and V04

V01 tries to have more units similar to improve modularity, while V02 tries to follow the case study development more accurately.




V03 and V04 were tested to challenge the system, looking for more versions that could result in a design where the distribution halls (stairs and elevators) were in the centre, searching for an optimal design proposal. These versions allowed to conclude that the anchor block did not work well mainly because of daylight problems. The next version, V05, changed the location of the main circulation areas to make them more central in the dwelling. (Appendix II).



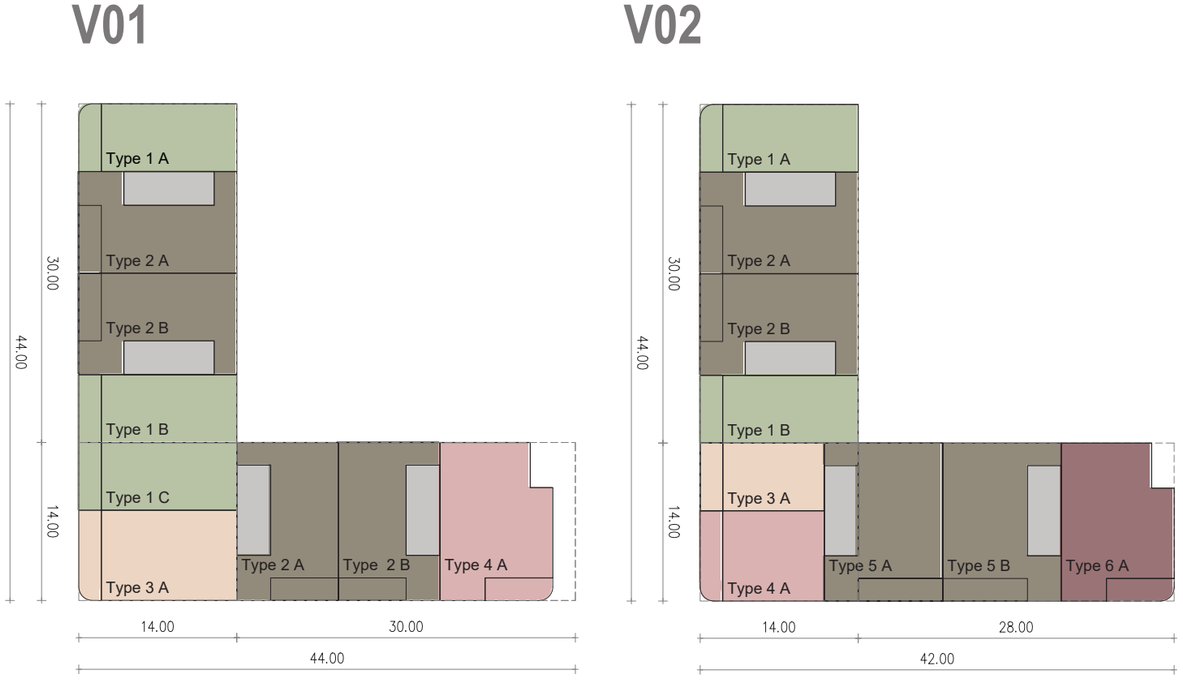
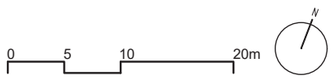




**Figure 37.** Floor plans typologies studies V01 and V02.

**Figure 38.** Floor plans typologies studies V03 and V04.



# Final Design Proposal (Master Thesis)

## Typologies Concept Model - Previous Studies
## Version V05 Spatial Configuration E

V05 with Spatial Configuration E (Appendix II) is then one of the last draft versions for the attempt to propose a final design, having improved the modularity of the dwellings in terms of similar sizes and enhancing the possibility of replication and multiple solutions that then led to V06 A, which kept the similar spatial configuration D from V05.

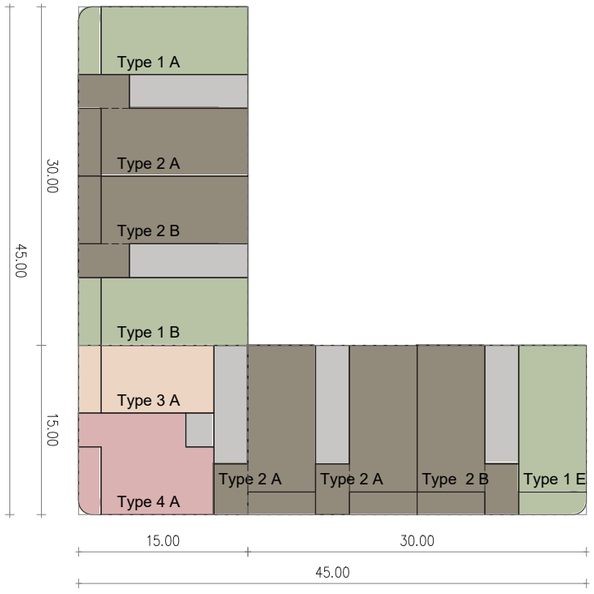
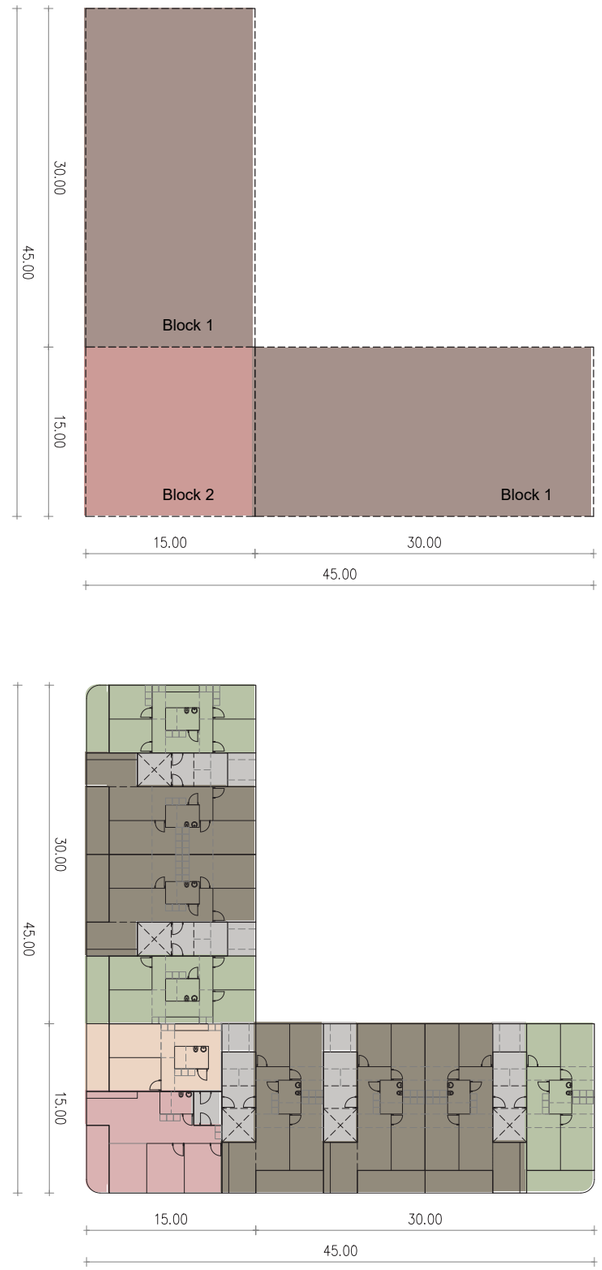



**Figure 39.** Floor plans typologies studies V05.





# V05



# Final Design Proposal (Master Thesis)

## Typologies Concept Model - Final Design Proposal

V06 version was designed intending to comply with BBR requisites in terms of space quality and areas for living, but also with the minimum of 12,5 m2 for the “multipurpose room” prerequisite, thus representing a minimum value of 12,5 m2 for smaller “room” areas and in some cases offering even more extensive areas of 14 to 16 m2 for the larger “rooms”.

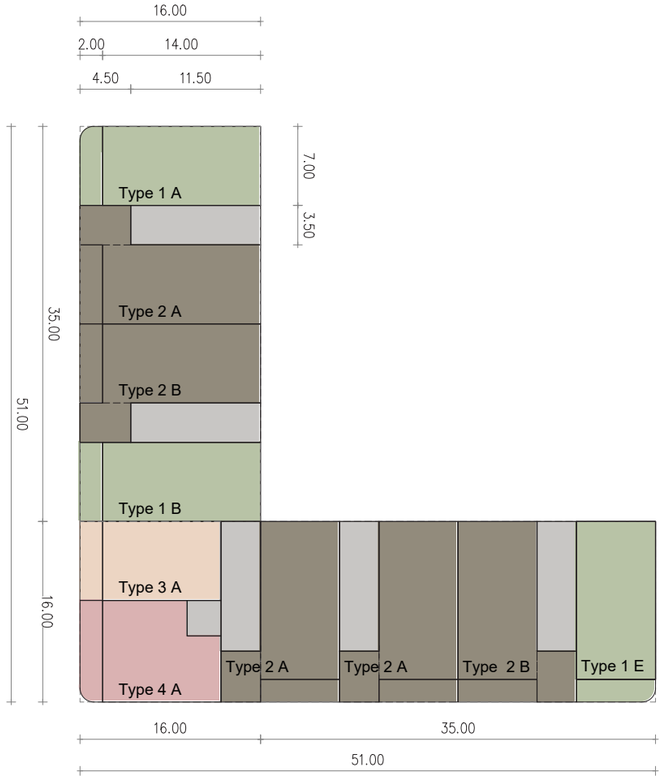
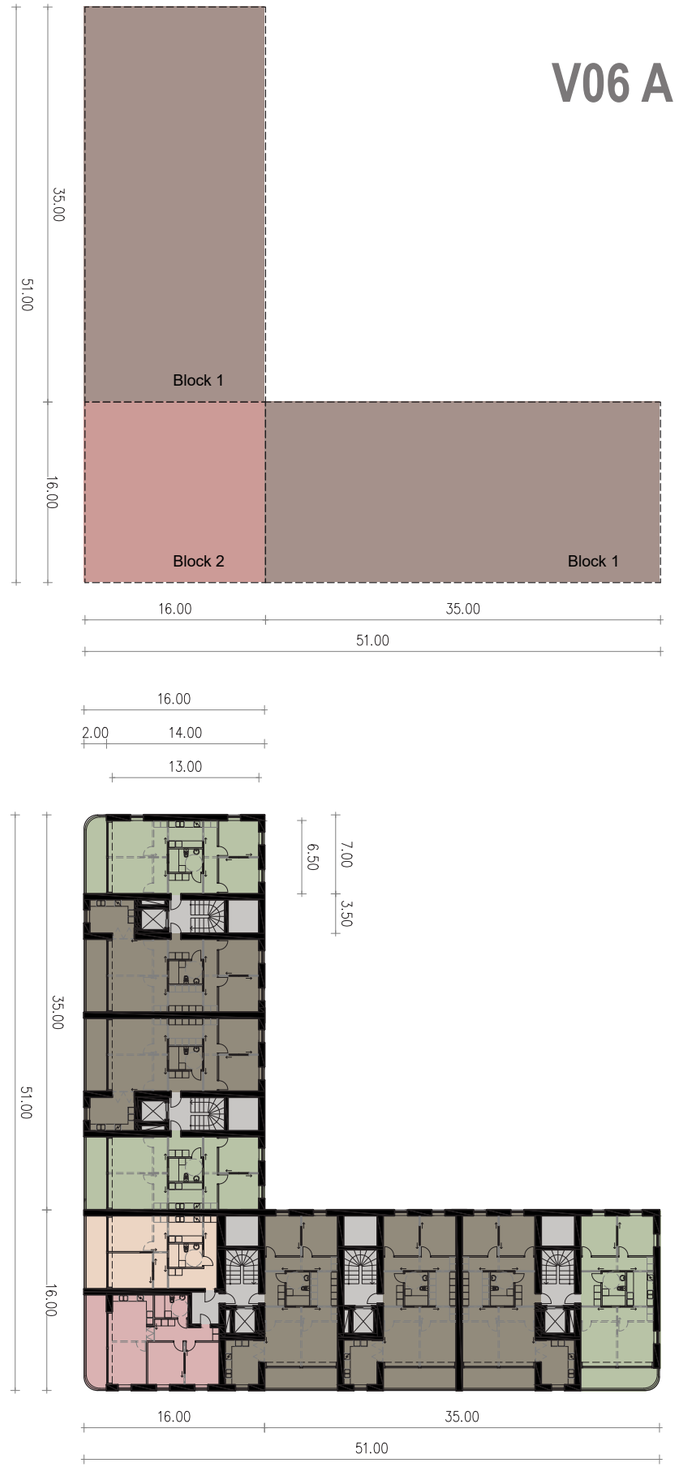



**Figure 40.** Floor plans typologies studies V06 A, final design proposal.







# Final Design Proposal (Master Thesis)

## Typologies Concept Model - Final Design Proposal Version V06 B Spatial Configuration E

An adaptation of the Final Design Proposal V06 A is presented below. In this variation, a circulation core (stairs and elevator) and one apartment module is removed to reduce costs, revealing how the building design may adapt to different requirements.

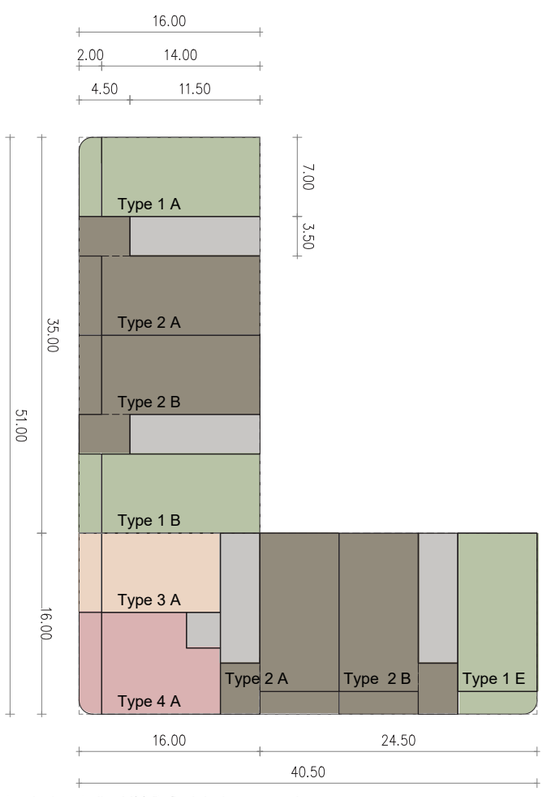
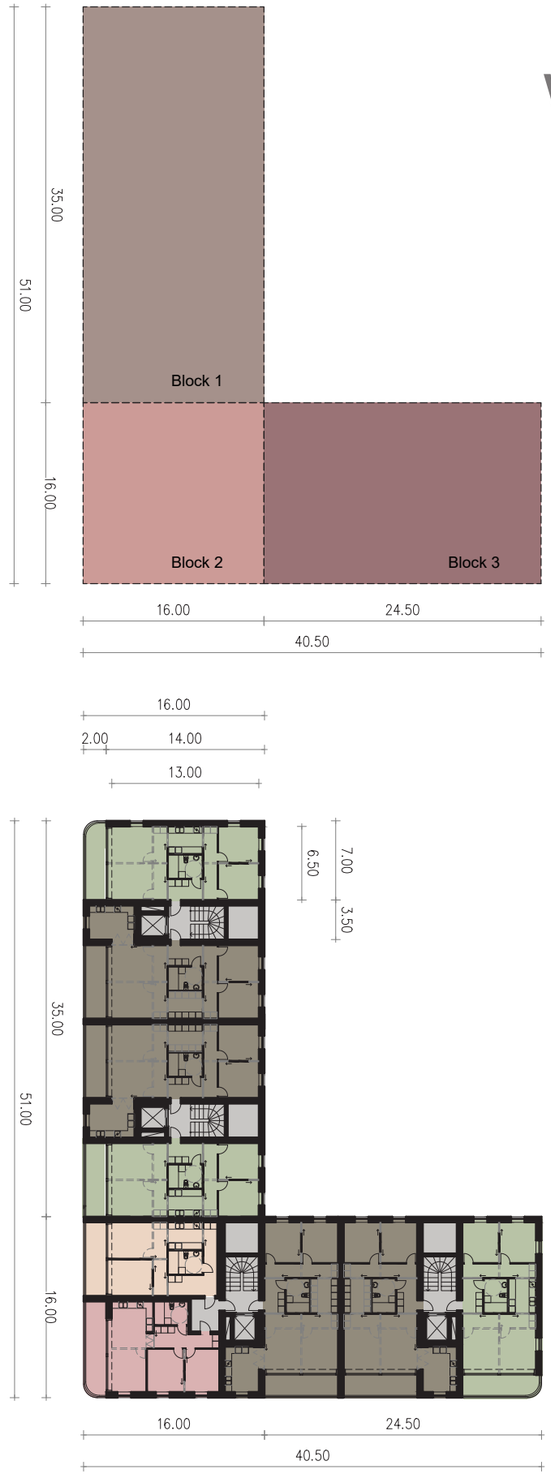


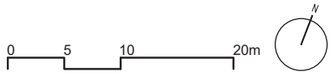

**Figure 41.** Floor plans typologies studies V06 B, final design proposal.





# V06 B



# Final Design Proposal (Master Thesis)

## Typologies Concept Model - Many Possibilities

### Modularity and Composition

The design proposal is also based on the precondition of the modularity that wooden construction offers to make the dwellings adaptable. With the proposal of several typologies (wooden modules), it seeks to create a concept model that can replicate those same qualities found in each apartment type in future projects, and this precondition has become a crucial part of the final design proposal.

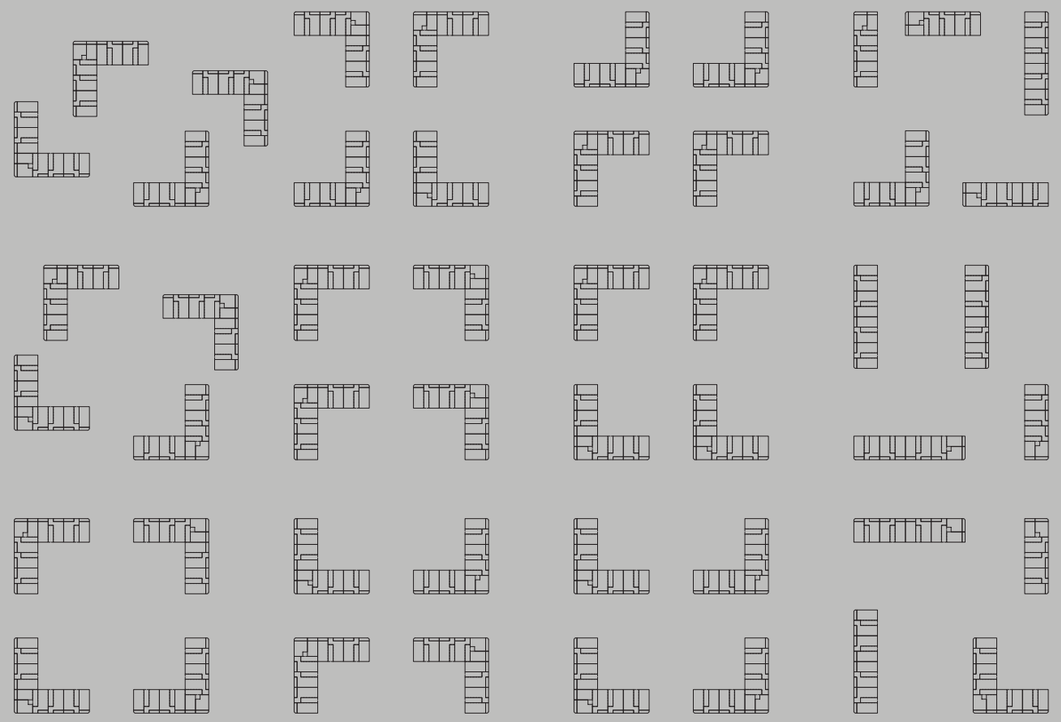


**Figure 42.** Floor plans typologies showing many possibilities.

Chapter 3 - Multi-family Residential Project for *Gibraltarvallen*

### Physical Model (Wood)

Physical models helped test the different possibilities that the concept offers.

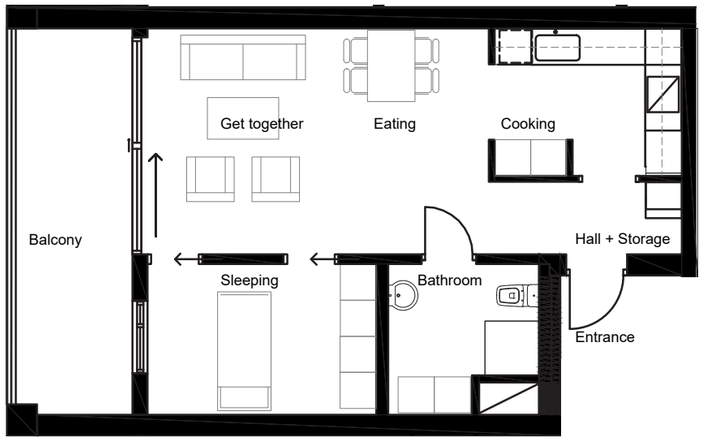
For this, two models are presented: the final design proposed and another for the Typologies Concept Model, showing many possibilities, where different typologies can be combined and replicated in future projects. The latter allows visualisation, experiment, and testing of the concept model's many possibilities.

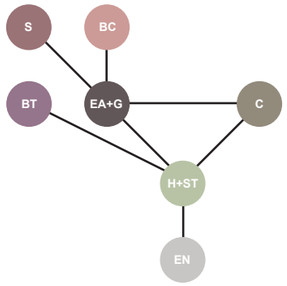
The model represents the typologies concept studied in the design proposal. Five types of wood, each with a different colour, suggest identifying the typologies studied in V06 and are presented from the lightest to the darkest colour: Limewood, Pinewood, Beechwood (Bok), Oak Oakwood and Mahogany wood.

**Figure 43 and 44.** Photos of the physical model 1 for the Final Design Proposal.

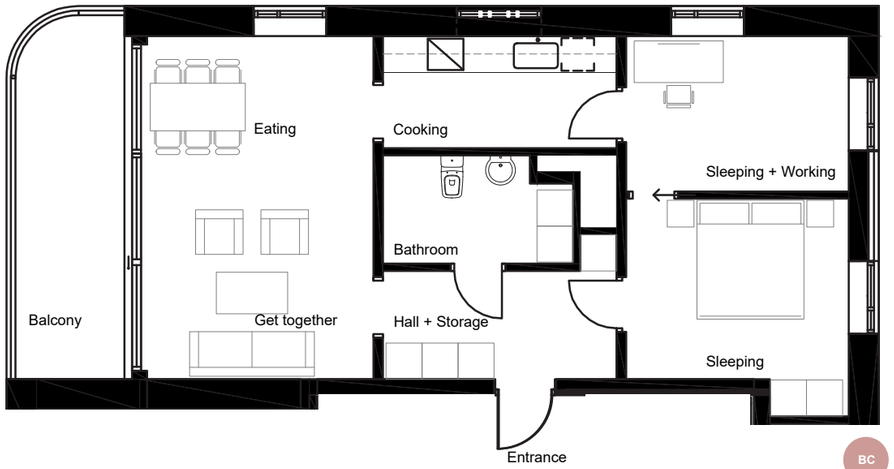
**Figure 45 and 46.** Photos of the physical model 2 for the Typologies Concept Model, showing many possibilities.

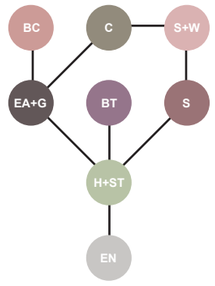
# Existing Proposal (Sweco)




## The Small dwelling
## 2 rooms
## 50 m2



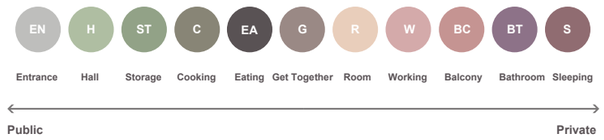

## The Medium dwelling
## 3 rooms
## 67 m2

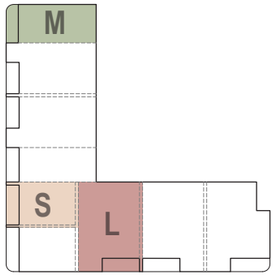


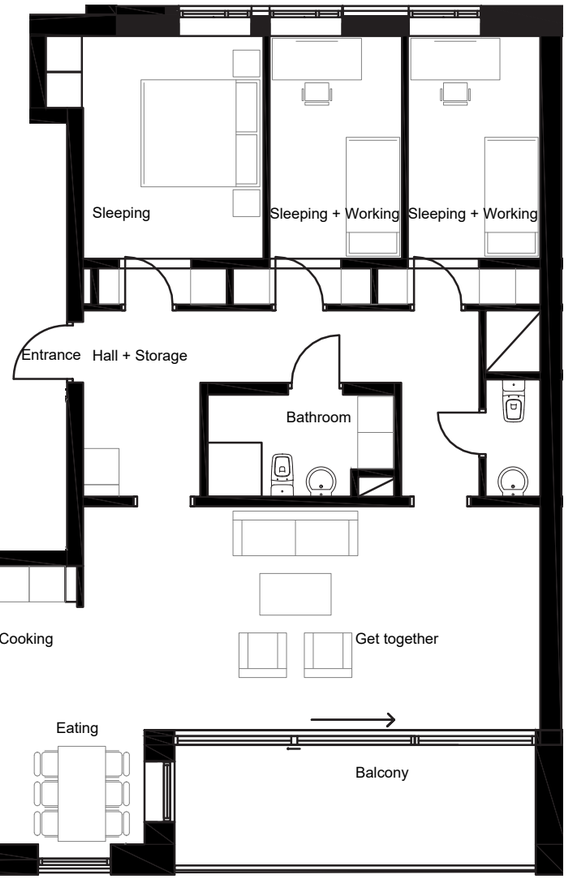


# Spatial Analysis - Space Syntax

## Dwelling Type S, M and L




## The Large dwelling
## 4 rooms
## 100m2

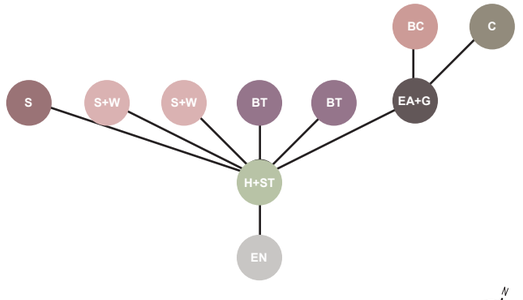
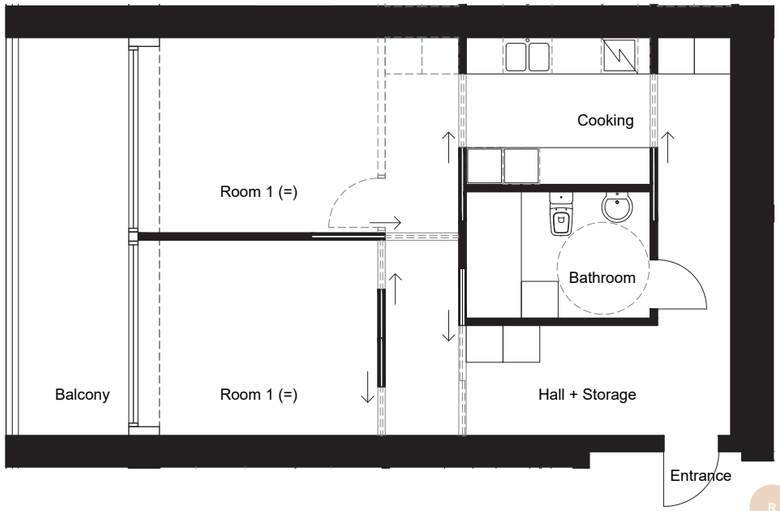
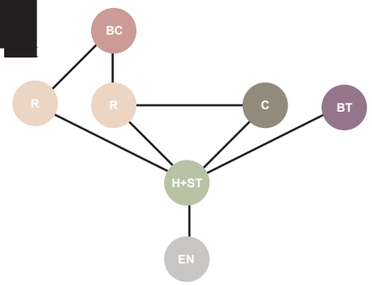




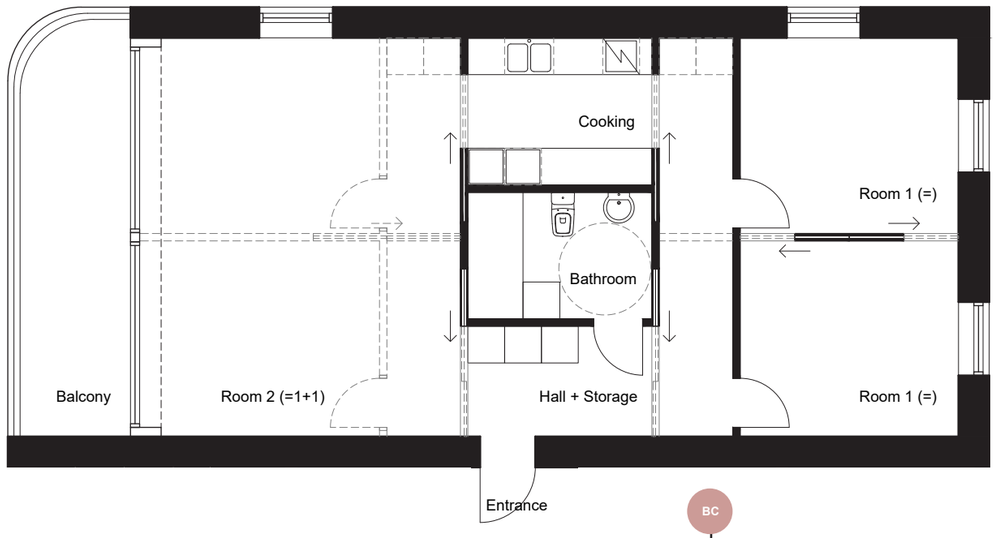
**Figure 47.** Floor plans analysis according to module proposal of the three dwellings (S, M and L) and correspondent connectivity graphs, for Existing Proposal (Sweco).

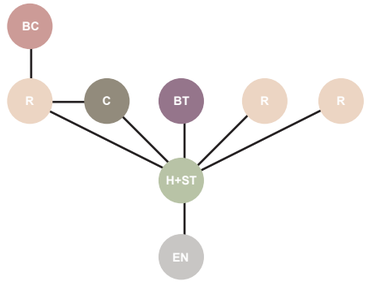
# Final Design Proposal (Master Thesis)




## The Small dwelling
## 2 rooms
## 55 m2




## The Medium dwelling
## 3 - 4 rooms
## 83 m2

**Figure 48.** Floor plans analysis according to module proposal of the three dwellings (S, M and L) and correspondent connectivity graphs, for Final Design Proposal (Master Thesis).

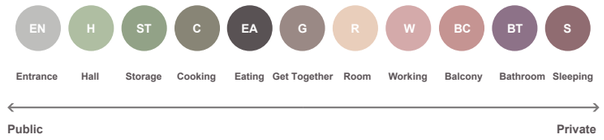


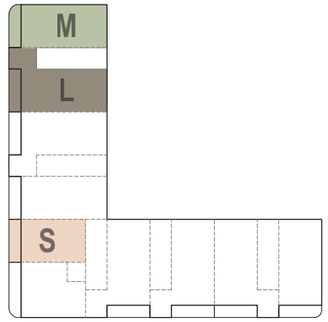


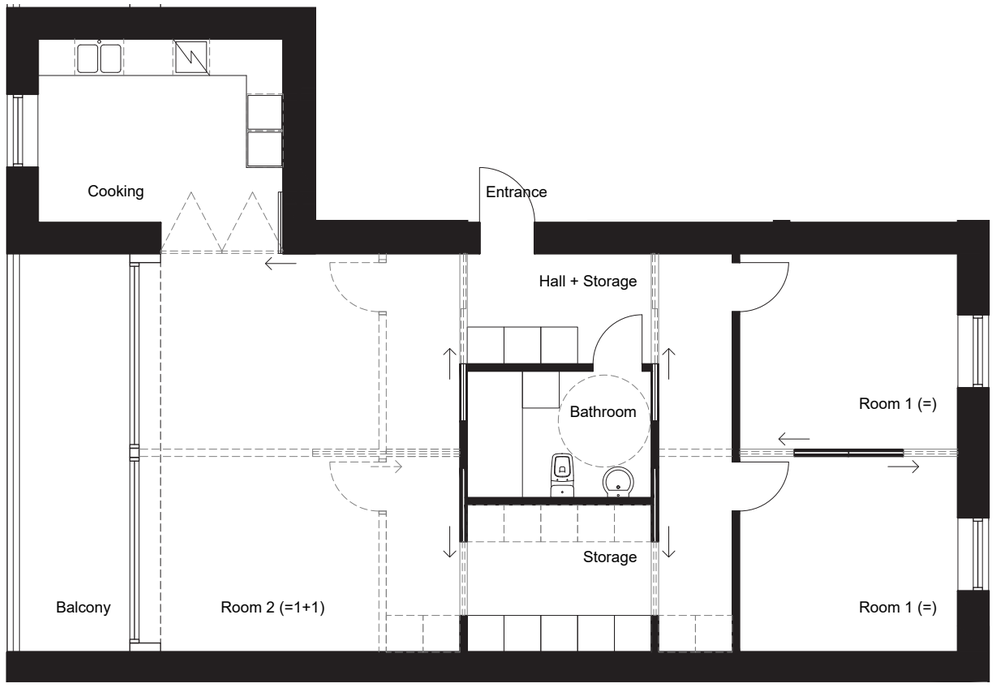
## Spatial Analysis - Space Syntax

# V06

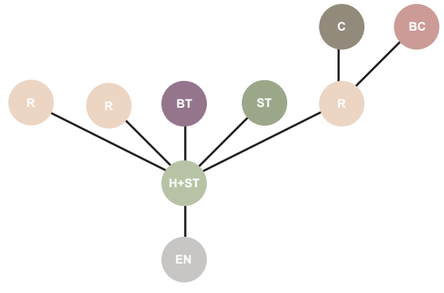
## Dwelling Type S, M and L

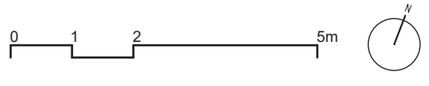


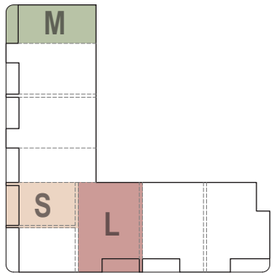

## The Large dwelling
## 3 - 4 rooms
## 96 m2



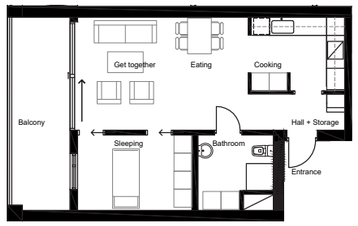



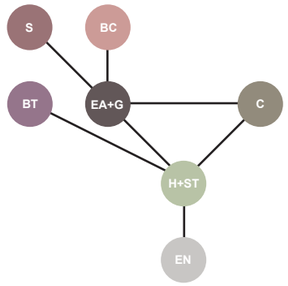
# Existing Proposal (Sweco)

## Space Syntax Comparison - Dwelling Type S, M and L



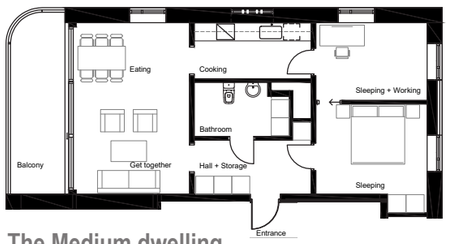

**S**

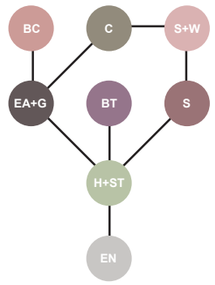



The Small dwelling
2 rooms
50 m2

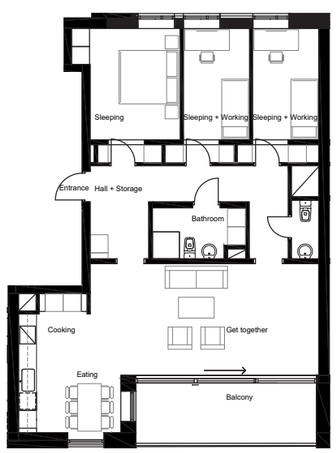
**M**

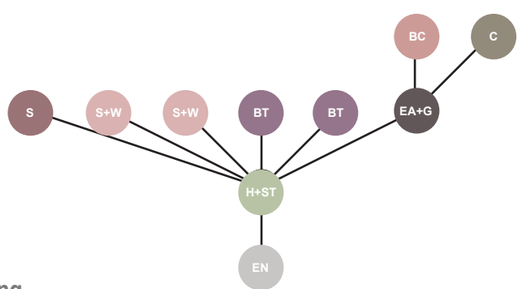



The Medium dwelling
3 rooms
67 m2

**L**




The Large dwelling
4 rooms
100m2

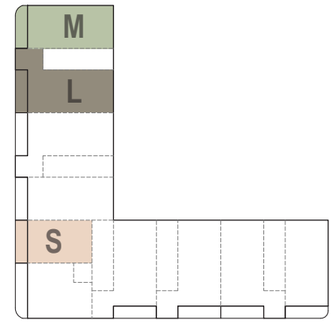
**Figure 49.** Floor plans analysis comparison between Existing Proposal (Sweco) and Final Design Proposal (Master Thesis).



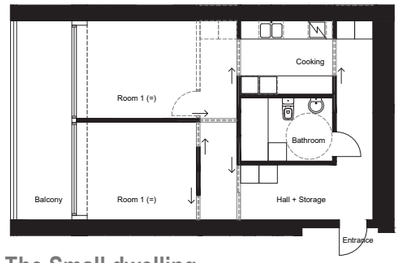


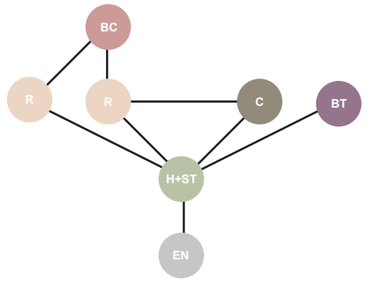
# Final Design Proposal (Master Thesis)

## V06



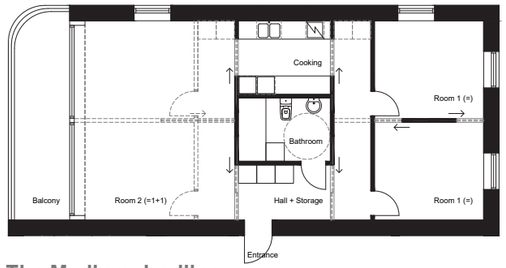

**S**

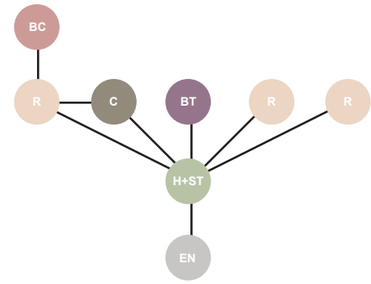



The Small dwelling
2 rooms
55 m2

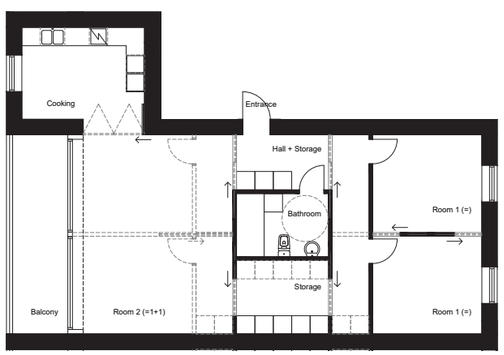
**M**

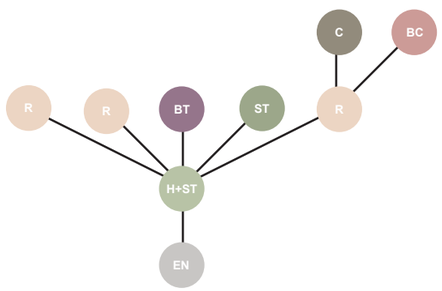


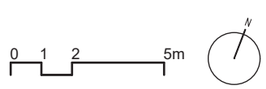

The Medium dwelling
3 - 4 rooms
83 m2

**L**




The Large dwelling
3 - 4 rooms
96 m2



# Final Design Proposal (Master Thesis)

## The Dwelling Type S, M and L

Within this thesis, the concept of adaptability sees through the lens of the common condition of expanding and contracting household sizes.

The thesis examines the sequence of periods in life in which the family needs to change and ultimately move out, to study the process of expanding and contracting. During this time, a family goes through its life course. If the apartment can offer the ability to expand or contract with the household size, this reflects a quality that can serve many different household types. (Braide, 2019).

The design proposal develops different typologies to define three types of dwellings: small, medium, and large. Furthermore, it uses these three definitions to analyse and compare the Existing Proposal from Sweco and the Final Design Proposal from this Master Thesis.

## Allowing Many Scenarios

Different conditions in a residence of the same size are studied and analyzed for research during the current year of 2022, a hypothesis for five years extension until 2027 and for ten years until 2032. Thus, creating three different scenarios in the possible useful life of each apartment S, M and L. Here possible layouts are proposed for a useful life of 10 years where transformations occur in each household. The proposed scenarios to be experienced for five years may also represent changes in shorter time periods.

When writing this thesis, the author genuinely hopes and believes that the reader can see himself represented in one of the possible scenarios presented in one way or another and thus reflect on the possibilities that spaces allow for changes and adaptations, whether physical or not.

Further, as architects/professionals or users, we may eventually be able to widen our vision to encompass these possibilities and choose a more resilient future entirely, consciously, and wisely for ourselves and future generations.

## Time-Space Model

The time-space model is a design model for understanding spatial needs over time, a strategy that is a critical tool for visualizing the apartment's living process and spatial use and can be applied in floor plan studies. (Braide, 2016)

One housing project that provides examples of the idea of a household's spatial needs evolving with its changing life course situation is the "Experimenthus" in Järnbrott. (Figure 12 and 13 p.38)

It is a complex challenge to design adaptable apartments; it is preferable to propose a way to understand and deal with the challenge rather than define how to design apartments, as this thesis understood. Moreover, the intention is to design apartment spaces that should consider the household's living process and life course and that the design can incorporate the social dimensions. Time-space model provides a toolkit for integrating these qualities. (Braide, 2019)

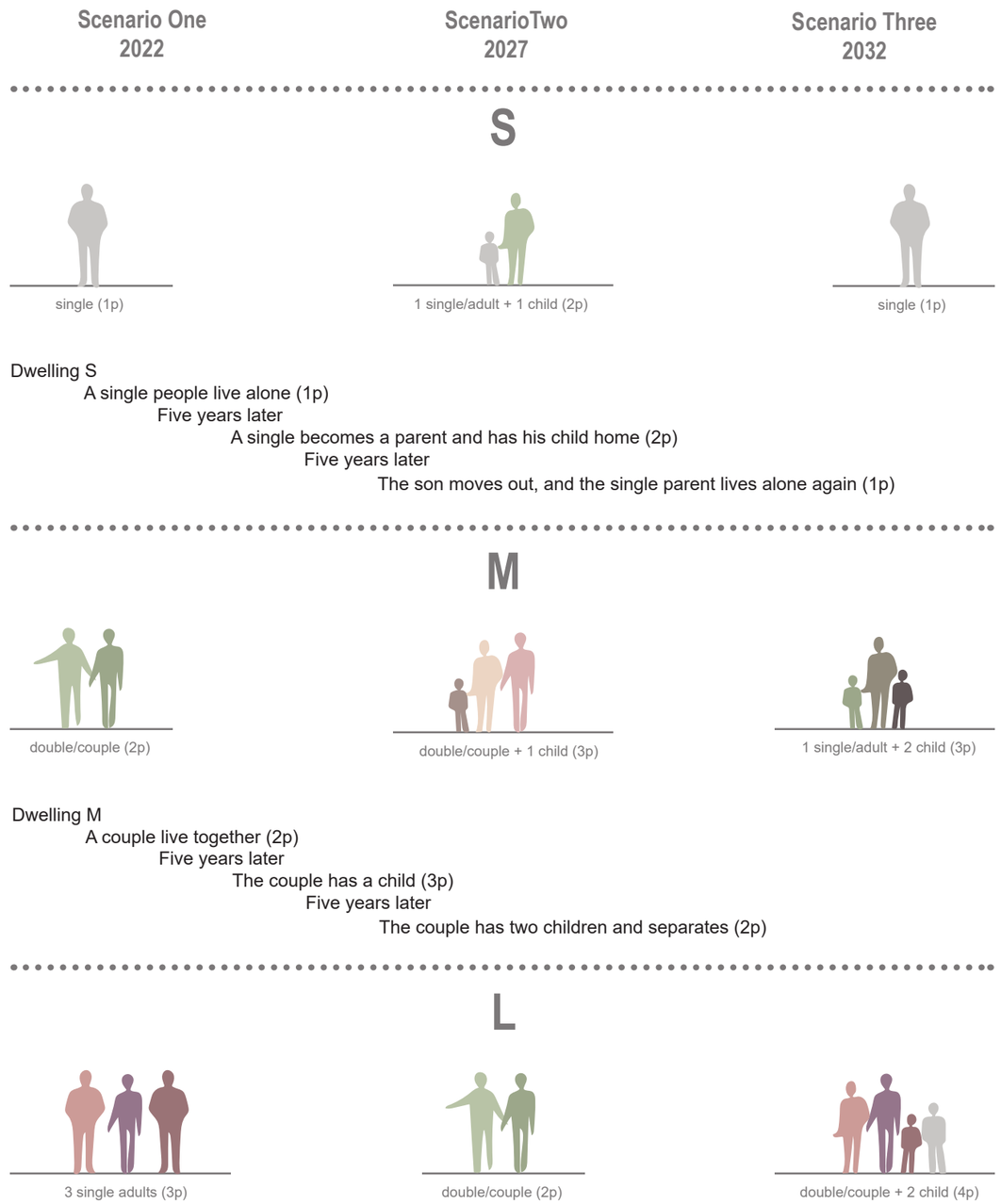


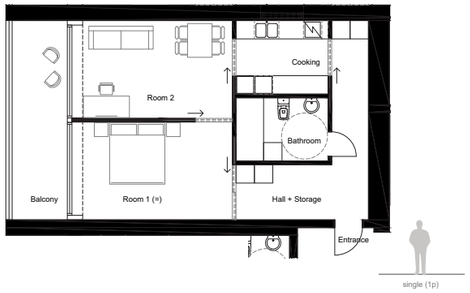

**Figure 50.** Scenarios and households type, are defined for the three dwellings (S, M and L).



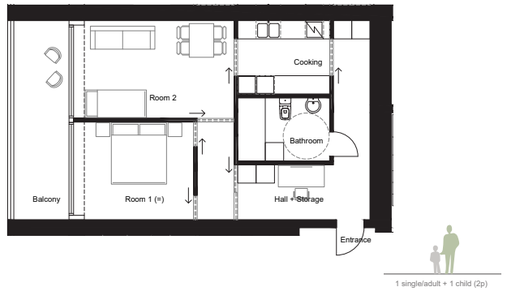
Chapter 3 - Multi-family Residential Project for *Gibraltarvallen*

# Final Design Proposal (Master Thesis)

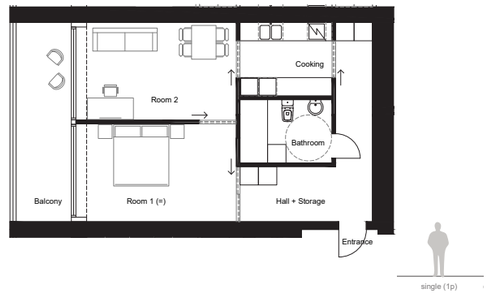
## Scenario One 2022



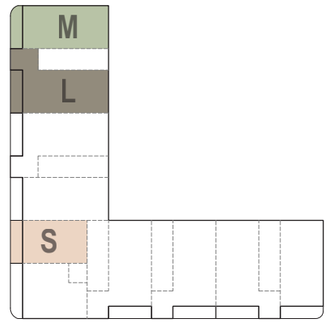

## ScenarioTwo 2027



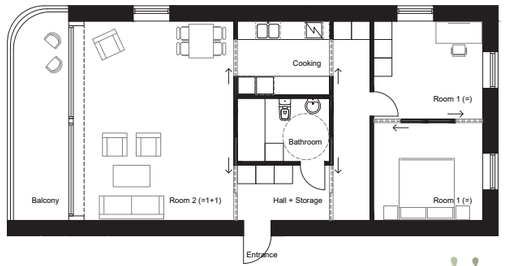

## Scenario Three 2032

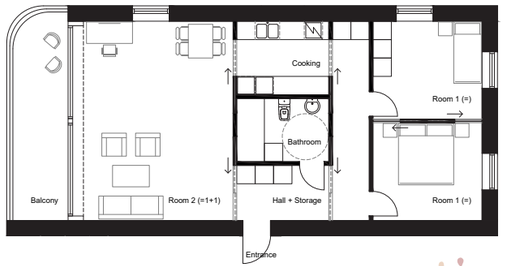


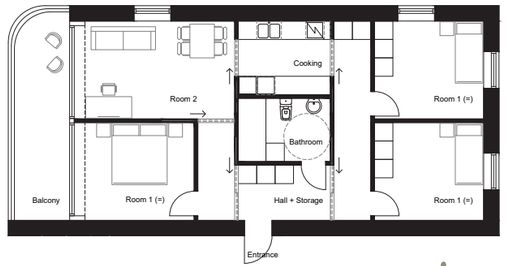

## S




Dwelling S
A single people live alone (1p)
Five years later
A single becomes a parent and has his child home (2p)
Five years later
The son moves out, and the single parent lives alone again (1p)

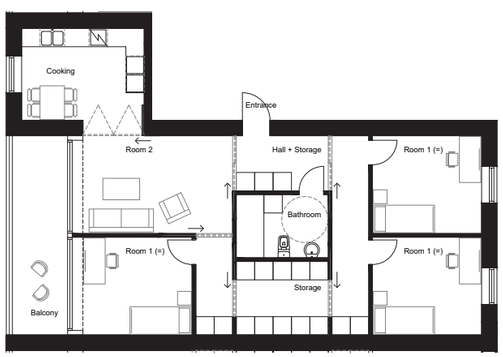


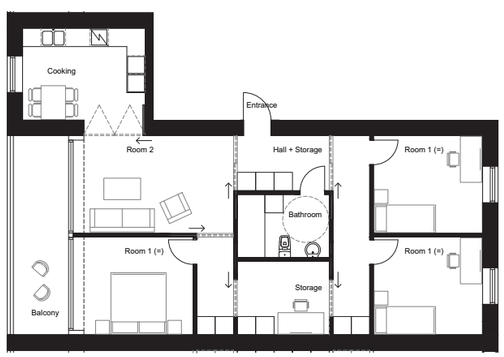




## M

Dwelling M
A couple live together (2p)
Five years later
The couple has a child (3p)
Five years later
The couple has two children and separates (2p)








## L

Dwelling L
Three adult students share an apartment (3p)
Five years later
One student leaves the apartment, and two live together as a couple (2p)
Five years later
The couple has two children (4p)

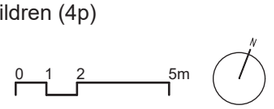



**Figure 51.** Final Design Proposal (Master Thesis), many scenarios and households type, for the three dwellings (S, M and L).

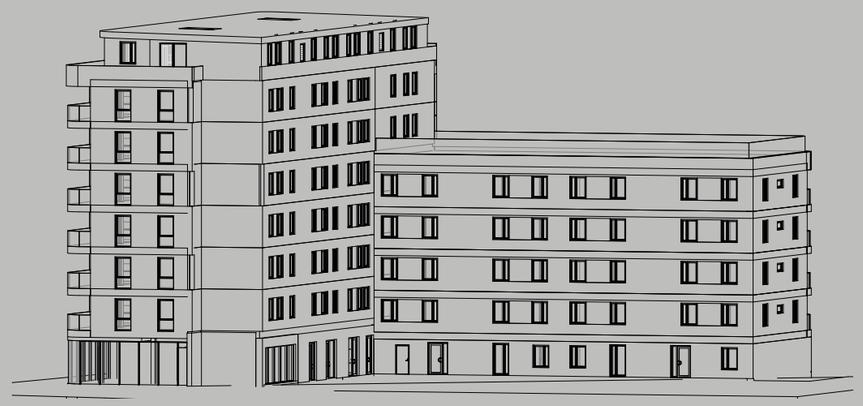


**Figure 52 and 53.** Technical drawings, showing elevations and perspectives.

# Chapter 4 - Conclusion

***"Finally, we need to reassert the central role of design and the new architecture to envision new futures, not in an ungrounded or merely speculative manner but in a way that materialises and spatialises revised social conditions and relationships, in which alternative narratives might be imagined. The climate emergency demands that we discover new ways of living; designers and the new architects after architects can be the agents of envisioning them, always in partnership with others." (Till, 2020)***

## Final Reflection on Adaptability Strategies and the Final Design Proposal

For each type of dwelling, the main objective was to define a design proposal based on the four strategies analysed in the theoretical framework: Generality, Flexibility, Elasticity and Polyvalence.

Understanding the most effective conditions to design, the ones that worked best were Generality and Polyvalence, also since both go together.

Flexibility can be achieved but raises more technical issues than any other, which, when considered truthfully, can be solved with more detailed drawings and accurate information for both (User and Housing developer).

Elasticity appeared difficult not only for the housing developer but also for the resident since some aspects of ownership could be challenging to define and implement.

With its ability to accommodate parallel activities and allow for different scenarios to become effective, the “Multipurpose Room” is one solution proposed, and this can be seen both as a Generality and Polyvalence strategy. A “room” is defined here as a space with no specific function and a size of around 12,5 m2 (Nylander, 2007), where many different activities can take place.

Schneider & Till (2007) defined “Functionally Neutral Rooms” as a system that provides several equal-sized rooms from a central hall or circulation spine. As a benefit of the “Functionally Neutral Approach,” the same dwelling can accommodate various user groups.

As a result, different social interactions and interpretations can evoke diverse cultural scenarios, creating independent spaces that can be used according to the needs of users, which inevitably change over time, while eliminating the hierarchies contained in room labelling. It involves allowing successive occupants to organise their lives spatially.

The central hall is an integral part of the design proposal, which uses this idea to provide light and other spatial qualities.

Initially, the Existing design (case study) was to showcase apartments where flexibility is a strong selling point for the “users” - enabling residents to live longer in the apartments, which is also beneficial for the housing developer. These ideas were getting lost throughout the design process, proving the difficulty of implementing concepts outside the mainstream when designing and selling houses for the current market.

It seems necessary that all the professionals involved in the project work together and in partnership from the beginning; this will enable to solving some of the technical issues that may arise in the future.

Another critical aspect that is an advantage of the case study when discussing adaptability, is that wooden construction responds to many technical problems, using prefabrication and having a producer who can produce the different elements in one place. The technicians involved work together, and the digitalisation of construction techniques using technologies such as BIM (Building Information Modelling) and CAD (Computer-aided design) is a positive aspect.

As mentioned in the previous chapter 2.4, wood construction presents an ecological advantage that transcends technical efficiency, speed of assembly, and waste reduction, and it now offers new possibilities for production and innovation with BIM and CAD. Advances in technologies in construction can also identify and overcome barriers in preconceived and already established ideas about the type of apartment a user wants and needs; this is a barrier that often persists.

Standard construction in the industry is inherently inflexible or inadaptable: cavity walls, trussed rafters in roofs - all these and more restrict future changes. Modern construction methods present a rare opportunity to reconsider how housing is constructed and can include adaptability without a more significant expense.

In order to achieve adaptability, two factors need to be considered: the design of the building, room, or unit, and the method of construction. It is necessary to think together about design and construction to achieve adaptability in the building. The starting point is to design inadaptability (inflexibility) out of the plan to construct adaptable housing. (Schneider & Till, 2007).

Wooden construction is not a condition to achieve adaptability in apartments, but its use can help implement it more efficiently and achieve a lighter and more modular construction, resulting in the modularity of different typologies.

Some of the wooden solutions (e.g., walls or doors) that are on the market or that may still be optimised and developed in the future can also help adaptability to be implemented by its users more effectively.

For the housing developer, the modularity of wooden construction can present a considerable advantage in the modularity of typology. The concept is intended to represent an optimal solution of apartment types for future projects, which can provide long-term benefits that are not only practical, but also economical as well as more environmentally friendly.





***“An understanding of the importance of a high-quality built environment and typologically flexible buildings will only be accomplished through an in-depth understanding of resilient development, particularly from its socio-spatial premises. This kind of development and the surfacing of it in the physical environment could be advanced by new initiatives that combine practical and theoretical knowledge and would also mediate them into practice so that it becomes the “normal” condition of society.” (Krokfors, K. (2017).***

**Figure 54.** Photo of the physical model 1 for the Final Design Proposal.

## Discussion

During discussions with the housing developer, one point that was noted was that in its first project (Brf Viva), offering flexible solutions in the design, was only able to adapt the apartment in the first phase, while in the following phases, it was no longer possible to do so or even inform the client (user) of these opportunities. According to the findings, it is essential to inform clients (users) about the adaptability of the space not only in the first phase when the client begins to use the apartment but also in the subsequent phases when the user changes and the apartment continues to be used, thereby aiming for adaptability not only in the short run but also over time.

This study argues that space and its production offer the possibility for new kinds of activities through the adaptive and transformative features of buildings. In promoting resilient development, structural concerns and materials are essential elements, but the key to the longevity of building space is the potential for a wide range of different uses. The contexts and needs of urban buildings change over time.

Natural resource exhaustion and climate change will lead to severe consequences, so it is imperative to establish the proper design and processes, specifically to determine which questions need to be asked in order to develop appropriate new approaches.

An increasingly multifaceted society based on differing viewpoints and objectives can lead to different outcomes. This study seeks to open and evaluate new perspectives for further analysis and development.

Referring back to the research questions:

*- How can adaptability strategies develop and create spatially optimal living environments that are resilient and best serve people?*

The theoretical research results and, consequently, the application of the concepts of Generality, Polyvalence, and Flexibility, together with the experimentation of the various design proposals, indicate that the answer is broadly positive while revealing the potential of the space. As a result, it provides users with a variety of different scenarios that may be encountered, and at the same time, it provides housing developers with numerous possibilities for future development due to the various types of housing being proposed. It promotes the opportunity for both to adapt the living space in the daily needs and the long term, bringing with it the desired resilience.

*- In what way can apartments in a multifamily residential building be constructed using cross-laminated wood and designed to meet the requirements of adaptable space?*

The proposed “typologies concept model” answers this question by exploring the modularity of apartment typologies, proposing more uniform dimensions that built-in wood improves the production of construction already described in the advantages of wood construction (chapter 2.4). It shows that more than just favouring the choice of wood as a constructive option, it also improves flexibility strategies if we think of light, easy and more ecological assembly, helping overcome some of the pre-established ideas of some of the technical limitations of adaptability.

Wood construction does not necessarily presume adaptability, but it can help overcome ideological barriers and preconceived difficulties relating to implementing these strategies, namely flexibility. The numerous innovations that are beginning to emerge can thus make it possible and propose new solutions in which adaptability is easy to apply.

The construction in modules of cross-laminated wood implies a significantly lighter construction than the traditional concrete structure; this allows greater freedom of positioning and a smaller number of walls and structural pillars. For this reason, the possibility of freer floor plans and wider spaces makes the possibility of applying the concepts of adaptability in floor plans also increase, proving that wooden construction is an advantage for the design of adaptability concepts.





## Conclusion

Despite the numerous advantages of wood construction, the question remains: Is the choice of wood in the construction of buildings a genuinely sustainable choice?

Furthermore, regarding the use of wood in building construction, and in order to achieve resilience, the industry cannot rely exclusively on exchanges of construction materials (such as concrete and steel for wood-based products), and it must adapt to a new sustainable framework, regardless of the inconvenience it may cause.

When analysed, research on how dwellings can be adaptable may provide a more comprehensive understanding of the vast possibilities.

In the context of changing and unpredictable uses, adopting different adaptation strategies in dwellings could produce a new generation of homes with interesting spatial organisation and substantial resilient expectations.

This thesis explores some other ways to think about adaptable spaces in architecture. In particular, it raises questions about the kind of knowledge needed in designing, producing and enjoying buildings to become resilient for the future in housing.

Will we have the possibility to change and adapt our dwellings at the pace of our real needs in the Future?
Will we in the Future build our buildings in wood?
Will we overcome the climate challenges ahead we are facing globally?

Only Future will tell.

It is vital to move past short-term thinking to long-term thinking to drive change.

## Final Notes from the Author

*As an architect, this is how I want to work now: including people, citizens, questions of resilience (social, economic and environmental) and all these crucial matters that I had the opportunity to reflect upon during this valuable time.*

*My skillset includes responsibility towards people and the planet, commitment, high competence, learning process and curiosity.*

*Thank you.*
*Raquel Domingues*

# References


10 New Insights in climate Science UN (2021). [Motion Picture]. Retrieved from https://www.youtube.com/watch?v=iW4fPXzX1S0.

Andersson, B., Jonasson, K., & Olsson, S. (1988). Experimenthuset i Järnbrott: erfarenheter från ett hus med flyttbara väggar. Stockholm: Stadens Råd för Byggnadsforskning.

Awan, N., Schneider, T., & Till, J. (2011). Spatial Agency: Other Ways of doing Architecture. Routeledge.

BBR, B. b. (2011). https://www.boverket.se/globalassets/publikationer/dokument/2019/bbr-2011-6-tom-2018-4-english-2.pdf.

Boverket. (2016). Reviderad prognos över behovet av nya bostäder till 2025. Karlskrona: Boverket.

Braide, A. (2016). Residential usability and social sustainability: towards a paradigm shift within housing design. Gothenburg: Chalmers University of Technology.

Braide, A. (2019). Dwelling in time: studies on life course spatial adaptability. Sweden: Chalmers University of Technology.
CIX. (2020). http://www.hallbarbyggnation.se/.

Elastiska-Hem_En-verktygslada-for-att-gora-boendet-mer-elastiskt. (2021). https://kodarkitekter.se/projekt/elastiska-hem/.

Femenías, P., & Geromel, F. (2019). Adaptable housing? A quantitative study of contemporary apartment layouts that have been rearranged by end-users. Journal of Housing and the Built Environment, 481-505.

Femenías, P., Holmström, C., Jonsdotter, L., & Thuvander, L. (2016). Arkitektur, materialflöden och klimatpåverkan i bostäder. Stockholm: E2B2.

Göteborg, D. f. (2020). https://goteborg.se/wps/portal/start/byggande--lantmateri-och-planarbete/kommunens-planarbete/plan--och-byggprojekt/!ut/p/z1/lYzNCoJAFEafpvW9o8OMLmcCJa-olZLejQhG2I9KSIuePmlVG6lv98E5BxhK4L55dKdm6oa-uc6_YlVnItp6VhhMQz_ATU5ZkFCcIkk4vAH8mkG7c6yLGKYO8P_-Z-k3fw.

Groák, S. (1992). The Idea of Building: Thought and action in the design and production of buildings. London: E & FN Spon.
Groat, L., & Wang, D. (2013). Architectural Research Methods. New Jersey: John Wiley & Sons, Incorporated.

Gustafsson, A., Eriksson, P.-E., Engström, S., Wik, T., & Serrano, E. (2012). Handbok för beställare och projektörer av flervånings bostadshus i trä.

Hanington, B., & Martin, B. (2012). Universal methods of design: 100 ways to research complex problems, develop innovative ideas, and design effective solutions. Rockport Publishers.

Heckmann, O., Schneider, F., & Zapel, E. (2017). Floor plan manual housing. Basel.

Hertzberg, H. (1991). Lessons for Students in Architecture. Rotterdam: 010 Publishers.

Hertzberger, H. (n.d.). www.ahh.nl.

Hill, J. (2003). Actions of Architecture. Architects and Creative Users. London: Routledge.

Hillier, B. (1996). Space is the Machine: A configurational theory of architecture. Cambridge: Space Syntax.

Hillier, B., & Hansson, J. (1984). The social logic of space. Cambridge: Cambridge University Press.

http://www.jeremytill.net.

https://automatedarchitecture.io/.

https://geodata.chalmers.se/.

https://goteborg.se/wps/portal/enhetssida/statistik-och-analys/goteborgsbladet/hamta-statistik/faktablad/goteborgsbladet.

https://goteborg.se/wps/portal/start/byggande--lantmateri-och-planarbete/kommunens-planarbete/plan--och-byggprojekt/. (2022).

https://goteborgsstadsmuseum.se/samlingar/.

https://kartor.eniro.se.

https://kodarkitekter.se/.

https://tengbom.se/2021/09/01/bo-stort-pa-liten-yta-movable-wall-system-utmanar-statisk-planlosning/. (2021).

https://timberontop.se/.

https://trabyggnadskansliet.se/.

https://trabyggnadskansliet.se/.

https://whitearkitekter.com/project/sara-cultural-centre/.

https://www.build-in-wood.eu/.

https://www.derome.se/.

https://www.dst.dk/en/.

https://www.ettelva.se/.

https://www.ipcc.ch/. (2022).

https://www.oxfordlearnersdictionaries.com.

https://www.ri.se.

https://www.riksbyggen.se/.

https://www.scb.se/.

https://www.setragroup.com/.

https://www.sodra.com/sv/se/.

https://www.statista.com/.

https://www.sweco.se/projekt/brf-gibraltar/.

https://www.swedishwood.com/.

https://www.thinkwood.com/.

https://www.un.org/sustainabledevelopment/cities/. (n.d.).

IPCC. (2022). Climate Change 2022: Mitigation of Climate Change. Contribution of Working Group III to the Sixth Assessment Report of the Intergovernmental Panel on Climate Change. Cambridge: Cambridge University Press.

Jockwer, R., Scharn, E., Goto, Y., & Crona, K. (2020). Design for Adaptation. Gothenburg: Chalmers University of Technology.

Krokfors, K. (2017). Time for space. Typologically flexible and resilient buildings and the emergence of the creative dweller. Helsinki: Aalto University School of Arts, Design and Architecture.

Landel, P. (2018). Wood Building Technology - Swedish Technical Benchmarking of Tall. Borås: RISE Research Institutes of Sweden.

Leupen, B. (2006). Polyvalence, a concept for the sustainable dwelling. Nordic Journal of Architectural Research, 23-31.

Lindbäcks. (2020). Arkitekt manual 2020. Retrieved from https://lindbacks.se/wp-content/uploads/2022/01/Arkitektmanual-2020.pdf.

Lopes, C. N., & De Paris, S. R. (2017). Housing flexibility problem: Review of recent limitations and solutions. Frontiers of Architectural Research, 80-91.

Manum, B. (2005). Generality versus Specificity; A Study on the Interior Space of Apartments.

Manum, B. (2006). Apartment Layouts and Domestic Life; The Interior Space and its Usability . Oslo: Oslo School of Architecture and Design.

Manum, B. (2009). The advantage of Generality: Dwellings Potential for Housing. 7th International Space Syntax Symposium, 1-14.

Nylander, O. (1998). Bostader som arkitektur. Gothenburg: Chalmers University of Technology.

Nylander, O. (2007). Bostadens typologi. In T., Berger (eds.), Bostaden and Kunskapen. Stocholm: Arkus.

Nylander, O. (2018). På tidsresa genom Göteborgs bostäder (CBA). Retrieved from https://www.chalmers.se/SiteCollectionDocuments/Centrum/CBA/Nyheter/Bostadsartikel.pdf.

Nylander, O., & Eriksson, A. (2009). Så använder vi våra bostäder. Stockholm: Svensk Byggtjänst.

Nylander, O., Femenias, P., Andersson, M., Morichetto, A., & Braide, A. (2018). Bostadsforskare om bostadskvalitet. Stockholm: Centrum för boendets arkitektur.

Positive Footprint Housing. (s.d.). Livet i Brf Viva Rapport. Gothenburg: Riksbyggen.

RISE. (2020, Tall Timber Buildings). Tall Timber Buildings. Retrieved from https://www.ri.se/sites/default/files/2020-08/TTB_HogaHusTra_print.pdf.

Roberts-Hughes, R. (2011). The case for space, the size of England’s new homes. Retrieved from RIBA Royal Institute of British Architects: https://www.architecture.com/-/media/gathercontent/space-standards-for-homes/additional-documents/ribacaseforspace2011pdf.pdf/





Schmidt III, R., Eguchi, T., & Austin, S. &. (2010). What is the meaning of adaptability in the building industry? 233-242.

Schneider, T., & Till, J. (2005). Flexible housing: opportunities and limits. Architectural Research Quarterly, 157-166.

Schneider, T., & Till, J. (2007). Flexible Housing. Oxford: Architectural Press.

Tarpio, J. (2015). Spatial principles and logics of dwelling flexibility. Arkkitehti.

Tervo, A., & Hirvonen, J. (2019). Solo dwellers and domestic spatial needs in the Helsinki.

Till, J. (2020). http://www.jeremytill.net/read/130/architecture-after-architecture.

UNEP. (2021). “The heat is on” A world of climate promises not yet delivered – Emissions Gap Report 2021. United Nations Enviornment Programme.

Why we should build wooden skyscrapers (2013). [Motion Picture]. you tube. Retrieved from https://www.ted.com/talks/michael_green_why_we_should_build_wooden_skyscrapers?language=en

wood, w. (2022). Mass Timber Design Manual. Retrieved from www.thinkwood.com.

# List of Figures



**Note:**
All images and illustrations where the origin and author are not mentioned are by the author of this thesis.

# Appendix

## Appendix I

## Appendix II

# Appendix I

## Graphical and Written Manifesto

Graphical and Written Manifesto

HaH

Architects challenge

modern wooden architecture

social, economic and environmental

timber

resilient living solutions

Housing

Adaptability

Elasticity

Long-term perspectives

change the way architecture approaches housing

define design strategies
for resilient housing

H

Flexibility

usability

Generality

Different families need
different households

Multi-family housing

after

Sweden

Dwelling: home.

world population: 75% people living in cities in 2050

improve resilience in housing construction

Polyvalence

diversity

User

bottom-up perspective

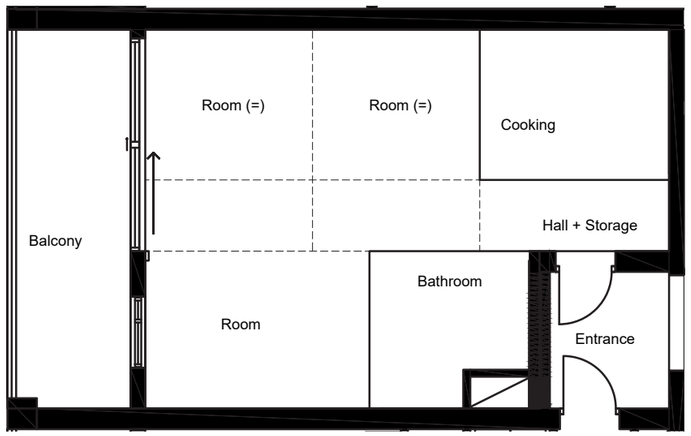
Housing

adaptable spaces

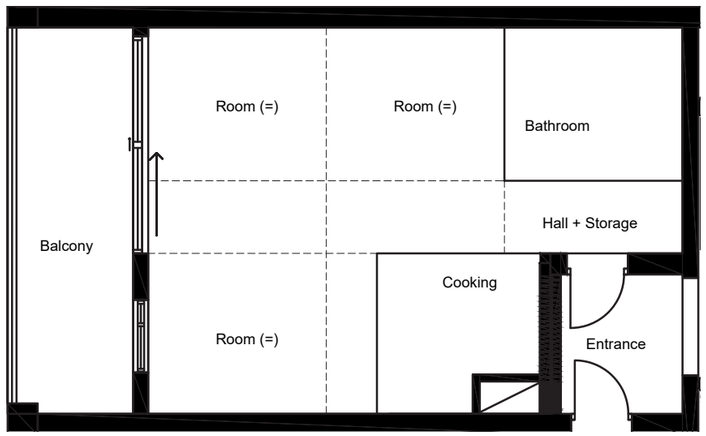
# Appendix II

## Design Proposal - Spatial Versions Tested (Master Thesis)

## Design Proposal - Analysing different configurations: A, B, C (Master Thesis)




**Small dwelling - V02**
**Module 3 A**
**Spatial configuration A**

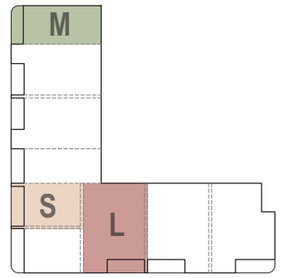


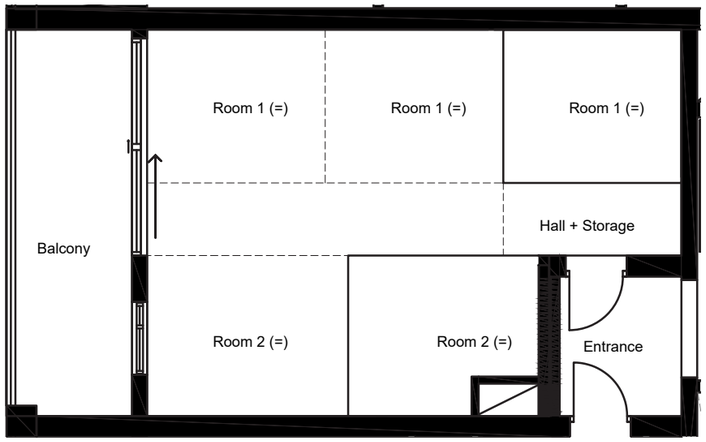

**Small dwelling - V02**
**Module 3 A**
**Spatial configuration B**



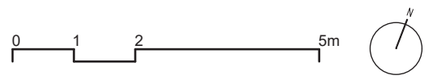


## Dwelling S - V02 - Module 3 A

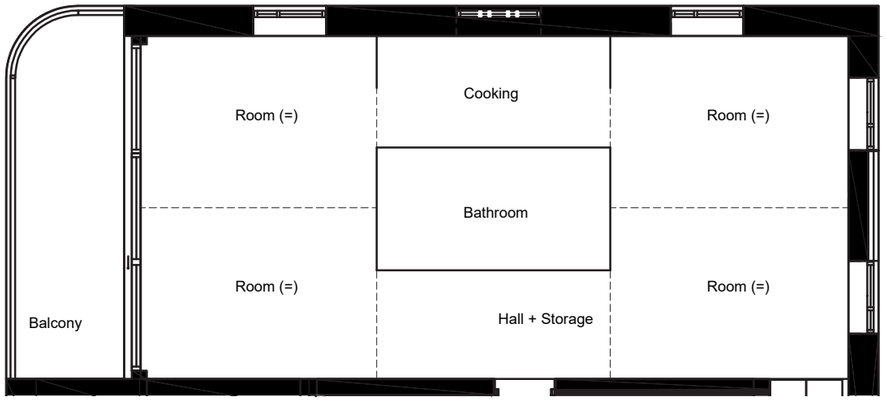


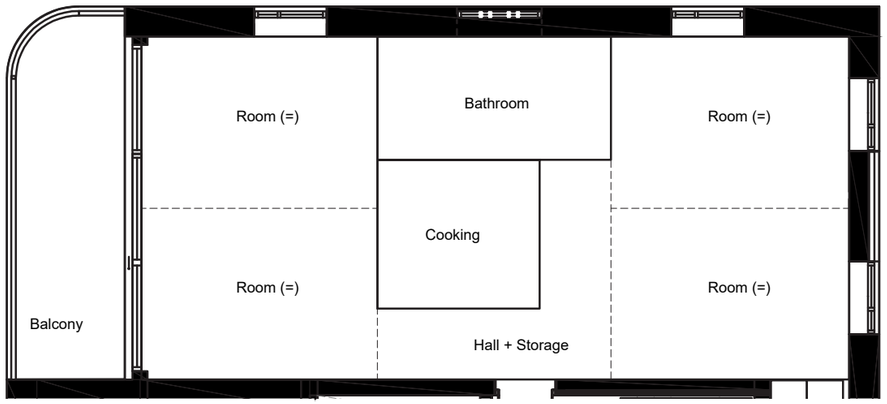

**Small dwelling - V02**
**Module 3 A**
**Spatial configuration C**



## Design Proposal - Analysing different configurations: A, B, C (Master Thesis)




**Medium dwelling - V02**
**Module 1 A**
**Spatial configuration A**

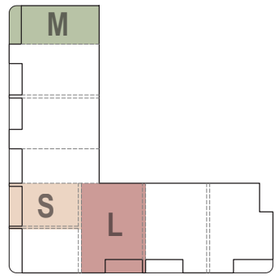


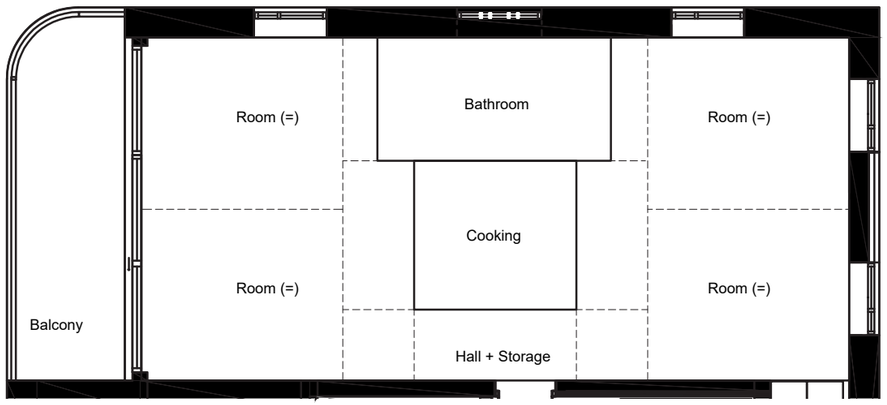

**Medium dwelling - V02**
**Module 1 A**
**Spatial configuration B**



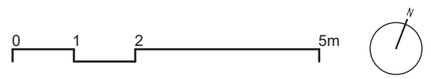


## Dwelling M - V02 - Module 1 A

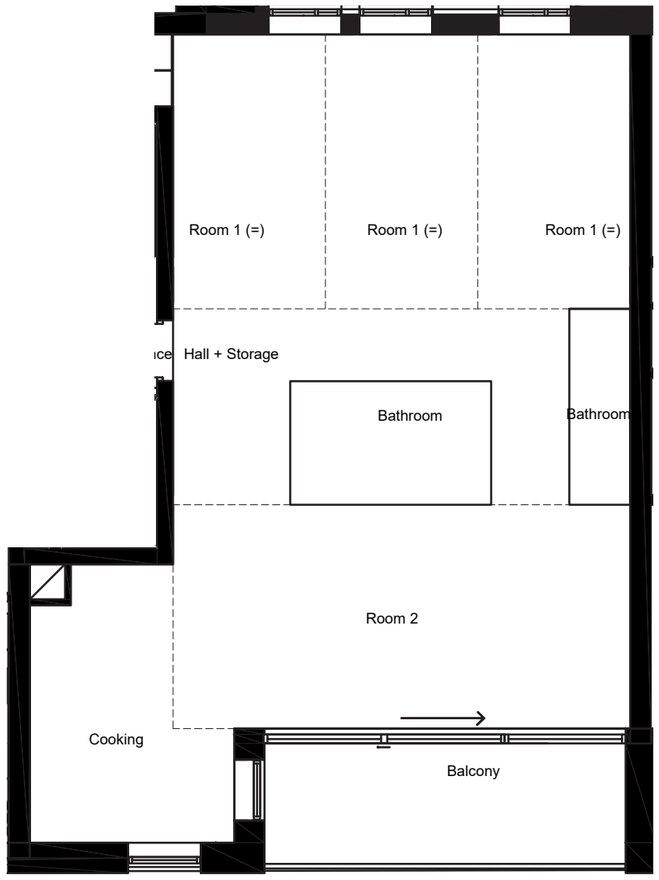



**Medium dwelling - V02**
**Module 1 A**
**Spatial configuration C**



## Design Proposal - Analysing different configurations: A, B, C (Master Thesis)

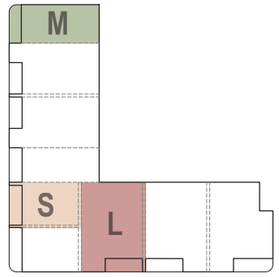


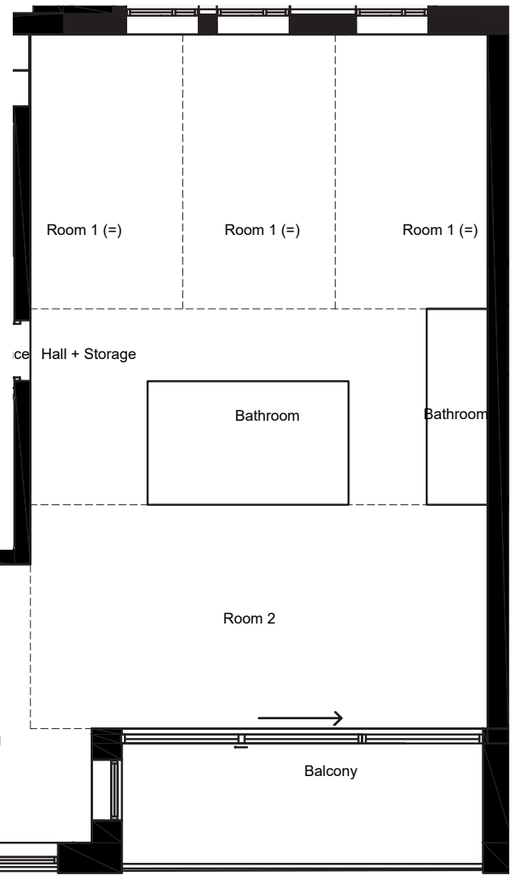

**Large dwelling - V02**
**Module 5 A**
**Spatial configuration A**





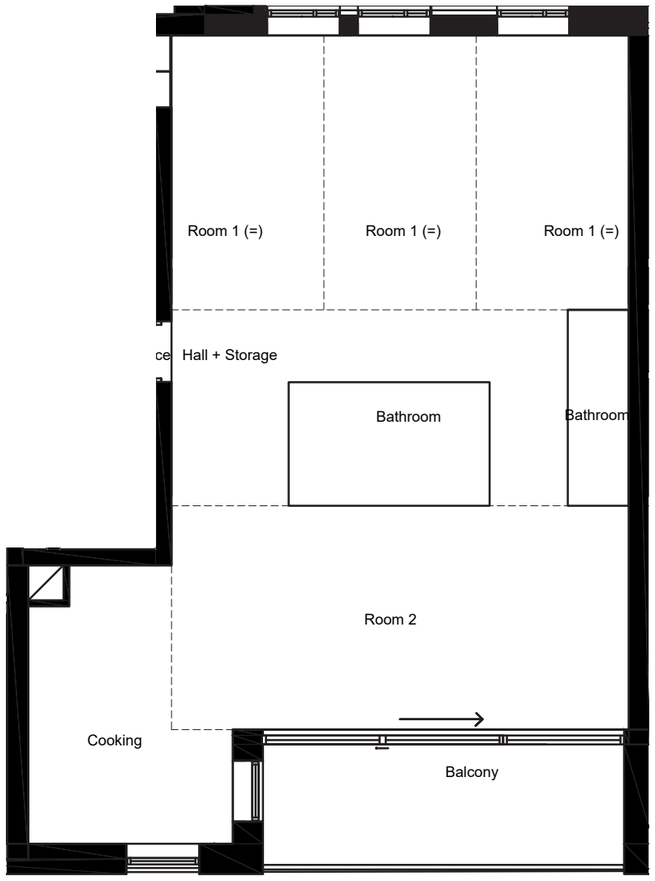
## Dwelling L - V02 - Module 5 A




**Large dwelling - V02**
**Module 5 A**
**Spatial configuration B**

## Design Proposal - Analysing different configurations: A, B, C (Master Thesis)

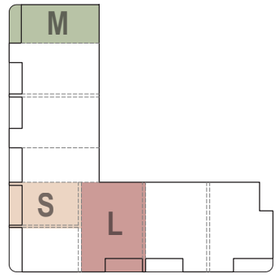



**Large dwelling - V02**
**Module 5 A**
**Spatial configuration C**

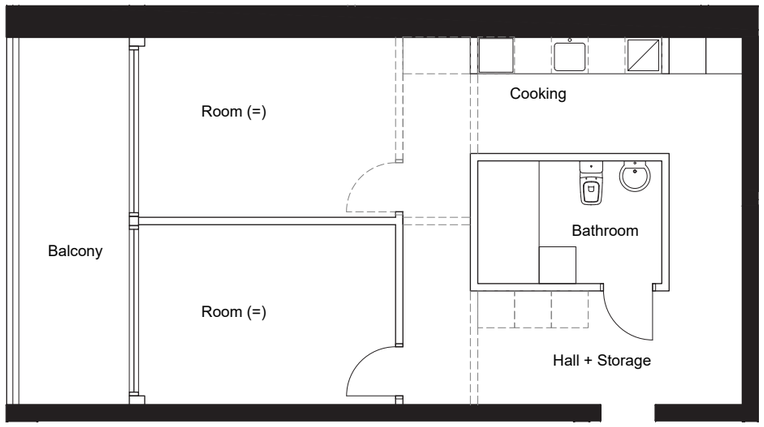




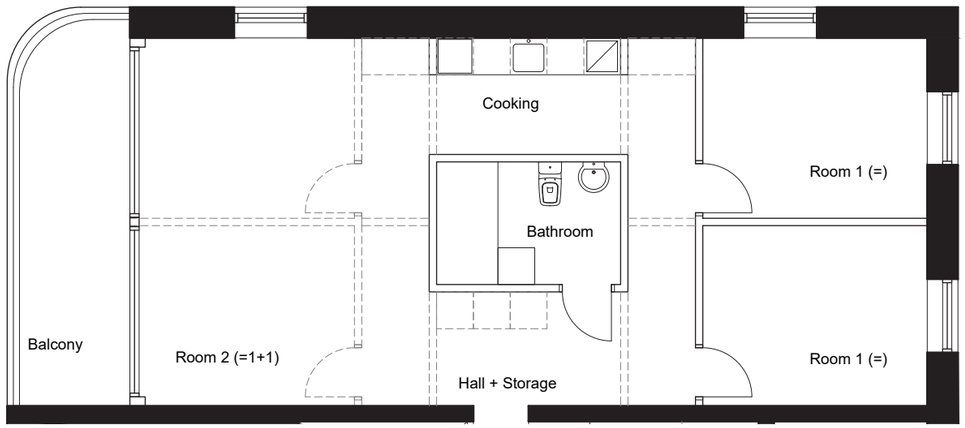
## Dwelling L - V02 - Module 5 A




## Design Proposal - Analysing different configurations: A, B, C (Master Thesis)




### Small dwelling - V05
### Module 3 A
### Spatial configuration E

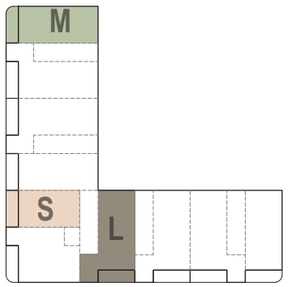


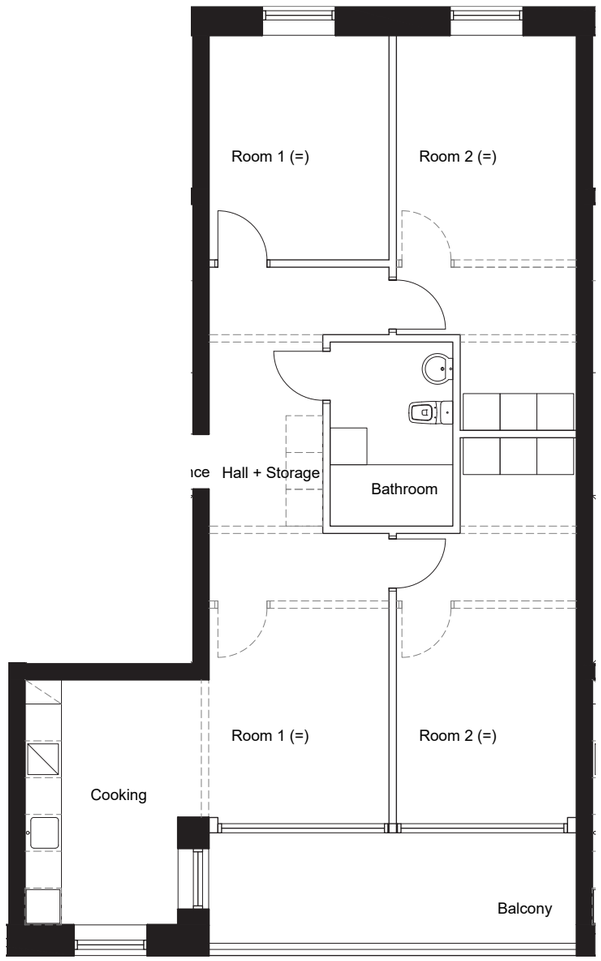

### Medium dwelling - V05
### Module 1 A
### Spatial configuration E



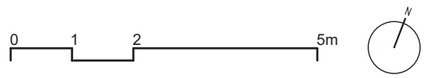


## Dwelling S, M and L - V05



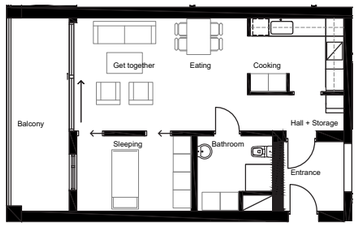

### Large dwelling - V05
### Module 2 A
### Spatial configuration E

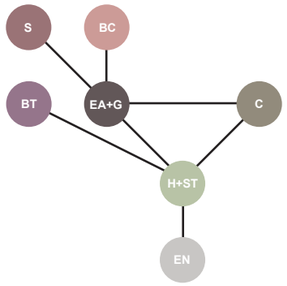


# Existing Proposal (Sweco)

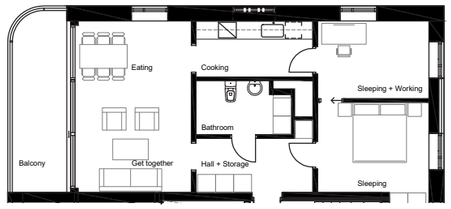
## Space Syntax Comparison - Dwelling Type S, M and L

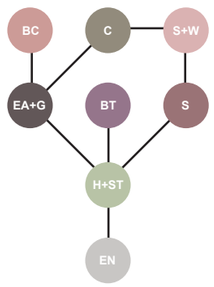
### S



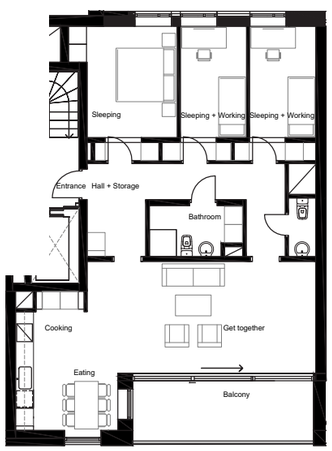



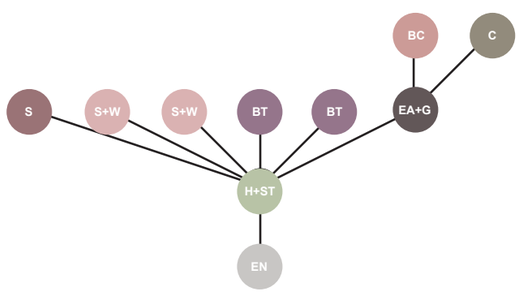

### M




### L



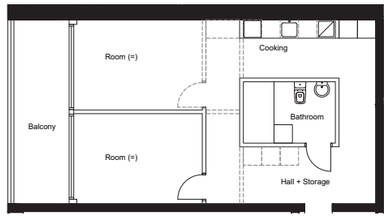


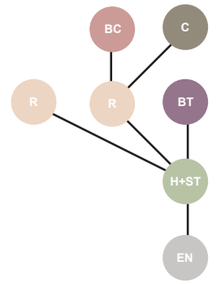



# Final Design Proposal (Master Thesis)

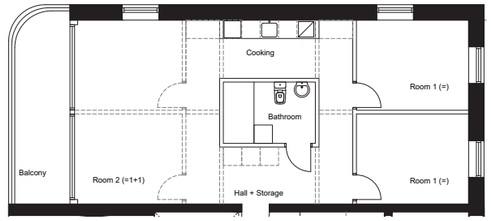
## V05 Spatial configuration E

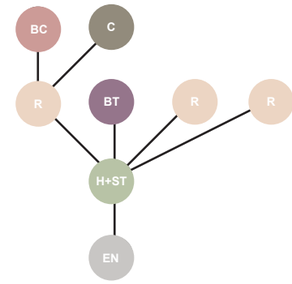

### S



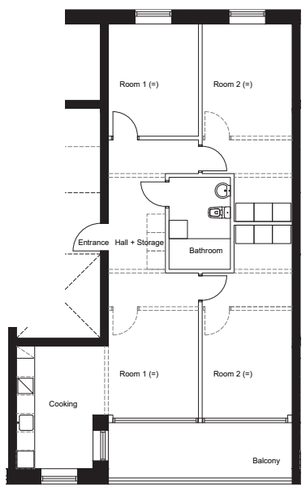



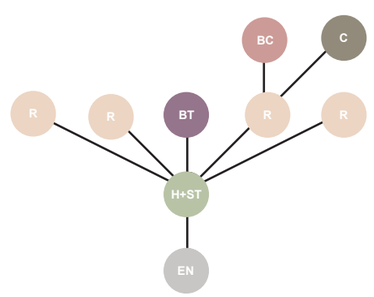

### M

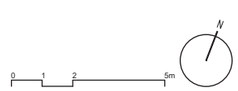



### L



# Housing after Housing

*Design strategies for resilient housing, focusing on adaptability concepts in modern architecture in wooden buildings*


CHALMERS
UNIVERSITY OF TECHNOLOGY

**A master thesis written by**
**Raquel Domingues**

Chalmers University of Technology
Department of Architecture and Civil Engineering
Gothenburg
Sweden