CHALMERS
UNIVERSITY OF TECHNOLOGY

A Framework for Sustainable Renovation in the Inventory Phase

A case study in Gamlestaden, Gothenburg

Master's thesis in the Master's Program Design and Construction Project Management

ELISABETH BÖBER
MARIA JULIA CARDOSO MARTINS

Department of Energy and Environment
CHALMERS UNIVERSITY OF TECHNOLOGY
Gothenburg, Sweden 2016

MASTER'S THESIS

A Framework for Sustainable Renovation in the Inventory Phase

A Case Study in Gamlestaden, Gothenburg

Master's Thesis in the Master's Programme Design and Construction Project Management

ELISABETH BÖBER
MARIA JULIA CARDOSO MARTINS

Department of Energy and Environment
CHALMERS UNIVERSITY OF TECHNOLOGY

Gothenburg, Sweden 2016

A Framework for Sustainable Renovation in the Inventory Phase
A Case Study in Gamlestaden, Gothenburg
Master's Thesis in the Master's Programme Design and Construction Project Management

ELISABETH BÖBER
MARIA JULIA CARDOSO MARTINS

Technical report no 2016:07
Department Energy and Environment
Chalmers University of Technology
SE-412 96 Gothenburg
Sweden
Telephone + 46 (0)31-772 1000

A Framework for Sustainable Renovation in the Inventory Phase
A Case Study in Gamlestaden, Gothenburg

Master's Thesis in the Master's Programme Design and Construction Project Management

ELISABETH BÖBER
MARIA JULIA CARDOSO MARTINS

Department of Energy and Environment
Chalmers University of Technology

Abstract

This thesis was written in Challenge Lab, a hub for integrative and transformative thinking at Chalmers University of Technology, where students are in the centre of academia, private, and public sector, acting as change agents to tackle sustainability development challenges. Through analysing the present situation of Gothenburg regarding urban development, major challenges were identified. Through the Backcasting method, the research problem has been analysed from different perspectives and with different disciplinary impact.

One major deficit is the renovation of old building stock within the city of Gothenburg, especially multi-dwellings. There have been many attempts in research to achieve a sustainable renovation concept. Yet, industry and property owners focus mainly on energy efficiency, meaning the environmental-economic perspective rather than the social or well-being dimensions. In order to achieve a sustainable renovation, the different sustainability dimension need to be balanced and enhanced by an architectural and cultural-historical aspects.

A case study of a renovation in a multi-dwelling in Gamlestaden, Gothenburg, was conducted. Interviews were held with the tenants, the property owner, an independent renovation consultancy company, and several experts, in order to understand the complexity of a renovation. It provided important insights into the practice of industry, and it was found out that the renovation framework provided by Boverket is rather insufficient and vague on how to proceed in the inventory phase of a renovation process.

Therefore, the major outcome is a revised framework for the inventory phase of a renovation process, as it was found out this is a crucial phase to achieve a sustainable renovation.

Keywords: Dialogue, Inventory phase, Renovation, Renovation processes, Sustainable renovation, Tenants dialogue, Tenants participation.

Acknowledgements

This research has involved several people, and we are grateful that they shared their experience and expertise with us, throughout the process of investigation.

First and foremost, we would like to thank our Supervisor Paula Femenías at the Department of Architecture and her research colleagues at the Department of Building and Environment Paula Wahlgren and Pär Johansson, who has supported and provided us with a range of information and gave important input and feedback on our work, which often brought the investigation even further.

An important support was from Anders Svensson from the Department of Architecture, who helped us as an expert designing the workshop with the tenants. In addition, we would like to thank the Challenge Lab support team John Holmberg, David Andersson, Örjan Söderberg, Daniella Mendoza, and Johan Larsson for the support, inspiration, and the opportunity to write our master thesis at the Challenge Lab. It was a great experience and we had the opportunity to learn a lot about our personal values and the ongoing challenges in society.

We would like to give our special thanks to Tobias Matsson and Olle Björquist from the Property Management Administration, who gave us the opportunity to have Banérsgatan 6 as a case study, and all the tenants who opened their doors to our visit and interviews, as well as those who participated in the workshop. In addition, we would like to give special thanks to John Kåwert. from Rotpartner and Pernilla Gluch from Chalmers for their expertise.

And last but not least we would like to thank our fellow Challenge Lab colleagues for the time that we spent together, the moral support and the everyday lunch breaks.

14th June 2016

Elisabeth Böber and Maria Julia Martins

Table of Contents

List of Abbreviations

BBR:	Boverkets Byggregler
BKR:	Boverkets Konstruktionsregler
BREEAM:	Building Research Establishment Environmental Assessment Method
EPIQR:	Energy Performance Indoor Environment Quality Retrofit
LCA:	Life Cycle Assessment
LCC:	Life Cycle Costing
LEED:	Leadership in Energy and Environmental Design
MLP:	Multi-level perspective
TWh:	Terawatt Hour

1. Introduction

The debate around climate change and fossil fuel dependency is crucial. Challenges as biodiversity loss, land degradation, ocean acidification and global freshwater use are only a few to name. The global challenges we face are twofold. The demand for resources will increase over time while the amount of resources will decrease. The major driving force behind this phenomenon is often seen to be the ongoing and static population growth. With increasing population, the consumption of material and energy will rise. Soon there will be over 10 billion people living on earth and already over half of today's population lives in urban areas (Holmberg, 2016). Therefore, the grade of urbanization will increase throughout the next years. Cities and urban models need to be re-thought, and existing infrastructure and urban metabolism have to become more efficient. Therefore, business as usual cannot be the solution anymore (Holmberg, 2016). New collaborations are needed, and it is important to understand that sustainability and sustainable development concerns each one in society. The 17 UN Sustainable Development Goals, a set of goals adopted by countries in 2015 to end poverty, protect the planet, and ensure prosperity for all as part of a new sustainable development agenda, have been a step forward in order to face these challenges, yet, they need to be put into action and become much more visible through specific projects and strategies (SDSN, 2016).

In order to address and tackle global challenges, it is necessary to start small and make minor changes within the existing systems with a view to change fundamental behaviour, and the systems themselves. The Challenge Lab is one attempt to make interventions in these systems and tackle global challenges in the long run. However, these minor actions need to be taken on in various disciplines and need to address and relate to a fundamental change in human behaviour.

The consequences of climate change and acting outside of the planetary boundaries have taken over and are undeniable. Instead of focusing on radical changes in human behaviour, the world, and many disciplines are continuously stuck in their business as usual processes. The built environment is well known for having a crucial impact, especially when it comes to environmental aspects, such as the use of material and energy resources. Over decades, mankind has spent the majority of its existence trying to manipulate the natural environment to better suit its needs, thus, today our daily lives are carried in and on constructions of one sort or another; we live in houses, travel on roads and work and socialize in buildings of all kind (Dixon, 2010). Buildings have a long life cycle, so have cities and therefore, what is developed and produced today will impact future generations. Around 40% of the total energy consumption in the EU is accounted to the building sector, whether it relates to new or old buildings. The European Union has developed ambitious climate and energy goals, aiming to achieve these throughout the next years. The renovation of existing buildings can become an important part of achieving these goals. Yet, the

focus is still towards new construction rather than looking into the large stock of existing buildings (Thuvander et al., 2012). Although figures vary across Europe, the Swedish National Programme for Energy Efficiency and Energy-smart Construction has stated a goal of a 20% reduction in energy use by 2020 and 50% by 2050 compared to the year 1990 (Swedish Energy Agency, 2015).

In recent years, renovation of especially the multi-dwelling stock has come to the centre of the political debates in Sweden, with a great stock from the Million Homes Program and prior to that, in need of renovation (Lind et al., 2014). Whether to demolish or renovate a building is a common question and the decision depends on many factors, but very often the decision is based on the economic benefits of renovating or demolishing and building it again. In Sweden, about 56% of all investments in housing are related to building renovation. Nevertheless, building regulations prioritize new construction. In addition, the efforts towards sustainable construction are indeed receiving attention in national and global levels, including the process of renovation, with various sustainability assessment tools and methods. Yet, most of the certifications and regulations concentrate on new buildings. It has been argued that there is a lack of standardised practices, policies, and regulations that specifically focus on the renovation process despite a sustainability focus or not. (Stenberg et al., 2009; Thuvander et al., 2012).

A great number of case studies have been carried out, and handbooks and best practice examples of sustainable renovations have emerged. On EU-level, renovation gets a higher emphasis, meaning conferences and platforms have evolved within the past years. In Sweden, several universities and researchers investigate towards different aspects of a sustainable renovation.

1.5 Challenge Lab

In order to tackle the above-mentioned challenges, transformative and integrative thinking and collaboration among various stakeholders is required. With nowadays challenges to meet the sustainability goals, the Challenge Lab is not only a physical space but moreover a place for creative thinking, dialogues, and understanding, to break through complex systems. Initiated in 2014 by John Holmberg, professor and vice president of Chalmers, the Challenge Lab aims to strengthen the educational dimension of sustainability and find transformative and integrative approaches towards sustainability-related challenges. In order to tackle these, it is important to understand the challenges from different perspectives, for which the Challenge Lab brings together students and stakeholders from multiple disciplines and with various cultural backgrounds. This creates a unique setting and makes each year of Challenge Lab individual and with an unforeseen outcome related to the challenges that are going to be tackled. This year's Challenge Lab team consisted of 14 students with various educational backgrounds, and it has been the first time that students from Gothenburg University have participated.

The Challenge Lab has an open character and can, depending on the interests of the students, approach challenges on various dimensions. In addition, Holmberg (2014) describes the Challenge Lab as a student-driven transition arena where students will become change agents by taking on complex societal challenges within Industry, Academia, and Society. The focus thereby is on sustainability challenges and to find transformative and integrative solutions rather than technological opportunities or market needs. The Challenge Lab unites actors from public, private and academia to form what is called the knowledge triangle (Fig. 1). Within the knowledge triangle, its mission is to provide a natural hub for the triple helix actors (stakeholders from Academia, Public, and Private sector), where all parties are drawn together because of the students. The aim is to build trust and initiate collaboration through the students and the open character of the Challenge Lab. The advantage that is taken is that every stakeholder can relate to how it is to be a student since all have been through the same experience. At the same time, the students get the opportunity to develop unique skills in working across disciplines, creating networks and driving cooperation (The Challenge Lab, 2014).

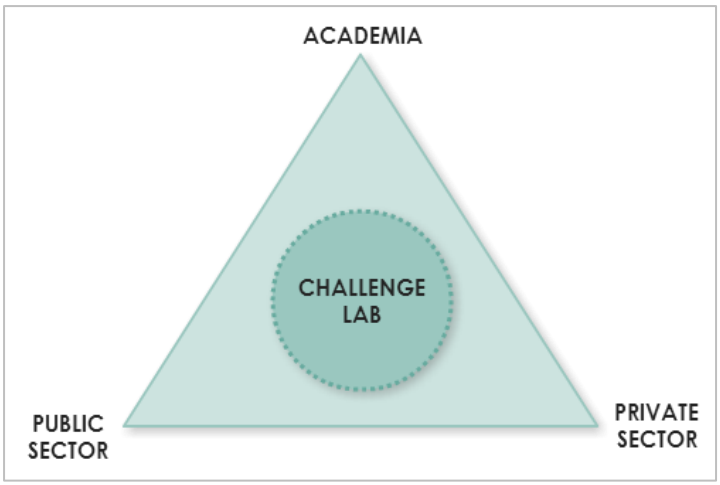


Figure 1 Challenge Lab in the centre of the knowledge triangle (adapted from Holmberg, 2014)

1.1 Statement of the Problem

Gothenburg is facing many challenges with shortage of housing, where the demand is currently higher than the offer. There are many urban development projects going on, especially new housing projects. In addition, Gothenburg has a big stock of existing housing in need of renovation, both large stock of post-war buildings from the Million Homes Program (Miljonprogrammet), but also older buildings with outstanding architectural and historical heritage. The actual state of these buildings does not correspond to the goals of energy efficiency and the targets to encounter climate change. To renovate and preserve, or to demolish and build new is often the question to ask. The residents of these buildings, its history, and cultural importance should not be of less importance when it comes to these decisions. The goal should be to preserve cultural and historically significant buildings, integrate them into the urban development by considering user's needs, and adapt them to more sustainable technical systems, in order to contribute to sustainable development.

A further and in-depth description of the research problem will follow at a later point at this thesis. (see *Structure).*

The Research Question has been developed and defined in the Challenge Lab. Throughout five weeks the Backcasting approach has been applied, including defining sustainability criteria and understanding emerging challenges in the City of Gothenburg and the Western Sweden Region. Through dialogues and the interaction phase, various questions evolved and a research topic crystallised (Appendix A). After analysing the topic in depth and getting feedback from various stakeholders, the following research question evolved:

- *How can a sustainable renovation be ensured from the inventory phase?*

This research question is formed and guided by following sub-questions:

- *What aspects need to be considered to ensure a sustainable renovation?*
- *How can tenants be involved in the renovation process? In what way can they contribute to sustainable renovation?*

The research question was stated after an analysis of different keywords such as “sustainable renovation” and “stakeholder involvement in renovation processes.” Moreover, were various information and aspects of the “renovation system” collected to understand and get an idea of the scope of the system. Many existing regulations and norms refer to new buildings and new construction rather than buildings that have to go through renovation. But old buildings have different aspects to consider and cannot be treated the same way new construction is. Often these buildings have a history and eventually tenants that need to be considered. Therefore, the challenge is to take into account these aspects, yet with respect to the four sustainability dimensions.

1.2 Aim of the Study

The overall aim of this thesis is to spread awareness of the need for transformative and integrative solutions in order to tackle sustainability challenges. Moreover, the thesis shall make a contribution to ongoing research and motivate for further investigations on the topic of how sustainable renovation can be ensured from the inventory phase on. Thus, the study intends to point out the importance of the tenant and user involvement throughout the whole renovation process but especially in the inventory phase.

1.3 Scope and Limitation

The need for looking at renovation processes and concepts has been noted and studied mainly through the last years. Especially in Sweden, the question how to renovate buildings originated during the post-war period under the umbrella of “Miljonprogrammet”, is a frequent discussion.

Relevant research has been done on organisational learning and communication among stakeholders throughout the renovation process, as well as research among contractors in order to analyse the barriers and motivation for their renovation strategies. Other research focuses on how to balance different sustainability pillars, like the economic and social aspects.

The research problem of this thesis has been studied throughout a Case Study, focusing on the city of Gothenburg and the Swedish context, including regulations, directives, policies, and standards. EU-regulations have been taken into consideration, yet not analysed in this research context. Therefore, some of the results might be strongly connected to the Swedish context.

A limitation might be the choice of the Case Study as research approach. The specific case of this work, is a rental multi-dwelling owned by a public organisation, and with the status of being located in an area with protection regarding original architecture and heritage values. Second, the case is a building from 1929 that has not undergone any major renovation since and has very low standards in comparison with average Swedish housing. As the case is very specific and does not represent the major building stock in Gothenburg, the findings aim to spread awareness towards the topic of sustainable renovation, and to analyse in what way the tenants and users can be part of the process and their attitude towards a sustainable renovation, in that sense the case is considered representative of other renovation project although its particularities will be discussed.

Further, due to the fact that renovation processes are quite complex, the research considers a renovation framework, but particularly the inventory stage of a renovation process. Looking at all sustainability dimensions, the social, architectural and historical, and well-being aspects are often not taken as much into consideration as the environmental and economic aspects. Therefore, this thesis has a stronger force towards these usually forgotten aspects, in order to close research gaps and motivate to more research, especially within this field. Another restriction is the terminology that evolved around interventions on a building. For this thesis, the term renovation was chosen and used as the main keyword. With renovation we mean anything that goes beyond normal maintenance of the building.

1.4 Structure

The thesis has been developed in two major phases. *Phase 1* (Appendix A) and *Phase 2. Phase* 1 describes the process of the Challenge Lab and how the research problem and question are defined. In addition, *Phase 1* explores the ongoing trends, challenges, and needs regarding the urban development in Gothenburg. The aim is to find energy within the system of urban development in order to find a research question that addresses a challenge that is shared by several stakeholders. *Phase 2* starts off with the research question and provides a theoretical

framework around the research problem, looks into the research approach, as well as the results and a discussion that has been made in order to address the stated problems.

Table 1 Structure of this master's thesis.

Chapter 1 - Introduction includes a general introduction into the matter of sustainability, the purpose of the study, scope, and limitations of the thesis as well as the Challenge Lab and the research question.
Chapter 2 - Background discusses briefly the situation of multi-dwellings in Gothenburg, the question of whether to demolish or renovate, and points out the variety of terminology that has been used throughout different literature.
Chapter 3 - Analytical Framework includes different concepts and theories explained throughout literature, such as the existing renovation framework by Boverket, the existing sustainable renovation processes and its different dimensions, tools and methodologies that support the decision-making processes, and the communication between stakeholders.
Chapter 4 - Methodology lifts up the chosen research approach, research design, and the selected methods to collect data. This chapter points out the researcher's role how the quality of the research was ensured.
Chapter 5 - Results presents the Case Study, the multi-dwelling Banérsgatan 6 in-depth and gives the first statement on the condition of the building. In addition, the main findings from the Interviews, Observation and Workshop are presented.
Chapter 6 - Discussion relates the research question to the analytical framework and the findings from previous chapters, and discusses the research question and sub-questions. In addition, suggestions a common renovation framework, focusing in the inventory phase is presented.
Chapter 7 – Conclusion summarizes the findings and discussions and gives an outlook for future research.

2. Background

The Background presented here, gives an insight on the condition and situation of multi-dwellings in Gothenburg. Further, as noticed is the main term used throughout this paper “renovation” but there is a rather broad terminology when it comes to interventions on buildings, which will be pointed out here. In addition, it will be motivated why renovation appears to be more sustainable rather than demolishing.

2.1 Multi-dwellings in Gothenburg

There is a general shortage of apartments, especially for people with limited economic resources in Gothenburg (Stenberg et al., 2009). The majority of multi-dwellings in Gothenburg (54 percent) operates on rental contracts regime while 26 percent are multi-dwellings operated as condominiums, where the apartments are owned by the households, and the other 19 percent are single-detached dwellings (Fig. 2) (Stadsledningskontoret, 2015).

The decision to renovate, as well as renovation projects, slightly differ in rental multi-dwelling and in owner-occupied multi-dwelling, whereas in the first case, the tenants have less influence in the decision-making, and in the latter, the owners have some influence through owner’s organisations (Westin, 2011). Meijer et al. (2009) explain that large renovations may be difficult to implement in owner-occupied multi-dwellings as the decision to renovate is shared among several households. For owner-occupants, high investment costs, long payback times, and other competing investment priorities act as barriers. In the rental sector, equally important in sustainable renovation, the owner invests while the occupant profits from the investment, unless there is a considerable rental increase, which hinders the achievement of social sustainability, which is explored in one of the following chapters.

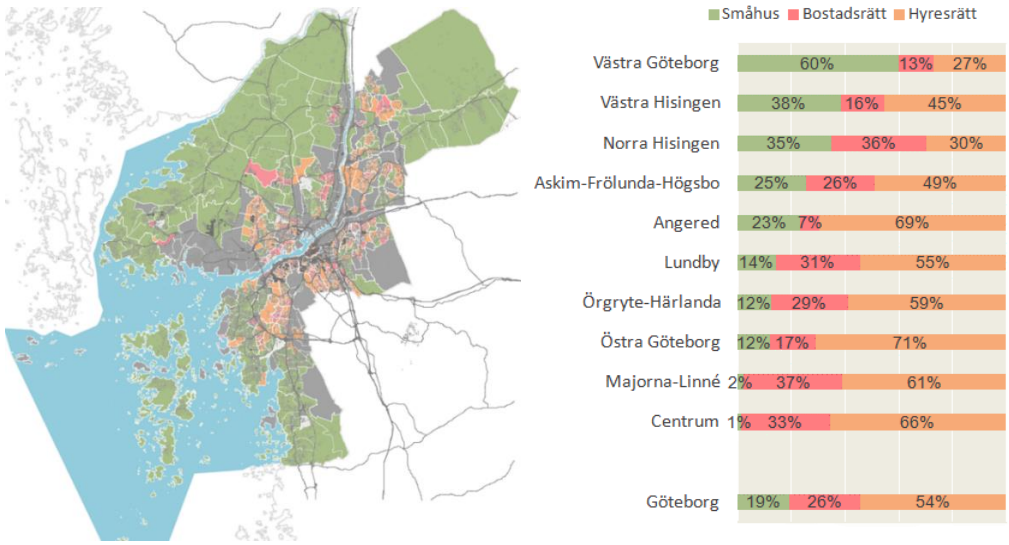


Figure 2 Dwellings by ownership in Gothenburg, 2014 (Stadsledningkontoret, 2015)

Meijer et al. (2009) affirm that the annual rate of new construction in Sweden is only 0.5 percent of the number of existing buildings, and is one of the lowest rates in Europe. Meijer et al. (2009) state that in Sweden, greater potential of energy savings can be achieved in the large stock of existing dwellings than in the relatively small proportion of newly built dwellings. Although the energy performance of existing dwellings is much poorer than new dwellings, the stock of existing dwellings is very large in an established built environment of most Swedish cities. In the past decade, awareness of the potential energy savings has spread widely among the many stakeholders involved. Nonetheless, most regulations and instruments are still aimed at achieving sustainable newly built construction, and most construction companies prioritize new construction projects (Meijer et al., 2009).

2.2 Terminology

In terms of terminology, a broad variety is used when it comes to interventions on existing buildings, and there is no general definition of the term and process of renovation (Thuvander et al., 2012). When researching on the term "renovation", one comes across various synonyms such as modernization, restoration, refurbishment, makeover, transformation, retrofitting, remodelling, to only name a few. The reason behind the diverse terminology is the variance and scale of buildings as well as the wide range of different actions, and series of reasons to make an intervention on a building (Thuvander et al., 2012). Changes to buildings can range from minor interventions, such as preservation or conservation that usually attempt to preserve the original building, to major renovations with larger changes of the original building, that can extend to the reconstruction or replacement of an entire building (Thuvander et al., 2012).

For this study, the term 'renovation' was chosen, which originally comes from the Latin word *re-novare*, meaning to restore to a good condition, make new or as if new again (Botta, 2005, p.24). Meijer et al. (2009, p. 534) highlight that the term 'renovation' is generally used to cover the terms modernization, retrofit, restoration, and rehabilitation or actions that go beyond mere maintenance. Referring to Botta (2005, p. 24), renovation implies physical and technical interventions to the building, but it also concerns the inhabitants, their way of using spaces and relating to their homes and their perception of their living space. Renovation techniques, cultural, social and economic evaluations as well as political interest influence how renovation work is approached and carried out. The purpose of renovation work is to extend and upgrade the use of existing buildings, but in addition, it affects the physical and social context in which a building is situated (Botta, 2005 p. 24).

2.3 Demolition vs. Renovation

In Sweden, and especially in Gothenburg, the focus in the construction sector is towards producing new apartments (The Swedish Research Council Formas, 2008, p. 5). Considering the high demand and the low supply of housing in Gothenburg, these apartments are needed (Stadsledningskontoret, 2015). On the other hand, maintenance and transformation of the existing stock seem to be less important. Many old buildings do not meet the current requirements regarding energy efficiency and living standard (BPIE, 2011). Therefore, the first question which often rises in the decision-making process is whether to maintain, replace or demolish the building.

Depending on different stakeholders, various ambitions can guide and drive such decision. Important thereby is the quality of the building and its actual use. Even more significant are functional and economic considerations, which are often the aspects that lead to the decision of demolition rather than renovation. A variety on decision support tools, mainly based on cost and benefit assessment, have been developed in order to assess more qualitative pros and cons of this choice (Botta, 2005).

When looking at the best way in terms of sustainability, environmental aspects are of growing importance, but as Thomsen and Flier (2009) mention, sustainability as whole does not seem to be a major aspect in the choice between demolition and renovation. When demolishing a building, one has to expect an increased stream of demolition waste, which impacts the ecological dimension of sustainability. In addition, the economic dimension is affected by the capital loss when demolishing a building and not building new (Thomsen and Flier, 2009).

Studies of the actual decision-making process whether to demolish or renovate are limited, but referring to Thomsen and Flier (2009), the decision whether to demolish or renovate has to be taken individually considering different aspects of dwellings. The decision to demolish, however, is often influenced by land prices and market demand instead of the technical quality (Meijer et al., 2009). Renovating is often a better solution when looking at the different sustainability aspects, as the actual life of buildings exceeds its estimated operation and service life. From a life-cycle assessment point of view, the energy and materials used to build, as well as its environmental impact, are higher than the operation of its whole possible life (Thomsen and Flier, 2009). Lind et al. (2014) reinforces that the question should not be whether the multi-dwellings should be demolished, but rather how they should be renovated and to what extent.

2.4 Renovation or Maintenance?

The purpose of the Swedish Board of Housing, Building and Planning is to define minimum requirements for buildings in Sweden in terms of design, accessibility and usability, resistance,

fire safety, hygiene, health, environment, management of water and waste, noise, safety in use and energy conservation (BFS 2011: 26 BBR 19, p. 13). In 2013, the Building Regulations (BBR 19) were updated and a major change has been made regarding renovation (Chapter Renovation, Rebuilding and Extension). Before the update, recommendations and advices were given, how to proceed in a renovation, yet there were not binding. These recommendations and advices have not changed into regulations, stating that any changes made on existing buildings need to follow the regulations as if constructing a new building. Exceptions can apply for single-family houses or two-family houses. Buildings with historical values must be analysed separately (Boverket, 2011).

In the same document, it is not always clear when a "change in a building" is considered renovation or maintenance. In the first chapter of the Planning and Building Act, there is the following definition for the modification of a building: "One or more actions that change a building's design, function, method of use, appearance or heritage value." The uncertainty on the difference between maintenance and modification is present in the document, by writing: "Any sharp distinction between change and maintenance is not defined". Further, it describes maintenance as an action taken in order to maintain, for example, a particular feature, in some contexts can simultaneously involve a modification under the laws and the rules according to BBR 19 (Boverket, 2011).

3. Analytical Framework

The aim of the analytical framework is to gain a better understanding of the context a renovation is carried out in. Including the renovation process as it is mentioned by Boverket and emphasising especially the inventory phase. A sustainable renovation requires to analyse the environmental, economic and social perspectives as well as tools and methods to evaluate these dimension in order to support the decision making-process. In addition, this chapter presents the perspective on individual well-being in a renovation process and how architectural and historical characteristics influence the renovation process. As renovation processes involve many stakeholders and is understood as a complex procedure, it is often challenging to balance the different interests of various stakeholders and the requirements for the sustainability dimensions. Some of these clashes among tenants and property owner or the social and economic sustainability dimension will be lifted up in the following.

3.1 Sustainable Renovation

Renovation is a complex matter, likewise is the topic of sustainability. Existing literature and scientific research has been defining sustainability in the context of the built environment and moreover in the context of renovation. However, literature often provides a discussion around the three most common dimensions of sustainability; such as environmental, economic, and social. Yet, the authors find it indispensable to take the well-being, architectural and historical dimension into consideration. Well-being is understood to be humans' physical and mental well-being, enabled by achieving the other aforementioned sustainability dimensions (Challenge Lab, 2016) Architectural and historical aspects are important to be preserved and are often neglected over technical and economic issues. As Häkkinen et al. (2012) point out, sustainable renovation is often considered with long-sighted perspective and with possible targets of repairing damages, technical aging, unsatisfied indoor climate and changing space division.

Thuvander et al. (2012) refer to sustainable renovation as the ambition to fulfil the dimensions of environmental, social and economic sustainability. Kaklausas et al. (2008) point out that the scope of sustainable renovation is to make a building healthier, and more energy and resource efficient. However, the concept as well as the renovation process itself, is understood and accomplished differently in each country. What Kaklausas et al. (2008) mention goes along with Thuvander et al. (2012), remarking that within the sustainability debate, improvement is often related to energy savings and environmental issues. Thuvander et al. (2012) claim that the social dimension should be taken into consideration equally. Botta (2005) more specifically describes the goal of a sustainable renovation as decrease of environmental impacts, limit the use of energy and natural resources, affordability, promotion of sustainable behaviour by being a role model, prolonging existing resources and maintaining the real estate value.

In the last decades, energy efficiency and various environmental considerations have been developed with a stronger focus towards meeting social aspects in order to address all dimensions of sustainability and fulfil the renovation in a more comprehensive way (Stenberg et al., 2009). Especially the Swedish government has realized that it is equally important to take the social dimension of sustainability in to consideration (Stenberg et al., 2009). Yet, the Swedish building industry has often been perceived of mainly focusing on energy-saving (Stenberg et al., 2009). Thuvander et al. (2012, p.1192) call attention to the complexity of sustainable renovation in which diverse values and objectives should be dealt with, and that there are in fact only a few examples where optimal results have been reached regarding all dimensions of sustainability. Often the objectives in the social dimensions, when it comes to equity, integration, and democracy, are not achieved in renovation processes.

Following, the five aspects, which are considered important in order to achieve a sustainable renovation, will be analysed in detail. As the built environment and each building belongs into a wider context, improvements or diminishments regarding sustainability have to be considered in a broader context. Meaning, that due to a renovation, structures within neighbourhoods can be changed, which can in the long run cause other obstacles.

A major contribution, in order to achieve a sustainable renovation concept, is made by the stakeholders being involved in the process. Referring to Cleveland and Morris (2015) a stakeholder is any person who affects and/or is affected by a decision or policy under consideration i.e., who has a “stake” in the outcome. Moreover, Cleveland and Morris (2015) point out that it also concerns others that are affected by these activities e.g. residents of the community in which it operates. As renovation processes are rather complex many stakeholders are part of the process. The stakeholders can change and vary depending on the stage the renovation is in. Therefore, it is important to keep track and ensure a common understanding of the renovations purpose and goals. Femenías and Thuvander (2015) point out that there is a lack of knowledge about renovation options that result in long-term sustainability. Another research by Femenías et al. (2013) has shown that there are multiple values among the stakeholders depending on their different disciplinar belonging, knowledge fields, powers and the legitimacy for action. Further Femenías et al. (2013) argue that a wider stakeholder engagement can increase the understanding of the complexity of renovation. For the stakeholders to have a common understanding is important to support the learning process throughout the renovation and safeguard cultural-historical but especially social values.

3.1.1 Environmental Sustainability

There are many environmental classification systems, on international, European and national levels, such as LEED, BREEAM, or Miljöbygg. They can be the starting point to assess and assure environmental sustainability in a building. A major issue is that these classification systems are often directed towards new buildings, rather than renovation, which can result in misleading assumptions (Lind et al., 2014).

Lind et al. (2014) argue that the most relevant aspects of the environmental dimension in a renovation is to tackle are energy use, choice of materials, waste and water management, and the quality of the indoor environment. Focusing on the energy efficiency of a building and decrease the energy use for heating can lower the use of fossil fuels and the emissions of carbon dioxide, air borne particle contaminations or sulphur dioxide (Janson, 2008). Regarding the choice of materials, Lind et al. (2014) state that there are several systems or classifying construction materials and components from an environmental perspective, such as Sunda Hus, BASTA, and Svanen/EU Ecolabel, that basically concerns the absence of hazardous chemicals and materials, and the likelihood to be recycled and reused.

Carrying out a renovation can be the opportunity to improve other features of the building that are relevant in order to improve the environmental sustainability dimensions. Depending on the project this can include the waste management, water management, improvement of green areas, bicycle rooms, charging stations for electric cars and bicycles, among other features (Lind et al., 2014). Another environmental aspect mentioned by Lind et al. (2014) is the indoor environment, which takes into account the tenants' health and well-being, or how they experience their house, regarding lighting, noise, temperature, ventilation, among other aspects.

One specific example is the energy use in Sweden. Old buildings can substitute their energy systems to more efficient economically and environmentally friendly systems, such as renewable energy sources or district heating. Another possibility is to improve the buildings insulation, ventilation and heating systems in order to save more energy (Lind et al., 2014). In Sweden, district heating is the most common system of energy usage for heating and hot water in multi-dwelling buildings, accounting for 23 TWh in 2013, while electric heating only accounts for 1 TWh (Fig. 3). Energy for heating residential buildings represented more than half (55 percent) of the total energy consumption in Sweden in 2013 (The Swedish Energy Agency, 2015). Therefore, efficient building insulation and effective heating systems can contribute to environmental and economic improvements (Sabouri and Femenías, 2013).

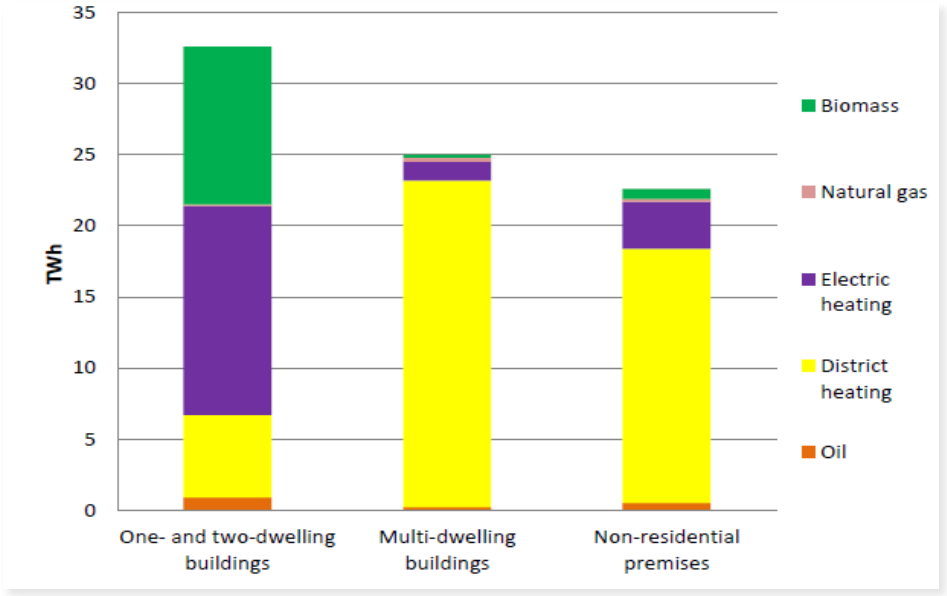


Figure 3 Energy use for heating in multi-dwellings in 2013, in TWh (The Swedish Energy Agency, 2015)

To comply with the Energy Performance in the Building Directive (2010/31/EU), that requires that all EU countries should aim for energy consumption reduction in construction, Boverket has created stricter rules. These rules became effective in 2013 and claim that, for extensive renovation of existing buildings, the same rules of new construction apply, to the extent that this is technically, functionally and economically feasible. (Wahlström et al., 2013). According to The Swedish Energy Agency (2015, p.13), Boverket has stated that "buildings shall be so designed and constructed that their energy use is restricted through low heat losses, low cooling requirements, efficient use of heating and cooling and efficient use of electricity."

n Sweden, district heated multifamily dwellings of all ages use on average of 166 kWh/m2 (The Swedish Energy Agency, 2015). Wahlström et al. (2013) show in Table 1 the values required for maximum energy use in Boverket's code for residential buildings, in kWh/m² Atemp. Atemp is the heated area and is defined as the internal area of the building envelope, on all floors, that is supposed to be heated to more than 10°C.

Table 2 Requirements for maximum energy use in Boverket's code for residential buildings in Sweden (Wahlström et al., 2013)

Residential buildings	**Annual energy use for heating, comfort cooling, domestic hot water provision and other shared services in the building (kWh/m²)**			
	Climate zone			
	1 (north Sweden)	2 (middle Sweden)	3 (south Sweden)	
with heating systems other than electric heating	130	110	90	
with electric heating	95	75	55	

In a study to compare energy consumption in various heating systems in multi-dwellings in Southern Sweden, Bagge and Johansson (2013) concluded that the use of district heating was higher at properties with under floor heating as the primary heat distribution system. On average 173 kWh/m², compared to 70 kWh/m² at properties with radiators as the primary heat distribution system.

Regarding energy consumption, Bagge and Johansson (2013) state that in the design phase, calculations and simulations of building performance are prerequisites for the analysis of the effectiveness of different designs and systems. When these predictions are used as a basis for decisions, it is of the greatest importance that they represent the actual building's performance. Otherwise, decisions that affect the building's performance, as well as its economic viability and the environment, might be made based on insufficient information, which often happens (Bagge and Johansson, 2013; Sabouri and Femenías, 2013).

The BBR specifies the demands of total energy use in buildings, which is based on the directive of the energy performance of buildings decided by the EU and to be used in Sweden. The document implies that property owners are obliged to declare the actual total energy use in the buildings and to report these parameters regarding the indoor climate. The aim is to decrease total energy use and make information about the actual energy performance of buildings, available (Häkkinen et al., 2012).

Bagge and Johansson (2013) explain that one big reason for the errors in modelling and predicting energy consumption is the user's behaviour, which is difficult to envision. Yang et al. (2014) state that "people are not passive recipients of their immediate environment, but constantly interact with and adapting to it". In addition, Jackson (2005) points out the existing models and simulation programs in order to measure and predict users' energy consumption and behavioural patterns. Häkkinen et al. (2012) states that the above mentioned directive could help the tenants to make decisions about how to decrease their energy costs and visualize their energy habits. Sabouri and Femenías (2013) add that, besides users' behaviour, other factors are likely to be unforeseen during building's lifetime such as household appliances, envelope quality, climatic conditions, unfeasible maintenance requirements, and building management account for the inaccuracy of measures and goals.

New technologies and methods, such as the passive house concept or heating with solar energy, are taking the environmental perspective into wider consideration. The passive house concept aims to reduce heat loss by applying sufficient insulation for on the building envelope, which at the same time provides fresh air. Especially in the passive house concept, not much energy is needed for heating. Combined with a heat recovery ventilation system the building becomes energy efficient in itself. Yet, it is not always possible to apply these technologies (Sabouri and Femenías, 2013)

3.1.2 Economic Sustainability

In terms of economic sustainability within a renovation process, it needs to be differentiated among long- and short term perspective and whether it concerns the property owner or the users.

In the survey carried out by Thuvander et al. (2016) among the largest Swedish housing companies (property owners), it was discovered that the main reason to start a renovation project is because of technical and economic aspects. A reasonable number answered, that the main reason for a renovation is motivated by raising technical standards, followed by high operating costs, high energy consumption, and high maintenance costs. Lind et al. (2014) points out the legislation developed by the Swedish government, stating that companies should act in a "business-like-way", meaning they must only invest if it gives such a return. The main barriers to sustainable renovation identified in European countries are a lack of knowledge and the unconvincing cost-benefit relation whereby an investor does not always profit from improved performance (Meijer et al., 2009, pp 546).

When the decision to renovate is made, maintenance and costs are ranked in the top of the priority list of concerns, followed by energy efficiency. The least priority was given to attractive architecture. Which makes sense with the fact that less than 50 percent of companies answered that they make an evaluation of the existing architecture and cultural inventory, and environmental systems analysis. When it comes to what they need it should be more developed in the industry, they point out that the main need is related to technical issues, such as more researches on renewable energy systems (50 percent) and passive house technology for renovation and ventilation and installation systems (both 44 percent). Issues relating cultural aspects are the least ranked (8 percent) (Thuvander et al., 2016).

Regarding investments in energy efficiency measures, Meijer et al. (2009) add that they usually have high costs and it hinders acceptance from property owners and households to invest on it, and from tenants to accept an increase on the rent due to these investments. However, if the savings in energy bills due to these interventions are perceived from a long-term perspective, it in many cases pay off such investments. Technological solutions, such as switching to the most energy-efficient technologies available, could save up to 40 percent in residential electricity consumption. However, the focus on technology alone appears to have its limitations.

3.1.3 Social Sustainability

In order to evaluate social sustainability within a renovation concept, different scales have to be considered. Urban planning of cities includes the city as a whole: districts, neighbourhoods, and individual buildings. As urban planning is a system with many stakeholders and interrelations, it needs to be considered that individual buildings or interventions on different levels within the

urban sphere, can affect the social sphere and structure on different scales. In return, this influences the health and well-being of its inhabitants (Commission for a Socially Sustainable Malmö, 2012). Physical planning within a city can:

- Reduce segregation between residential areas;
- Improve trust, safety and social opportunities;
- Contribute to deliberate location of schools in good environments;
- Contribute to a sustainable, mixed, inclusive city;
- Contribute to new economic and strategic structures;
- Make use of people's experience and knowledge.

Many authors describe social sustainability in renovation in terms of preservation of social capital and the local community. In addition, the renovation should be carried out in a way where the households and tenants can still afford to live in the same dwelling and are not compelled to move away to other areas (Lind et al., 2014; Thuvander et al., 2012; Stenberg et al., 2009). Westin (2011) uses the term *renoviciton* to describe the prevalence of less economically capable households and tenants that cannot afford to move back to their renovated dwellings due to extensive renovation and the increase of the rent-level. However, the *renoviction* strategy might be profitable for landlords in the short run, but it is mostly likely to be counterproductive for the society in the long run.

Westin (2011) points towards possible conflicts between the need to improve the housing stock and the need to improve the housing situation of low-income households. Lind et al. (2014) and Stenberg et al. (2009) argue that these events tend to contribute to segregation and most probably to a loss of social trust among the households that are forced to move out. Therefore, it is not possible to only look at renovation on a building scale but also how the renovation will affect the social and physical environment in the neighbourhood and the city.

A research carried out by Thuvander et al. (2016) investigates how large housing companies act before and during renovation projects. More than 60 percent answered that, to balance the expenses of a renovation project with reasonable rent, is one of the most difficult goals to achieve, being it more challenging than to meet energy efficiency goals, for instance. Only 35 percent of the companies have policies or goals related to tenants' social aspects. Thuvander et al. (2016) raise the question if the companies have the knowledge and tools in order to approach the tenants in the right way, therefore that they are often more focused on the technical aspects of a renovation concept.

Another important stakeholder in the social sustainability dimension is the Swedish Tenants Association (*Hyresgästföreningen*), which created a document called 'Sustainable Renovation - the only way forward' that, among other things, states that people must be able to stay in their apartments after these have been rebuilt or renovated. Moreover, it states that tenants must be

given greater influence over what is done in and within their home. They claim that it is necessary to have better opportunities to finance renovations and alterations, and that these aspects can enable social, economic and ecological sustainability (Hyresgästföreningen, 2015).

3.1.4 Well-being

Throughout literature well-being has often been considered under the social sustainability aspects (Lind et al., 2014; Botta, 2009). Therefore, both dimensions are closely interconnected and might be separated differently by different research. Acre and Wyckmans (2014) claim that the key to renovation acceptance is to secure people's well-being, meaning that disregarding non-technical effect on occupants is a mistake, especially in energy renovation projects. At the same time, the European Portal for Energy Efficiency in Buildings has recently published the Healthy Homes Barometer and how building renovation contributes to occupant' health and well-being. Regarding this study, people living in cold houses or having mould in their homes, are about 50% more likely to get illnesses like nose and throat infections (WBDG Productive Committee, 2015).

Graninger and Knuthammar (2010) point out stress and anxiety among tenants as common emotions associated with a renovation. Moreover, they state that there is a connection between personal control and well-being. Depending on how the renovation process is organised, and depending on the choices and opportunities that are given to the tenant, stress can to some extent be prevented or strengthened. Ekström (1994, Graninger and Knuthammar) points to the link between stress and the control individuals have over a given situation. Safety, uncertainty, as well as security and insecurity are other emotions that are connected to a renovation. When someone is forced to leave his or her home, it means insecurity and uncertainty.

A more general description of well-being as a sustainability dimension is, in order to be reached, the environmental, social and economic sustainability aspects need to be balanced to enable the general well-being (Challenge Lab, 2015).

3.1.5 Architectural and Historical Aspects

Considering that renovation processes are complex, there is a risk of underestimating architectural and cultural values, in favour of exterior and interior upgrading, energy efficiency, and financing. The built environment is an important part of Swedish cultural heritage, being part of its national and regional identity, and a hub for socio-economic development (Thuvander et al., 2012).

Architectural and cultural values of buildings are perceived as difficult to handle, many times, because they are immaterial values, susceptible to subjective interpretation. In one hand, laws and detailed plans protect these architectural and cultural values of buildings, but on the other

hand, the established methods, tools, and renovation processes lack in integrating these values into the process. The sustainability assessment methods, for instance, such as BREEAM, LEED, and EPIQR (presented in Table 2, in the following chapter) treat architectural values mostly as aesthetics, they do not balance material and immaterial values, and the cultural values are more or less absent. In general, the architectural and cultural values are handled in a very generic way (Thuvander et al., 2012).

In Sweden, there is a method to evaluate these values, the National Heritage Board's "Cultural Historical Evaluation", but according to a research and survey done by Thuvander et al., (2012), this method is perceived as complex, or even unknown to many actors involved in renovation processes. It was perceived a need for better integration of these values in renovation processes, especially when carrying out the inventory phase, and also a need for more simplified methods since property managers strive to handle various conflicts.

3.2 Renovation Framework

When it comes to a general renovation framework in Sweden, Boverket has developed a rather general process (Fig. 4). The literature review resulted in various different renovation strategies among companies and industry. In general, renovation processes have the same phases as in new construction, meaning pre-design, design, construction, commissioning, occupation, and maintenance (Baker, 2009). The preliminary investigation is a broad term, including the collection of various types of information. However, it can be simplified as an inventory of the status of the building, and the establishment of a documentation of the building prior to an alteration (Thuvander al., 2012).

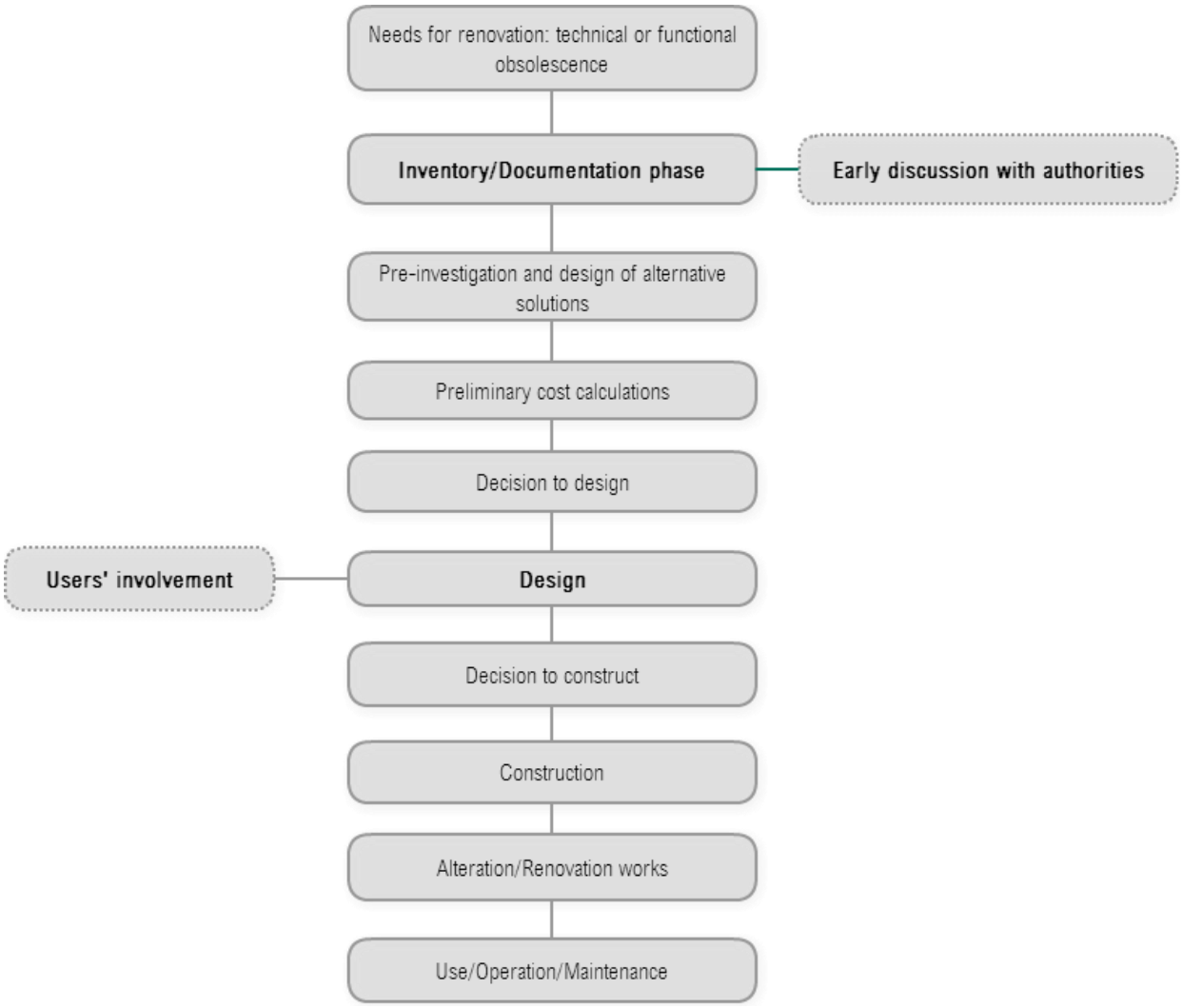


Figure 4 Renovation process (Thuvander et al., 2009, adapted from Boverket)

The Swedish renovation framework from Boverket (2006) states that a preliminary investigation should include surveys of the building and its environment, such as local context, general impressions, technical status, maintenance status, documentation of user requirements,

documentation of property data, contracts that concern the building, history (year of construction, previous renovations and alterations) drawings and pictures (Fig. 5). It is declared that a preliminary investigation should be objective and not include subjective evaluations in order to achieve satisfying results after the renovation. Knowing the building and its qualities and characteristics can help to choose the right renovation strategy and materials to use. That way a gentle renovation of the building can be provided (Thuvander al., 2012).

In order to gain this information and get an overall and detailed picture of the building, it is suggested to involve various experts and stakeholders at this early stage (Boverket, 2006). The social aspects are taken into consideration by involving the tenants and their knowledge and values utilized in planning. The inventory is especially important for the developer. Being aware of a building and its characteristics and condition can avoid unnecessary conflicts and surprises from the beginning of the renovation process which then results in better and cheaper solutions (Boverket, 2006).

Thuvander et al. (2012) suggest putting more emphasis on time and resources when it comes to the inventory phase, in order to investigate the actual condition of the building and consequently reach better results in the following steps. Thuvander et al. (2012) point out that it is frequent to renovation processes to start with insufficient documentation of building conditions, which will affect the following procedures. Thuvander et al. (2012, p.1206) state that in the preliminary investigation phase, the different values need to be studied one by one, but often they must be balanced one against another within certain economic frames. In order for all the different values to really be addressed in the preliminary investigation phase, they must be anchored in the organization's policy documents and a budget for them allocated. The different material and immaterial values need to be integrated into processes for construction management, project delivery and not only in risk management regarding, for example, potential loss of property value as a result of alterations of the original architecture.

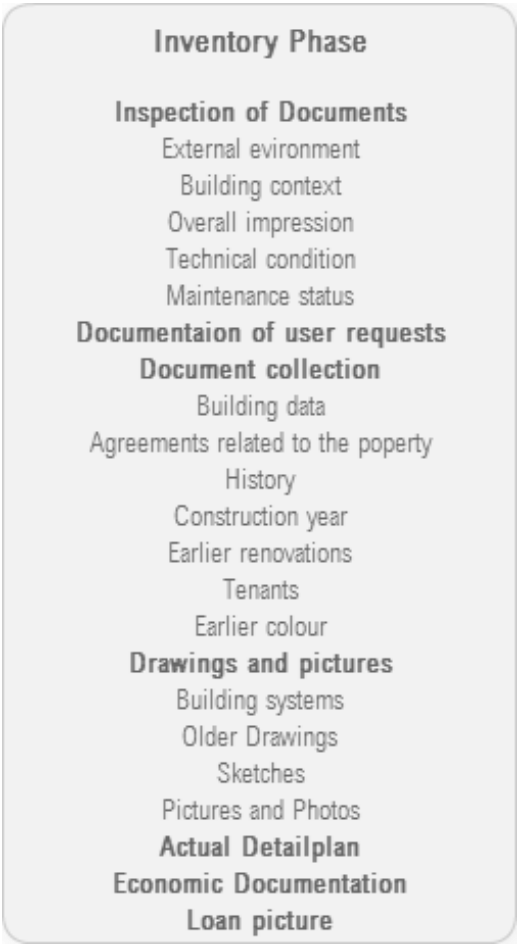


Figure 5 General renovation framework provided by Boverket (adapted from Boverket, 2006)

In addition to the existing renovation framework and the guiding steps for the inventory phase, researchers

involved in SIRen, an inter- and transdisciplinary research project involving Chalmers University of Technology, work towards detailed inventory checklist in order to proceed in a better way in the inventory phase (Mjörnell et al, 2015). This checklist includes a detailed analysis of technical and environmental conditions, energy-related measurements, the social description related to dialogue with the tenants, the cultural and architectural values, the overall assessment. Likewise, the same researchers put together who to involve in order to get the right competencies and method in order to analyse these specific aspects.

3.2.1 Tenants' Association Renovation Framework

The Tenants' Association in Sweden created a renovation framework to be followed that has a strong focus on the involvement of the tenants in the whole process. The framework is represented in Figure 6 and consists in a process map for tenant consultation in renovation, with six phases: Pre-process, Dialogue phase, Negotiation phase, Approval phase, Refurbishment phase, and Follow up. Each phase has a set of check-lists to be carried out. The rent negotiation occurs throughout the whole process, and this organisation plays an important role in rent negotiation in renovation projects (Leaning Lab Hammarkullen, 2016).

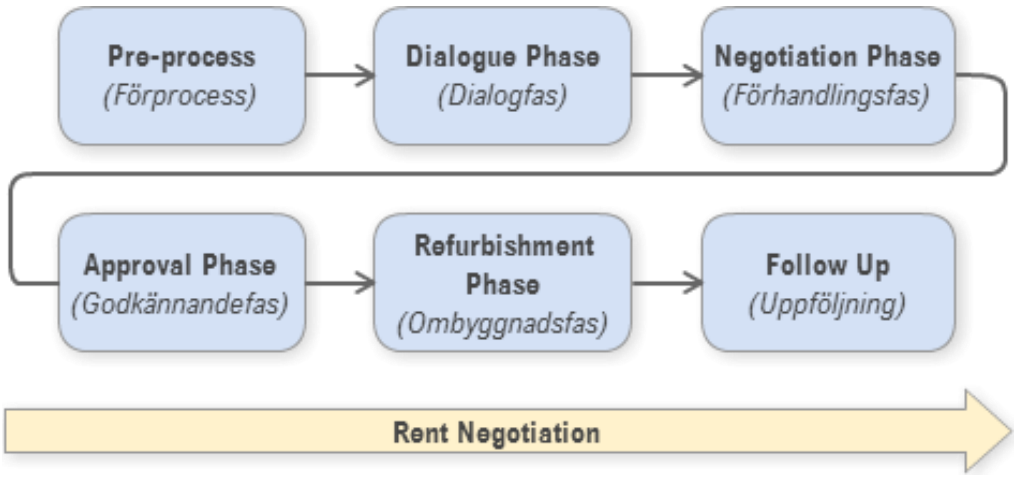


Figure 6 Tenants' Association renovation framework (adapted from Stenberg,)

The participation of tenants in this framework includes, among many things, proposals for legislative changes that create a more equal balance between the parties involved, leading to more sustainable rental housing, as well as improved economic conditions for both tenants and property owners. It stresses that every renovation project should have as a starting point for people to be able to stay after the renovation. If people are forced to endure excessive changes in their homes, fields and neighbourhoods, it means that the community needs to intervene and change the conditions of implementation of such changes (Hyresgästföreningen, 2015).

3.3 A Remark - Interview Rotpartner

The aim of the interview with Rotpartner was to get a better understanding of the inventory phase of a renovation process and, in addition, to get a perspective from an expert on carrying out renovations projects on different scales in Sweden. Rotpartner is a consultancy company specialised in renovation projects. Its renovation strategy involves two parallel processes throughout the project, one is the technical and physical renovation process, called Building Process (*Byggprocess*), and the other is the Human Process (*Mänsklig Process*), where they created their own method to involve the tenants, called Tenants' Dialogue (*Hyresgästdialogen*). The renovation process starts with the technical process, and the first step is the contact with the property owner to understand the needs. The interviewee pointed out that it makes a great difference whether the property owner is a public organisation or a private person or organisation. It mainly influences the vision the property owner has, meaning that private property owners often have a stronger focus on the economic aspects of a renovation, and their interest are mainly concentrated in raising the property's value and income, through raising its standard and rent.

When starting the renovation process, it is to be decided by the property owner whether Rotpartner shall manage the communication with the tenants or residents, through their Tenants' Dialogue process, or if the property owner will perform it independently. The interviewee mentioned several projects where the property owner decided to be in charge of the communication with the tenants, which turned out to not be very successful, in fact causing a lot of resistance from the tenants towards the renovation, as well as additional costs as a consequence of misunderstanding in the decision-making process. The interviewee mentioned that there are other larger property owners and contractors whose carry out renovation projects that have professionals especially responsible for the communication process with the tenants, and mentioned that it is of great importance for any renovation project, but sometimes it is underestimated. In general, property owners think positively about the Tenants' Dialogue, although they often decide that the contractor will manage this part, through one of their own Project Manager, which is often only in charge of the building process. As the interviewee mentioned, this should not be the task of a Project Manager and that the communication with the tenants is, in fact, very demanding.

When starting a renovation project, the first step is to carry out a feasibility study (*Förstudie*), that focuses mainly on the technical status and the overall condition of the building. In parallel (if Rotpartner is in charge of the dialogue with the tenants), a first analysis of the tenants takes place. This first analysis of tenants' profiles is done through information given by the property owner, such as the number of people living in each apartment, age, family structure, occupation, income, etc. In this phase, the tenants are not yet contacted personally. The documentation from the

inventory phase, related to the condition and technical status is passed on to the property owner, which then, based on that, evaluates whether the renovation is going to the next step.

The interviewee mentioned that, based on the technical status and a first meeting with the tenants, often a sample apartment (*Visningslägenhet)* is made, which can help the tenants to imagine the final results of the renovation. Whether such an example apartment will be produced or not, is very much dependent on the size of the renovation and how much apartments and tenants are affected by the renovation. If there is no chance to produce such an example apartment, they provide references, such as 3D models and images, to the tenants.

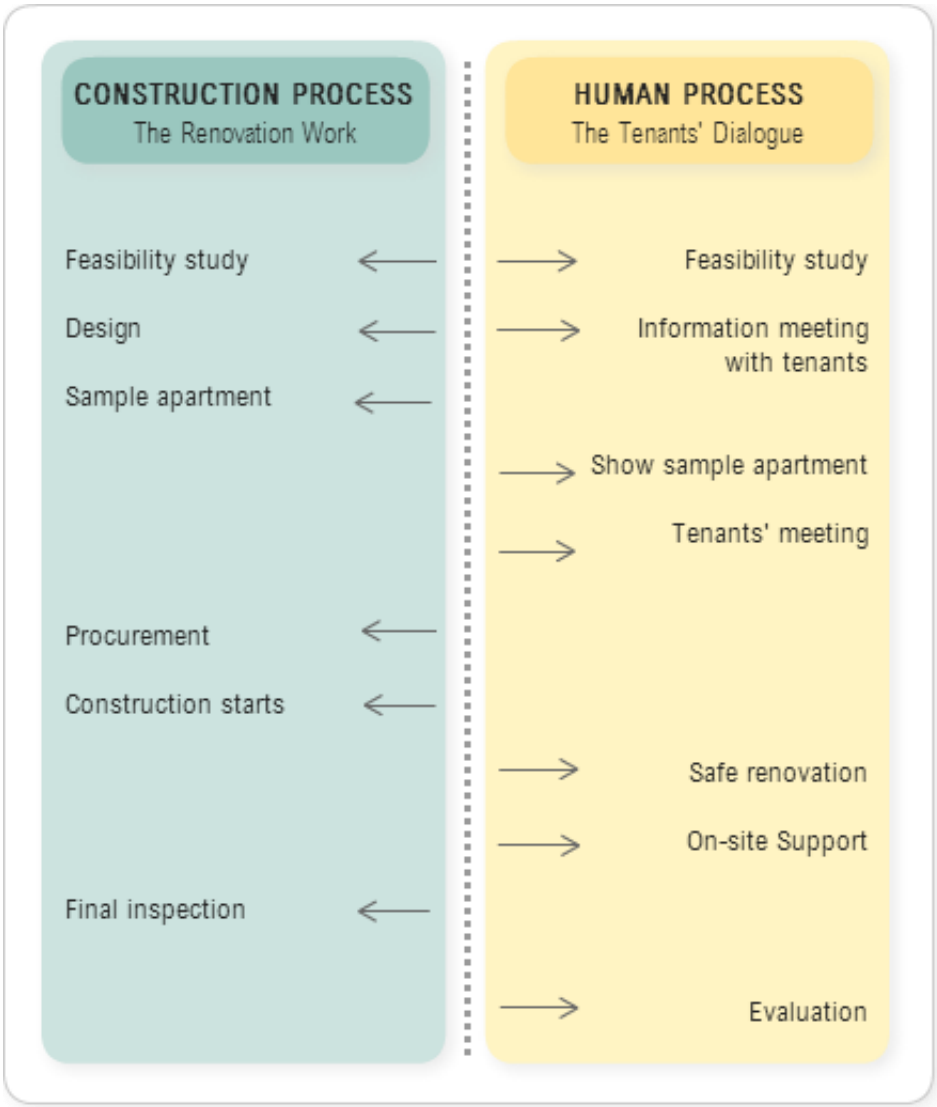


Figure 7 Rotpartner's own renovation process, Building Process in parallel with Human Process (adapted from Rotparner, 2016)

3.4 Tools and Methodologies for Decision-Making Support

When it comes to current decision-making methods in a renovation process, only a few options are available that assist in evaluating different renovation alternatives concerning that all of the sustainability aspects and in an early stage of the renovation process (Mjörnell et al., 2014; Thuvander et al., 2012). Therefore, many researchers focus on evaluating tools and methods that were developed for new construction could be adapted to renovation (Thuvander et al., 2012). Mjörnell (2014) points out that there are tools such as Retrofit Advisor, that consider all sustainability aspects, yet it is not possible to adapt them and include important parameters such as building characteristics and climate conditions. A similar statement is made by Thuvander et al. (2012) saying the many values considered in these methods are of interest for sustainable renovation, yet there is a gap. Environmental and technical values are covered quite well and described by a larger set of indicators, whereas economic and social issues are not well developed, just addressed by only a few indicators.

There is a wide range of international and national tools and methods for assessing or classifying buildings from an environmental or sustainability perspectives. The most established and widespread assessment methods are, among others, *BREEAM* (the Building Research Establishment Environmental Assessment Method, developed in the UK), *LEED* (Leadership in Energy and Environmental Design, developed in the USA), *EPIQR* (Energy Performance Indoor Environment Quality Retrofit) and the Green Building Tool, for instance. In Sweden, there are tools such as the Swedish environmental rating tool *Miljöbyggnad, EcoEffect*, and the Nordic eco-label *Svanen* (Thuvander et al., 2012). As they (2012) point out, many of these address new construction, some of them address existing buildings, and only a few take renovations into consideration, as for example, BREEAM with the Domestic Refurbishment section and LEED with Major Renovation section (Thuvander et al., 2012).

Table 3 Selected building assessment methods and values addressed. Adapted from Thuvander et al., (2012)

Methods	**Addressed values**				
	Economic	**Environmental**	**Social**	**Architectural**	**Cultural/ Historical**
BREEAM	Value management Whole life costs Ease of maintenance	Primary energy consumption Materials Land use and ecology Water Waste Management and risk LCA indicators	Comfort and Health Building safety assessment User well-being Accessibility Access to transport Social and ethical responsibility	Building aesthetics and context	-
LEED	Asset value	Primary energy consumption Materials Land use and ecology Water Waste	Comfort and health Building security Accessibility	Building adaptability	-
EPIQR	Refurbishment cost	Heating/cooling energy requirement and energy saving potential	Occupants and indoor environment quality	-	-

Thuvander et al. (2012) go one step further and analyse various methods in regard to a more integrated approach in the decision-making methods. The aim of this research was to compare a number of values such as architectural, social, cultural-historical, technical, environmental and economic values together with the process quality. Yet, none of the more established methods such as BREEAM and LEED addresses the complexity of balancing technical, environmental, economic, architectural, cultural, and social values (Thuvander et al., 2012).

3.4.1 Economic Aspects – Life Cycle Costing Tool

Life Cycle Costing (LCC) is a tool that can be used to evaluate building projects at an early stage. It seeks to determine the total expenditure on a project by analysing all materials, components, energy and other associated costs including maintenance costs throughout the life of a proposed building project. In addition, one of the main ideas of an LCC analysis is the discounting of future costs to the present value, and it allows the comparison of design options (Higham et al., 2015).

It is well known that the construction industry trends towards a more sustainable built environment, including EU directives, national legislation, policies, industrial standards, and other requirements. Consequently, many are adopting a more long-term sustainable life-cycle perspective, increasing interest in estimating long-term economic consequences of investment decisions, for example by using tools such as LCC (Gluch and Gustafsson, 2013).

This growing interest in LCC can be related to the single monetary unit as a possible means to translate environmental complexities into a more common unit of measure for a broader

audience. Interest in LCC can be related to the ongoing quest of finding more sustainable alternatives to meet the significant increasing need to renovate an aging building stock. This calculation is advantageous for property owners that seek long-term involvement with their built environment asset (Ludvig et al., 2010).

3.4.2 Social Aspects – Identifying Social Aspects Relevant for Renovation

Mjörnell et al. (2014, p. 4237) identify a set of social aspects important to a renovation and define social sustainability as aspects that include justice, trust, and civic participation, as well as fair living standards and health. This includes e.g. the existence of relevant services in the vicinity of the building, access to venues where it enables a varied social life to arise, and the environment having qualities that people can easily relate to.

To access social sustainability aspects, employees of the Municipality of Gothenburg have developed a knowledge matrix called S2020 (Mjörnell et al., 2014). The aim is to encourage various stakeholders to give the same priority to social issues as they do to economic and environmental aspects. The tool considers six levels when planning for social sustainability on a city level; individual buildings, local areas, neighbourhoods, the city and the region.

A research done by Mjörnell et al. (2014) suggest taking a set of various indicators into account that shall ensure the social sustainability. The indicators as such are cohesive city, social interaction, teamwork and meetings, a well-functioning everyday life, identity and experience, health and green urban environments, safety, security and openness. When talking about cohesive cities, Mjörnell et al. (2014) refer to the variance a city should have in housing supply and the effects this has on the demographic composition of the population. To be specific, there need to be a variety of apartments, variation in rent levels and ownership.

In addition, tools as SIA (Social Impact Assessment), SROI (Social Return on Investment) and Social LCA (Social Life Cycle Assessment) have to support the analysis of the mentioned indicators. Especially the Social LCA requires a greater degree of involvement of stakeholders and require the concern on how to define the functional unit, utility, and role of the product play for the user. However, the social aspects and indicators are early attempts to measure the social aspects of a renovation but have not been tested yet. It requires following a renovation from its beginning all the way to the end, when there will be a next renovation, demolition or deconstruction (Mjörnell et al., 2014)

3.4.3 Environmental Aspects

In order to conclude whether a renovation is environmentally sustainable, the whole building life cycle should be taken into consideration (Mjörnell et al., 2014). Therefore, Mjörnell et al. (2014)

suggest an Environmental Life Cycle Assessment (LCA) in order to compare between different renovation measures from an environmental perspective. When it comes to the environmental impact of a building, it often relates to its energy and resource use in the use phase. But it is important to consider the production phase and its environmental impact in construction materials and consumption as well (Mjörnell et al., 2014). The LCA tool focuses on comparing renovation alternatives to reference cases. This requires that the buildings are fairly similar in the heating system and energy consumption level.

After analysing tools and methods, Thuvander et al., (2012) point out a need for a top-down approach in order to develop a sustainability assessment system. This requires the involvement of various stakeholders and a great need for the further development of tools and methods to support integrated decision-making in sustainable renovation (Thuvander et al., 2012). Until now, most building owners bring in consultants to make decisions regarding which designs and technologies to use for renovations. Thus, a tool that facilitates less complicated evaluations of architectural and social values is needed, as there are often difficult to deal with conflicting technical, environmental and economic values (Thuvander et al., 2012).

3.5 Conflicts and barriers within a renovation process

It is not always easy to understand which aspects of a renovation process belongs to each sustainability dimension. Stenberg et al., (2009) argue, that when one tries to consider the environmental aspects separately, it can be hard to distinguish them from the social aspects. They (2009) add that measures and goals to achieve environmental sustainability are most likely to succeed if the tenants accept and get familiar with these measures and goals. Which makes it clear, that the environmental and social dimension cannot be separated. To achieve environmental and social sustainability goals and to obtain lasting results, knowledge needs to be incorporated into the organisations involved, such as the property owner and the tenants. Gluch and Gustafsson (2013) argue that lower costs in the renovation process and concept can mean higher environmental impacts since especially new technology can be costly which does not always harmonize with the economic aspects.

Regarding energy efficiency, investments in renovation measures are usually high, but delivers energy savings. For householders, lower energy bills mean higher disposable incomes. For rented dwellings, the energy bill is included in the rent in most cases in Sweden, thus, energy savings likewise reflect on rent levels. For those experiencing energy poverty, greater comfort levels can be achieved for the same or a lower cost, and the potential health impacts of living in inadequately heated accommodation avoided (National Renovation Strategy, 2014). Ástmarsson et al. (2013) describes the conflict between property owners and tenants regarding investments in energy efficiency. It is called “the landlord/tenant dilemma”. It occurs when the property owner

provides the tenant with the housing and installations, but the tenant pays the energy bills. Thus, the property owner does not want to invest too much in energy efficiency, while the tenant wants to lower the energy costs. As the property owner does not pay for energy consumption, there are few incentives to invest on it.

Lind et al. (2014) suggest a fourth sustainability dimension to be considered in renovation, named technical sustainability, stating that choosing a long term and well-tested solution can be described as selecting a more technically sustainable solution. It concerns more to the indoor environment; that takes into account the tenants' health and well-being, or how they experience their house, regarding lighting, noise, temperature, ventilation, etc. Lind et al. (2014) explain that this concept of technical sustainability cannot be reduced to neither environmental nor economic sustainability. The long term solution might use more material and cost more, and thereby affect the environment to a greater extent than other short-term solutions are chosen.

Another conflict that most of the housing owners face when carrying out a renovation project is how to prioritize the different sustainability dimensions. Within social sustainability, there is a conflict between a focus on the current tenants and their situation, and trying to create more diverse communities, bringing in new tenants (Lind et al., 2014). Thuvander et al. (2012) found out, in a survey with housing owners in Sweden, that they tend to focus on future tenants instead of focusing on the existing ones.

To combine all the sustainability dimensions can be challenging and requires various stakeholders to collaborate. To be energy efficient and implement new solutions to save energy can cause an economic impact, which the tenants are often not willing to take on. However, it needs to be considered that the cost might seem higher in the short-term but might even out in the long-term perspective.

3.6 Communication between stakeholders/tenants in renovation projects

The Communication between various stakeholders during a renovation process has been studied during last years. Yet, how tenants can be involved in developing the concept for a renovation has not been subject of many studies. There are several different stages within a renovation process that the tenants need to be informed about, but moreover, where they could be involved. One of the first steps is to inform the tenants about the intended renovation. According to the Guidance on Tenant's Relocation in Renovation Projects, by Boverket (2016), the housing owner must inform the tenants about the intended renovation, and at least 50% of the tenants must approve the renovation. If the renovation is rejected by more than 50% of tenants, the owner must apply for permission in the Swedish Court for regional rent and tenancies tribunal (Hyresnämnden). However, successful renovation projects are often connected to an effective

tenant dialogue, which tends to lead to better results, and especially higher acceptance among the tenants (Boverket, 2016).

To take into account tenants' opinions is most likely to lead to increased satisfaction among them and decrease resistance, due to awareness of the process and the value of the change that they might be afraid of, and it can strengthen the relationship between the housing owner and the tenants (Hällgren and Xygkogianni, 2015). It is further recommended by Boverket (2016) to housing owners to appoint a responsible person for the dialogue with the tenants, to capture their opinions, answer questions and keep them informed about the renovation process.

According to a study on evaluation of the communication processes in a multi-dwelling renovation, performed by Hällgren and Xygkogianni (2015) the involved tenants ask for effective communication, not only between the property owner and the tenants but also between the property owner and other stakeholders. Due to the often temporary projects and changing stakeholders in construction and renovation processes, a proper way of communication and creating a common understanding can be challenging (Chinowsky et al., 2011 in Hällgren and Xygkogianni, 2015). The importance of bringing together different stakeholders is also pointed out by Thuvander et al. (2012) who argues that especially when working towards a sustainable renovation concept stakeholders need to be brought together in dialogues, to facilitate communication between practitioners from different areas and property owners, in order to identify and balance the sustainability aspects.

Such dialogues play a significant role in the outcome of renovation projects, as the involved parties have the ability to influence and have a direct impact in the project (Hällgren and Xygkogianni, 2015). Hällgren and Xygkogianni (2015) add that dialogues should be seen as the cornerstone of the process and not only a part of it. However, past research has shown that frequently there is a lack of understanding the purpose of such dialogues between stakeholders, thus, there is consistently a risk for the processes to become inefficient and for the participants to be less committed (Smedby and Neij, 2013 in Hällgren and Xygkogianni, 2015).

There is a large potential in working with a transdisciplinary arena in order to address the complexity of sustainable renovation as a mean to develop practice through raising discussions, point to emerging aspects that should be handled, bring in larger spectra of knowledge, and establish a common understanding which will raise the awareness and the acceptance of the outcome (Thuvander et al., 2012). Furthermore, to dialogue with tenants before a renovation project can increase the feeling of well-being and participation, and reduce concerns among them regarding the project (Boverket, 2016).

4. Methodology

This section describes more in detail which research design has been chosen and motivate the decision in order to provide a comprehensive understanding of the used method. In addition, it will reflect on the research approach and the quality of the research

4.1 Research Approach

The research approach sets the framework for the procedures for research that span the step from broad assumptions to detailed methods of data collection, analysis and interpretation (Creswell, 2014, p.4). Choosing the research approach will determine the procedures of inquiry and specific research methods of data collection, analysis and interpretation. The main research approaches are qualitative, quantitative and mixed method, and the decision is determined by the research problem which needs to be addressed (Creswell, 2014).

Before it was decided which research approach to use, a first literature search with related keywords, such as *renovation, sustainable renovation, owner-tenant relationship during renovation, energy-efficient renovation* was done in databases such Scopus, Google Scholar, and Summon/Chalmers Library. The aim was to determine whether the research problem was worth studying, and in addition, to set the scope and limits of the addressed problem. A more in-depth literature review took place later in the process aiming to analyse ongoing debates on the studied research problem, and in order to draw relations between related topics.

To address the research problem stated in this thesis, an inductive and qualitative research approach was found to be most suitable. The qualitative research approach allowed to explore and understand the meaning individuals or groups ascribe to a social or human problem (Creswell, 2014, p.4) which was analysed with various emerging methods such as interview data, observation data, audio-visual data and workshop data. This process involved collecting data in the participants setting, and the researcher can make interpretations of the meaning of data which helps to render the complexity of the situation.

4.2 Research Design

The research design refers to the overall strategy for collecting and analysing data in a coherent and logical way and ensuring that the research question will be addressed in the right manner. The research design should be determined by the research question and not the other way around (Creswell, 2014). When choosing the research design, it was considered that it will affect the results and therefore the outcome of the study.

When facing complex problems and unique events such as a renovation process, a case study was found to be a suitable and appropriate design for collecting and analysing data. Case Studies allow to simplify rather complex concepts and illustrate a particular context, which allows the author to study the case within the present situation and therefore gain a deeper understanding of the subject (Yin, 2008).

The data related to the Case Study was conducted during a very short time period, and therefore, the amount of data could have been more comprehensive, which is a clear disadvantage of the Case Study method. Therefore, it was chosen to look mainly into the pre-investigation phase of a renovation, rather than a whole renovation process. Through conducted interviews with experts, it was possible to get a comprehensive understanding of the context of renovations, and especially of the inventory phase.

When using a Case Study method, there are no specific methods for data collection and data analysis that are recommended or advised (Yin, 2008). Therefore, the data analysis is much dependent on interpretation, meaning there is no right answer, and the problem arises in validation of the solutions (Yin, 2008). Yet, this allows to analyse the data from a different perspective, and due to consultations with experts and supervisor, the data collected and analysed was found to be relevant.

The research design considers only one case rather than comparing among multiple cases. This was chosen to be the ideal approach since the case object is rather specific, with very particular characteristics. However, every project in construction (renovation or a new building) is unique and requires a different approach. The studied case is a rental multi-dwelling owned by a public organisation, situated in Gothenburg, Sweden. The building needs to be renovated, and has unique architectural and historical characteristics that made it challenging to draw general conclusions from it, yet it allowed to study a specific case in-depth.

There are many controversies on generalising qualitative research results; some say the intent of qualitative research is not to generalise findings to individuals, sites, or places outside of those under study (Creswell, 2014). In fact, it is to be said that the value of qualitative research lies in the particular description developed in the context of a specific site (Creswell, 2014). However, Yin (2009) argues that qualitative case study results can be generalised to some broader theory.

4.3 Selection of Case

The specific case was chosen because the Property Management Administration was looking for students that could create a renovation concept for Banérsgatan 6. After visiting the building and before making the decision whether to work with the building, the authors realized that it is a rather unique case. It was obvious that the building itself needed to be preserved in a way where

its architectural and cultural-historical characteristics are kept. In addition, it should be still possible to live in such an old building and adapt it to nowadays energy efficiency and climate goals. The authors aimed for proposing a renovation process that focus strongly on the user and tenants' perspective of the building. These first thoughts were discussed with the property owner and they saw the need to propose an adapted renovation process, since the building is rather unique. At the same time the authors saw this as an opportunity to influence the business as usual procedures within a municipal authority. Therefore, the case was also chosen because of the property owner and the interest of working with the Property Management Administration. The Property Management Administration of Gothenburg owns a great number of land and properties and has, therefore, major power in the development of these land and properties. Suggesting a sustainable renovation process for one of their properties can open the possibility to this process to be applied among other properties, and as consequence, having a major impact in the development of Gothenburg regarding sustainable renovation.

4.4 Research Methods

As Creswell (2014) mentioned, there are no specific methods or forms of data collection, analysis, and interpretation assigned to a Case Study. The data was collected throughout own observations, ocular inspections on the site, interviews, a workshop with the tenants and property owner, and the collection of historical documents in the city's archive.

4.4.1 Observation and Interviews

Important for this study was to conduct interviews with various stakeholders, but especially with the property owner and the tenants, in order to obtain qualitative empirical information. All interviews were conducted in a semi-structured way, which allowed having a certain framework to cover, but at the same time, it allows the interviewer to evaluate on topics of interest and speak more widely, which allowed the interview to take on the form of a dialogue.

The interview questions and the observation checklists (Appendix D) for the tenants were created in a standardized way, and with the framework of the research design in mind. The observation on the site were important to get an understanding and feeling for the case object as a person living outside the building. Before conducting the interviews with the tenants, a letter (Appendix G) was sent out to each tenant in order to inform about the research and its aim. In addition, the tenants were kindly asked to get in contact with the authors if they would be willing to answer a few questions and make their apartment available for a short visit and observation. Within two weeks ten out of twenty occupied apartments were visited. The visits included the observation and a short interview. The interviews followed the same structure with open questions, and additional questions adapted depending on the tenant. The interviews were carried out by two

authors in order to reduce the risk of misinterpretation, and to make it easier to ask follow-up questions. It allowed to control and steer the questions and get a deeper understanding of the object. The risk is that the provided indirect information was filtered through the views of interviewees and that not all people are equally articulate and perceptive (Creswell, 2014, pp. 191). The interviews lasted between 30 minutes and one hour and took place in the apartments. The purpose of the interviews was to gather first insights of the views and experiences of the tenants on specific matters, such as common spaces, shared sanitary, their well-being and everyday life in the building. The interviews were developed with caution in order to avoid using words that suggest a directional orientation.

The authors observations focused on the inside of the apartments, and documented the condition of each one, and if there were any distinctive features. Ocular inspections of the building were carried out on site. In order to be able to update the currently available drawings of the building, measures, and pictures were taken with the permission of the tenants.

An additional interview was conducted with Rotpartner, a consultancy company that act as a partner in renovation and development of buildings, based in Gothenburg. It was an interview with unstructured and open-ending questions. Questions were prepared in advance, yet on the spot, it was decided that the representative from Rotpartner would talk about the renovation process as it is done at the company. In between and at the end of the session, the interviewers could ask more in-depth questions. The aim was to get an insight in the renovation process as it is done by Rotpartner, and especially how they try to achieve a sustainable renovation, and how the work with the tenants are carried out. The interview lasted approximately 40 minutes and was held in English and Swedish

Another interview was conducted with Pernilla Gluch, at the Department of Technology Management and Economics also the Program Manager of the Master's Program Design and Construction Project Management, to understand which would be the most appropriate method to perform economic calculations for the renovation concept of this building. She has done researches and given workshops for Chalmers' students on this topic, and her suggestions were of great importance for this work.

Throughout the whole process, various meetings with the municipal Property Management Administration took place in order to get more information on the history of the house, and how its situation is nowadays. The administration manages approximately 50% of all the land in Gothenburg, but also some public buildings, commercial buildings, and a smaller number of housing that are not entirely defined according to the actual detailed plan. Property Management Administration was the initiator to develop the first ideas and a concept for the case. Another important part was to understand the property owner's future vision for the building. Five semi-structured meetings took place, which was documented in the form of notes.

4.4.2 Workshop

The workshop was carried out in May 2016, with the idea to enable collaboration between the tenants, working together to reflect critically on their challenges, with a view to understanding and improving these. In preparation of the workshop, various methods were discussed and analysed with an expert in CaseLabs, where different stakeholders come together and work towards a common purpose. After reviewing literature for different participation methods, the Dialogue Café was found to be the most suitable to bring together the tenants and the property owner. The idea of the Dialogue Café is to invite the stakeholders into a welcoming area and serve coffee and tea together with some snacks. The idea is to present the topic and the questions regarding the topic, while participants enjoy coffee and snacks. In groups of five to eight people, several question and sub-questions are discussed. Important is to give clear instructions on how long each question will be discussed. The results are written on paper and are presented to the other groups after (Broms et al., 2014).

The Dialogue Café took place at Gamlestaden's community centre (Medborgarhuset) and from 14 tenants took part of the workshop, representing 50% of the total number of tenants who live in the building, as well as one representative from the Property Management Administration. The Dialogue Café was divided into two parts, with a coffee break in between. The first part was about two hours and the main aim was to present the authors and the aim of the study, the Challenge Lab and the concept of sustainability. Thereafter, a short presentation of each participant was done, called Check-in, which was followed by the two questions:

- *What do you like most in your apartment or building?*
- *And what do you like the least?*

Subsequently, the tenants were divided into three random groups, in order to discuss the main questions of the workshop:

- *What kind of activities would you like to do together? What space do you think is necessary for that?*
- *What do you think would improve your comfort?*
- *How can you contribute to a more sustainable way of living?*
- *What would you be willing to pay more for?*

For each question, the tenants were provided with paper and utensils in order to brainstorm their ideas. The questions were answered one by one in order to ensure that each group paid attention to all of the questions individually. Per questions, the tenants had approximately 10 to 15 minutes to discuss and answer. After the first session, a 15 minutes' coffee break was provided in which the participants mingled and discussed the previous exercise.

During the break, one participant from the Municipal Property Department joined the workshop, in order to answer questions and to listen to the tenants' presentations. The aim of the second part of the workshop, which lasted about one and a half hour, was for each group to present the results of their discussion around the given questions. In the next step, all participants were given two times three votes, to rank among all the answers which ones were most important and least important for them. During the presentation, the tenants started to elaborate on their notes, which the authors took notes of in order to interpret the results.

In preparation for the workshop, the questions were discussed with an expert within the field of participation processes. The attention was to keep technical terminology as simple and understandable as possible, in order to make them better approachable for the tenants.

4.4.3 Archive

In order to get a complete understanding of the case object, it was necessary to document the various historical stages of the building at Banérsgatan 6. The Municipal Property Department could only provide incomplete documentation of the building related to the time after 1960 when they become the property owner. In order to get the whole framework of the building characteristics and history, it was necessary to collect older blueprints (Appendix F), drawings, and pictures at the Regional Archive (*Regionsarkivet*) and at the Municipal Planning Department's archive (*Stadsbyggnadskontoret Arkiv*). Thus, it was possible to understand the building's original exterior appearance, and its functional and structural systems, as well as the original layout of the apartments. However, information about its history and past are limited. This information supported the inventory analysis of the building and guided some suggestions present in its renovation concept, presented in the results and conclusion.

4.5 The role of the researcher

As the data is collected, analysed and interpreted through a qualitative research approach, one has to take into consideration the researcher's role in the process. Both researchers studied the Master's Program Design and Construction Project Management at Chalmers University of Technology, in Gothenburg, Sweden. One was born and raised in Brazil and holds a Bachelor of Architecture and Urban Design while the other was born and raised in Germany and holds a Bachelor of Urbanism. Either have been in contact with the property owner or the tenants at Banérsgatan 6 before defining the research. Either of the authors have been involved in a renovation processes, but in processes where human behaviour was subject of the study, which turned out to be of advantage for collecting the data. The architectural knowledge was of advantage when analysing the technical quality of the building.

Since both authors are not native Swedish speakers, the site visits and workshop were held in English and Swedish, which did not affect the results of this study, due to the fact that all information send out was in Swedish and the involved parties always had the option to answer in Swedish, since both authors are advanced in understanding the Swedish language. The Municipal Property Department assigned the task of developing ideas and a first concept for the case, yet it was the authors who emphasized taking the tenants into account and developing a concept throughout collaboration. However, the authors in the role of students and the Challenge Lab represented a neutral ground where neither the ideas of the property owner, nor the tenants were favoured.

4.6 Quality of research

In order to ensure the validity of the research, multiple validity strategies were incorporated in the research to enhance the researcher's ability to assess the accuracy of findings, as well as convince readers of that accuracy (Creswell, 2014).

To ensure the validity, different data collection methods and different data sources, such as tenants and property owner, were questioned to build a coherent justification. Another interview was conducted with a company that is not involved in the project. This aimed to justify or oppose the findings from this specific case. In addition, two researchers were involved in data collection and analysis.

After the first site visit and the short interviews with the tenants, these results were summarized and concluded and taken back to the tenants during the workshop, in order to get a *member check* and a feedback whether the participants feel this summary is accurate. In addition, it was aimed to describe the case as detailed and comprehensive as possible, to convey the findings and make it possible for the reader to follow up on the assumptions and interpretations made.

5. Results

This chapter will present and document the findings from the interviews and the workshop with the actual tenants, the conducted observation, pre-investigation and archive visits related to the building, and it will give insights of the findings from interviews with the property owner, and topic related experts. This will be used to present the Case Study in-depth and provide a comprehensive understanding of the case, as well of the tenants and users to support the Discussion and Conclusion chapters, where suggestions to reach a sustainable renovation of the building, object of the Case Study, as well as suggestions to be considered in a sustainable renovation framework in general.

5.1 Case Study - Banérsgatan 6

The following chapter presents the specific Case of Banérsgatan 6, a rental multi-dwelling in Gamlestaden, Gothenburg, owned by the Property Management Administration. However, in order to achieve a sustainable renovation concept, it is important to consider all possibly involved stakeholders. In the case of Banérsgatan 6 various primary and secondary stakeholders need to be involved. As primary stakeholders for the early phase, the authors identified the property owner~~,~~ (the Property Management Administration), the users/~~-~~tenants and Chalmers Challenge Lab, which is represented by the authors. Future primary stakeholders will be architects, a consultancy company with extensive knowledge on renovation projects, contractors, experts in the field of architectural heritage and technical evaluation. Especially in the inventory phase it is of importance to involve stakeholders from the City ~~museum~~ Museum and ~~archive~~ Archive in order to get ~~a~~ proper documentation of the building~~s~~. Experts on participation and communication processes are important to develop the right strategy for involving the tenants and other users. Another important stakeholder is the Swedish Tenants'~~s~~ Association, since they are helping to negotiate the rent. Secondary stakeholders, that are less involved and affected by the outcome of the renovation, are neighbours, different departments of the municipality that have to plan according to the renovation, but also Boverket and other public authorities. Boverket, for example, provides the general renovation framework and sets the regulations and legislations for the built environment.

5.1.1 Historical and building context

Banérsgatan 6 is located in the city district Gamlestaden in Gothenburg, which belongs to the area of Östra Göteborg, quite close to the city centre. Gamlestaden is one of the oldest areas of Gothenburg and is known as an old industrial area, characterised by old industrial buildings, factories, mills and one of the biggest, still existing industries, SKF. Throughout the years, many

industries and industrial buildings have evolved and have disappeared again. The unexpected growth of Gamlestaden as industrial area caused a high housing demand in the 19th and 20th centuries, which resulted in an increase of housing between 1915 and 1930. Typical buildings of that time in Gothenburg are the three storey, with the bottom storey made from bricks, while the two upper storeys are made of wood. The so-called *"Landshövdingehus"* was a result of a way to work around the building regulations back then, which allowed to only build two storey wooden buildings.

Figure 8 Two examples of Landshövdingehus in Gamlestaden, in the left a multi-dwelling in Götaholmsgatan today, and in the right, some mixed use buildings at Hornsgatan in 1935 (Source: own archive and Carlotta - Göteborgs Stadsmuseet)

During the 1960s, decisions for an extension of traffic leading in and out of Gamlestaden was made, which caused that several *Landshövdingehus* were demolished or changed. According to these plans, Banérsgatan 6 has been marked as additional infrastructure extension within the detailed plans of the city. Therefore, the ownership of the building went to the Municipal Traffic Department (Göteborgs Stad – Trafikkontoret). This caused that over many years nothing has been changed or invested into the building since its future was uncertain. During the 1960s, plans were made to reduce the traffic within the city, and the Traffic Department decided not to use the plot where the building is located as additional infrastructure extension. Therefore, the building was kept and went over to the Property Management Administration, which still owns the property.

The building is about one minute away from the tram stop Gamlestadstorget, which gives easy and fast access to the city centre. The area in which the buildings is placed was marked by the municipality as preservation and conservation area, meaning that these buildings have a cultural-historical value. Therefore, their characteristics need to be preserved in a gentle way, so it won't affect the cultural and characteristic picture of the area (PBL 8:17).

According to the present detailed plans of Gothenburg, the building is still marked as infrastructure area. However, in the near future and with the new detailed plans for the city, the building will be kept, and will be marked as residential area again (According to the document

Tjänsteutlåtande dnr 1125/13, Göteborgs Stad Fastighetskontoret). Lönnroth (1999) states that the area where the building is located is planned to get the status of protected cultural heritage (*kulturmärkning* or *k-märkt*, in Swedish), and according to the Property Management Administration the building in question might be protected as well. This means that a building placed in this category cannot be changed in a way that the cultural heritage is lowered, or its characteristics are destroyed. That is an important aspect that needs to be considered within the renovation concept.

The new detail plan for Gamlestaden aims for a denser and mixed neighbourhood, with new houses, commercial and cultural buildings, as well as improvements in all urban infrastructures, to start in 2017 until 2035 (Stadsbyggnadskontoret, 2016).

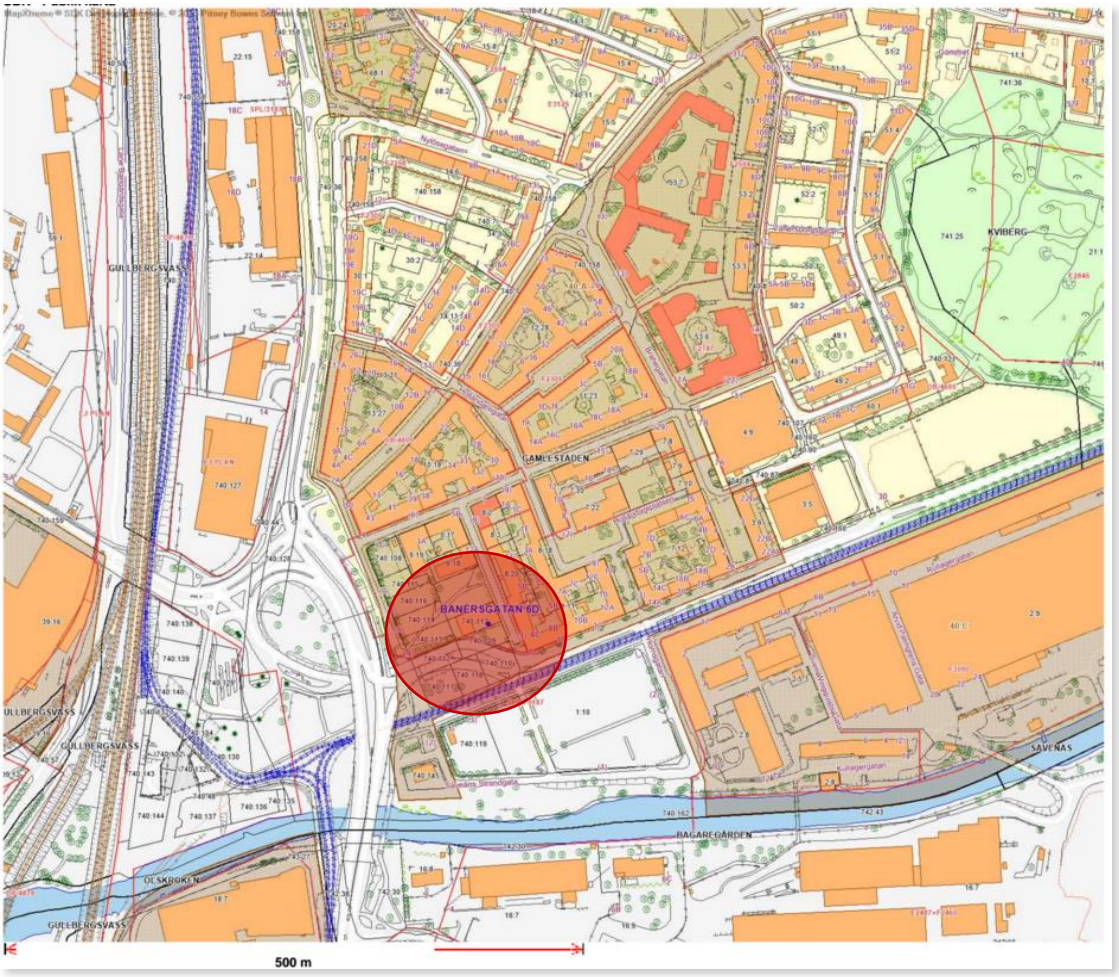


Figure 9 Detailed plan from 2014 where the building is in "historical interest area" (Stadsbyggnadskontoret Arkiv, 2016)

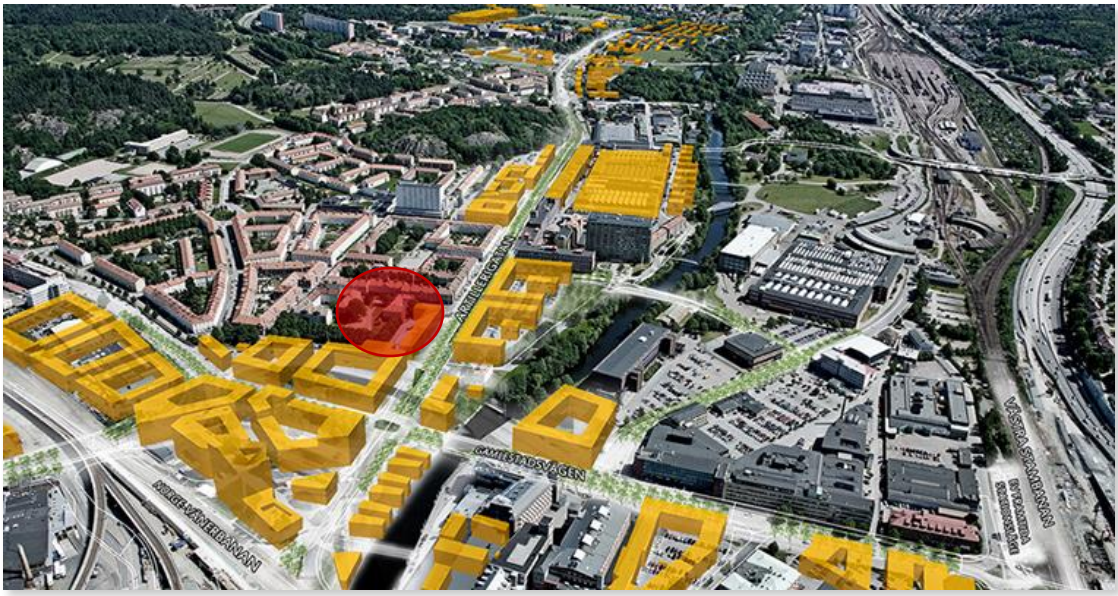


Figure 10 Detail plan to start in 2017, showing the development that will occur in the surroundings of the building (Stadsbyggnadskontoret, 2016)

5.1.2 Architecture and Characteristics

The considered building is a three story multi-dwelling which has been constructed in 1929. From the outside, Banérsgatan 6 has, as many other buildings in the area, the unique architectural and historical characteristics of a *Landshövdingehus*.

Figure 11 The building today, northeast facade (Source: personal archive)

Referring to many different styles of the *Landshövdingehus*, the house has been built in the so-called functionalist style or the "younger *Landshövdingehus*," meaning that it has been built after 1920. Characteristic of this period is the austere façade without any decoration. The wooden

panels of the upper stories are nailed vertically to give the wall a flatter modernistic look. The brick walls are without any decoration and the transition between brick and wood is characterised by diminutive strips in the splice.

Figure 12 Materials' characteristics, bricks and wood (Source: personal archive)

The building has four entrances (A, B, C and D, shown in Figure 14) that lead to a total of 26 apartments, of which 21 are occupied. The typology of the apartments is one and two-room apartments with a size of approximately 37 to 72 square meters. Some apartments have been expanded with rooms from other apartments, although it cannot be found in any documentation. While the two-room apartments have their own bathroom with shower (total of four apartments), the one-room apartments share, in pairs, a toilet that has to be accessed through the stairwell (total of 22 apartments and 10 toilets). In addition, they share one shower in the basement of entrance C. The basement has storage rooms which are mainly used to store bicycles, the laundry room and energy clocks and sprinkler machinery.

The apartments and stairwells of the different entrances vary in shape and condition, as a result of some modification throughout the years. In the first floor (ground floor), there are two closed-down commercial premises facing towards the street. Both commercial premises are used as private storage space by users, that have been former tenants, but have moved out approximately 7-10 years ago. As a common area, the building has a patio as well as two balconies on the first and second floor, and between the second and the third floor. All four balconies are accessed through the stairwell in house B and C. In the main entrance, the trash bins are located and a few bicycles. The main entrance leads to the common patio, that has some green space and furniture for social activities. The plot has approximately 680 square meters, where the projection of the building occupies 550 square meters. The building has approximately 2750 square meters of built area, which 550 square meters are the basement floor, other 550 square meters are the attic (roof) floor. The common resting areas (balconies and the patio) comprise approximately 130 square meters.

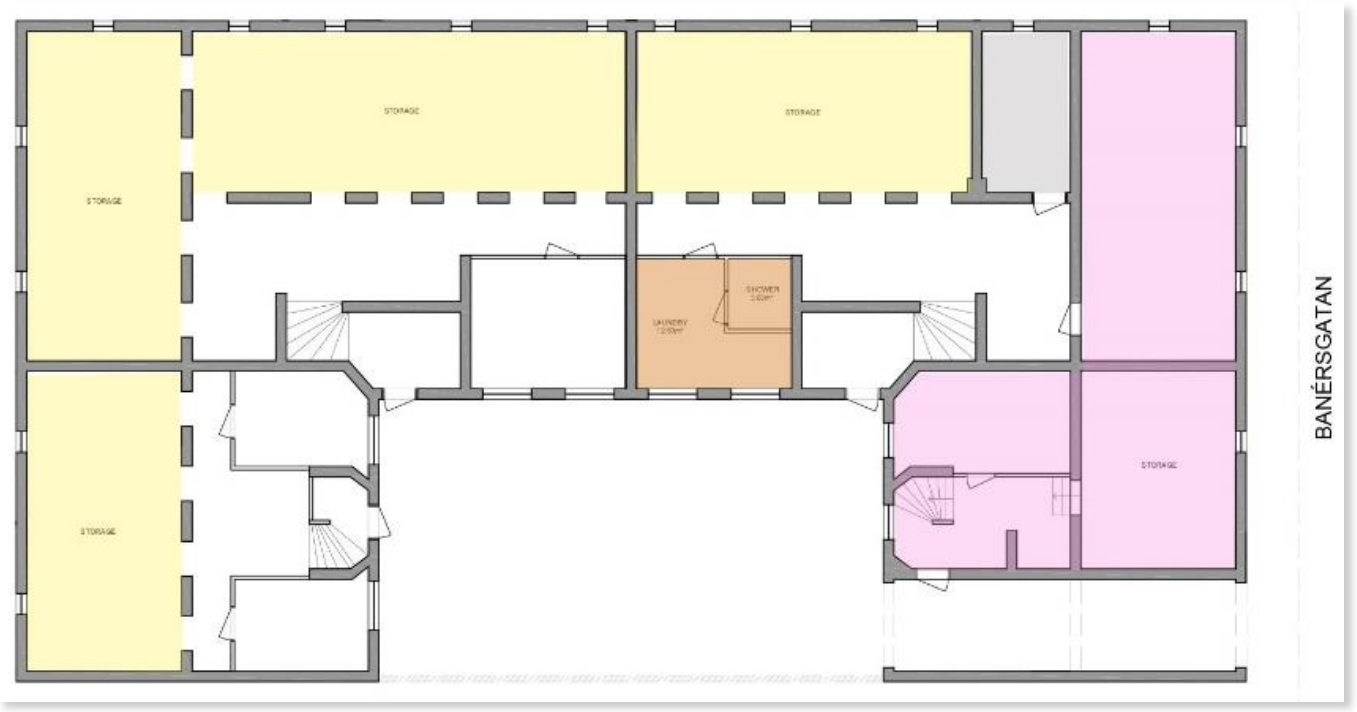


Figure 13 Actual basement, with brick walls. Marked in orange the common shower and laundry room, in yellow the common storage spaces, in pink the private rented storages, and in grey the sprinkler room (created by the authors).

Figure 14 Actual first floor (ground floor), with brick walls. Marked in orange the shared toilets, in pink the two private storages facing the street, in blue and green the different typology of apartments, in red the main entrance, and in grey the common patio

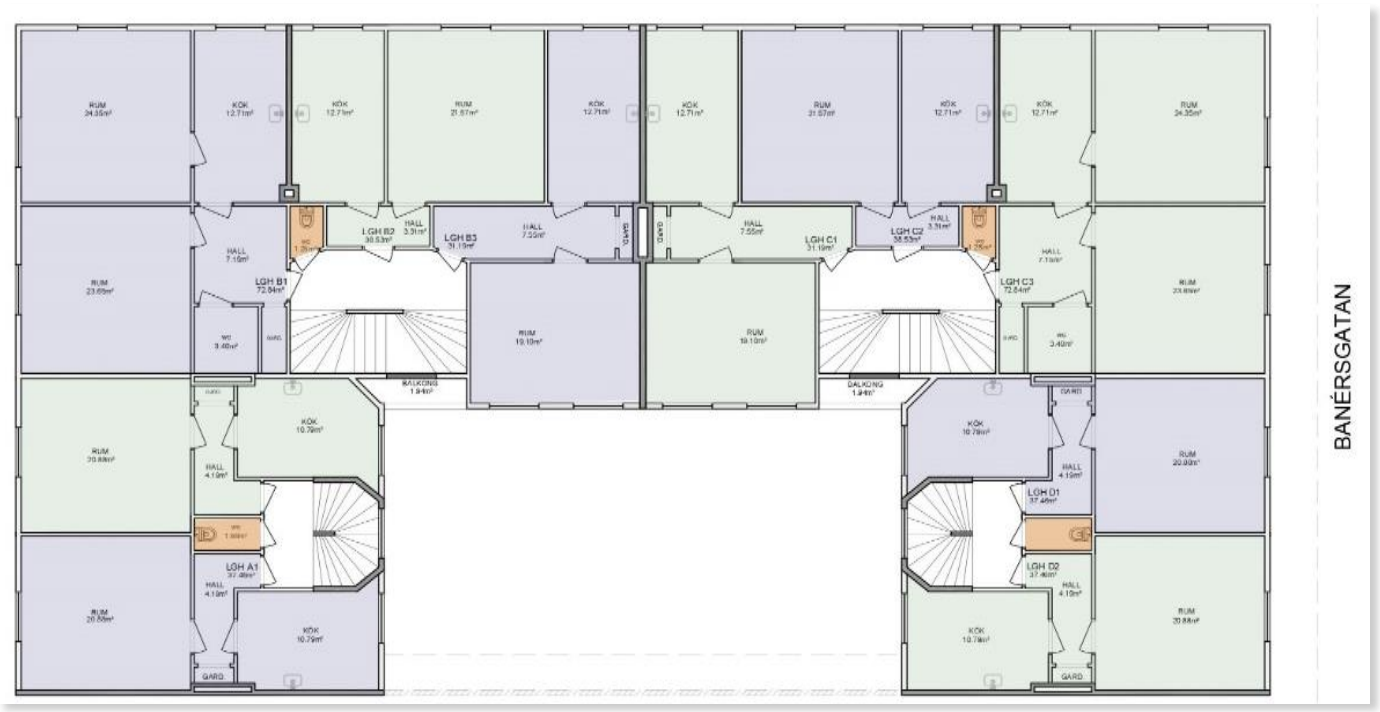


Figure 15 Actual second and third floors, with wooden walls. Marked in orange the shared toilets, and in blue and green the different typology of apartments (created by the authors).

5.1.3 Changes

Due to the aforementioned issues regarding ownership and the detailed plans, the building has not gone through a major renovation in its almost 90 years of existence. Since the building has been owned by Property Management Administration, they claim that it goes through punctual maintenance and has one member of its staff that is responsible for it.

It is evident that some of the windows were changed at some point, but it is unknown when. It can be seen that the ducts connected to antique wooden ovens were interdicted and cemented. Some apartments still have an original wooden stove in the kitchen, although not functioning. The same applies to gas ducts still present in some kitchens. However, the gas system was interdicted. It can be noticed that a fire prevention system was installed in the building, which is not in the original plans. The added radiators (electric) have not been mentioned in any documentation either, and throughout the years, tenants and former users have invested in different types of radiators in order to save electricity.

Two of the visited apartments had a changed layout, expanding into other apartments. This has not been done by the actual tenants. The private and rented storage rooms in the ground floor were two commercial premises in the original drawings. The tenants have no access to these areas.

5.2 Pre-investigation of actual conditions

A pre-investigation of the actual conditions was performed to support the inventory list in order to propose a renovation concept. It was done through own observations of the building, through interviews with the tenants, with the property owner and the caretaker. In addition, the supervisor and the rest of the research team visited the site in order to give an opinion on the technical condition of the building. The interviews with the tenants were useful to find out some of the main deficits, as they live in the building and are faced with the conditions of the building every day.

5.2.1 Environmental

The environmental characteristics are connected to the technical characteristics. Considering the actual conditions from the environmental aspects, it is important to mention that the building is poorly insulated, including the facade and windows. As mentioned above, some of the windows have obviously been exchanged for different ones, yet all of the windows are in poor shape and are in need of renovation or to be replaced.

Figure 16 Windows and wooden façade (Source: personal archive)

The poor insulation is one of the main complaints from the interviewed tenants, for two reasons, first, because the indoor temperature is not comfortable, especially during the winter, and second because the heating radiators are electrical, the majority complained about the high average price they pay for the electricity. The electricity costs are not included in the rent.

A general analysis of energy consumption was done. Banérsgatan 6 does not have the energy declaration registered at Boverket and the property owner has no information about energy consumption of the individual apartments, since each apartment has its own electricity account. It was possible to have access to the energy consumption of two apartments, through the electricity bill provided by two tenants. Therefore, the estimation of energy consumption is

limited by the constrained data. Based on the quantity of energy consumed (in kWh), the size of the apartments (in sqm), the month of the year, and the price paid, it was estimated how much energy each apartment uses in average (in kWh per sqm) during the whole year (assuming that during summer the consumption of energy falls by half) and how much each tenant pays in average of electricity per month (in SEK). It was compared to the suggested values by Boverket in 2013 (maximum energy that new and renovated residential buildings must use in kWh/sqm in one year to analyse if the building has a low or high energy consumption. More information on the calculations is available in Appendix J.

Apartment 1: 30 sqm ≈ 210 kWh/year/sqm
Energy consumption is **280% higher** than asked by Boverket*
*Maximum energy that new and renovated residential buildings (with electric heating, in climate zone 2, middle Sweden) must use in one year is 75 kWh/year/sqm (Boverket, 2013).
The tenant pays 4432 SEK/year for electricity, which is approximately 27% of the rent's value (16800 SEK/year). The price is according to the bill provided by the tenant, including taxes.

Apartment 2: 60 sqm ≈ 192 kWh/year/sqm
Energy consumption is **256% higher** than asked by Boverket*
*Maximum energy that new and renovated residential buildings (with electric heating, in climate zone 2, middle Sweden) must use in one year is 75 kWh/year/sqm (Boverket, 2013).
The tenant pays 6900 SEK/year for electricity, which is approximately 24% of the rent's value (28800 SEK/year). The price is according to the bill provided by the tenant, including taxes.

There have been many complaints by the tenants about the poor ventilation system and that it happens quite often that the unpleasant smell of apartments underneath gets carried to upper apartments. In fact, through observation, a proper ventilation system could not be detected. It is mainly due because before 1969, in Sweden, only natural ventilation was used in multi-dwellings, to ventilate the smoke from burning wood. Since the chimneys are now cemented in this building, the natural ventilation is blocked. A check up on the ventilation system was done in 2010 (Appendix F).

Figure 17 Ventilation closed inside the apartments, and in the basement (Source: personal archive)

It was mentioned by the users that there are no waste recycling options nearby, and a few tenants complained that the next recycling station is quite far away, which is not a good motivation to actually recycle. In the entrance area are trash cans for general waste, which causes bad smell and eventually blocking the entrance passage in case of emergency. Since the recycling station is in some distance, part of the waste that could be recycled ends up in the general waste bins located inside the building, and which has been set up by the users on own behalf.

Regarding the building materials, they are almost entirely original from the year of construction, either exterior or interior. All the visited apartments still have their original wooden floor and original wooden kitchen in-built furniture, both typical characteristic of a *Landshövdingehus*. It needs to be mentioned that throughout the use of the apartments, different users have maintained the apartments. Therefore, the quality of, for example, the wooden floor, can vary among different apartments. From an environmental point of view, it is positive that the original materials are still fulfilling their functions for a long period of time.

Figure 18 Original wooden kitchen and wooden floor (Source: personal archive)

5.2.2 Social

This building has a unique social environment, with a lot of interaction between the users. The tenants are very attached to the building; some have been living here for over 43 years while others moved in recently. The tenants that have been living in the building for a longer time period have usually changed the apartments a couple of times throughout the years. The age structure of the tenants varies from 6 years to 83 years, which gives rather mixed age structure.

Almost all of the interviewed tenants highlighted the social interaction with their neighbours as one of the main favourable aspects about living in this building. The fact that the tenants have to share bathrooms and one shower makes clear that there has to be personal communication and structure since all tenants pointed out that there are no major problems with this, although there is no booking system for the shower. The tenants declared to use the common areas for social interaction, such the balconies in the stairwells and the central patio, yet that these spaces could be optimized. In the basement, they initiated a “trade-table” where things that are not needed anymore are put, and someone else can make use of it.

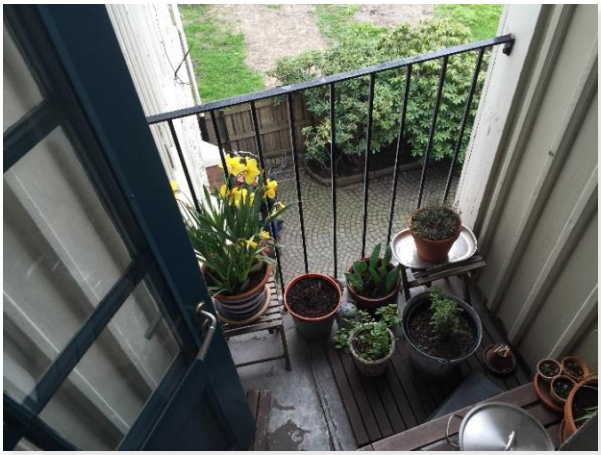



Figure 19 Common areas: balcony and patio (Source: personal archive)

5.2.3 Economic

One of the most remarkable characteristics of this multi-dwelling is its low rent, especially when compared to similar multi-dwellings in the same area in Gothenburg. It is noticeable that the standard of this multi-dwelling is not high due to lack of renovation. Sharing a toilet and shower is nowadays not at all common in Gothenburg. The low rent was claimed for all the interviewed tenants as one very significant motivation to live in the building.

Another important aspect to mention is that the housing owner claims that the amount collected on the rents does not cover the basic expenses of the building, such as maintenance, insurance, electricity for the common areas, taxes, among other things. The fact that this property has a

negative balance between income and expenses is the main reason to the property owner to wish for a renovation.

The Property Management Administration claims that their intention for this property is to raise the standard in order to raise the rent (income), lower the maintenance costs and make it profitable, or at least not unprofitable, as it is today. It is worth to mention that since the Property Management Administration belongs to the municipality of Gothenburg, the expenses that this property cannot pay itself is covered by taxpayer's money. In 2015, for instance, the building cost for the owner (and taxpayers) 233.000 SEK (Appendix I).

5.2.4 Well-being

The major complaints regarding the indoor environment were expressed by the tenants as the low temperatures inside the apartments, especially during winter. Some tenants mentioned the poor ventilation and pointed out an unpleasant smell from other apartments. Another collective complaint was the traffic noise, especially from Artillerigatan, a busy road with tram lines next to the building. In a particular case, one tenant placed the bed in the kitchen, facing the opposite side of the street, to avoid the noise while sleeping.

Through the observation and mentioned by one tenant, was the mould that can be detected particularly on walls, in addition, one tenant mentioned the unpleasant smell of the mould that occurs when just entering the building. In the long run, this mould can cause serious health issues and affect the well-being of the users.

Other tenants mentioned the discomfort that occurs through the park the building is surrounded by. The tenants often become observers of the disturbing presence of drug and alcohol use, which threatens the tenants' perception of safety.

Figure 20 Biological growth in external and internal walls (Source: personal archive)

The common shower, together with the laundry room in the basement, is in poor condition, with for example cracked tiles in the shower cabin, which can result in injuries while using. There is a bathtub next to the shower that is not in use. This room has poor insulation and lightning. Interior surfaces need to be painted, plastered or replaced. Regarding the shared bathrooms, the interviewed tenants were mostly positive about sharing, but the great majority claimed that they would like to have a sink inside the bathroom, since the only sink they have access is the sink in the kitchen, and a few mentioned that they would like to have hot water in addition to a sink. The majority claimed to prefer to continue sharing the shower and bathroom rather than have a bathroom inside their apartments if it would take too much space and increase the rent substantially.

Figure 21 Common shower, common laundry and mould in the basement (Source: personal archive)

5.2.5 Architecture and Form

By its shape and materials, the building can easily be recognized as a *Landshövdingehus*. Although, through closer observations, it was noticed that the facades are in bad physical conditions. The bricks have some visible stains resulted from graffiti removal and the wooden parts show deficits through broken and rotten spots. The painting of the wooden facade peels off and requires new coating. The windows, as mentioned before, are in poor condition.


Figure 22 Facades are in bad conditions, yet its materials are to be kept (Source: personal archive)

Inside, the stair cases have interesting materials and colours that should be kept, even though it needs maintenance. The same accounts for the entrance doors of each apartment. The attic can be accessed by all tenants and is only used for storage. It has nice natural lighting, wooden elements and potential to be used as open space for social activities. However, the attic shows some deficits such as water leakage. This has caused additional biological growth, which could harm the construction as well as the well-being of the users on the long-term perspective. The basement evinces signs of moisture that could come from various sources, such as a poor ventilation system in the shower and washing area. Another reason could be hydrostatic pressure from underneath the building. This has resulted in biological growth on the inner and exterior walls of the basement.


Figure 23 Attic and hall (Source: personal archive)

5.3 Findings Workshop

The purpose of the workshop was, through dialogue, to discuss with the tenants how a possible sustainable renovation concept for Banérsgatan 6 could look like and how the economic, social, ecological and well-being aspects could be balanced in order to satisfy the different sustainability aspects. The workshop took place in a public building in Gamlestaden (Medborgahus), in cooperation with the Property Management Administration, where 14 tenants participated, accounting for 50% of those who live in the building. Various questions were discussed in smaller groups of three to four people and presented afterwards.

The first question asked was about what the tenants like most at living at Banérsgatan 6, and the answers were considerably similar. It was mentioned that many like the social life and the community in the house and the feeling of living with friends and being part of something. A common answer to that question was the low rent and the location of the house that allow them to be close to nature but also the city centre. A few mentioned the nice garden and the community areas, as well as they, like the charm the building has with its materials and its history. One specifically mentioned, that it is the "not being perfect" charm that is much appreciated and the reason why people live there.

The second question to answer was about what the tenants like least about their apartments and building. One person mentioned the smell and visibility of mould in and around the building, and they assumed that this might not be very healthy for them to live there. Some of the most common answers were the bad condition of the insulation, including the bad condition of the windows and ventilation system. Another aspect that was mentioned rather often was the condition of the facades, referring to the insulation but also the lack of painting. Other aspects mentioned were the condition of the staircases, and the traffic noises caused by a busy street near the building, Artillerigatan. A main concern was the bad condition of the basement and especially of the shared shower and laundry. At this point, it was mentioned that the tenants wish a better and more detailed communication with the property owner.

Figure 24 Workshop with the tenants and the Property Management Administration (Source: personal archive)

These first two questions were stated as “check-in” questions, which each tenant had to answer individually, after presenting themselves. After the check-in the tenants were divided into groups, answering following questions:

- *What kind of activities would you like to do together? What space do you think is necessary for that?*

  - As part of this question, many tenants expressed the wish to open up area of the two commercial premises that are at the entrance of the building. Here they could imagine ideas like an open space for social activities such as cooking together, a flea market, a garden association, and space for various workshops. Another idea was a Christmas market in the garden, where people outside the house could be invited;
  - One tenant recently founded an association called “Östra Göteborgs Alternativa Träffpunkt” (Eastern Gothenburg Alternative Meeting Point) and is looking for a location to rent. The space in the house would be interesting to this organisation because it has a central location, it has display windows, and the rent would be affordable. Some ideas that could be realized there are workshop space, for interested parties to rent the location, exhibitions, a café or even for discussion evenings.

- *What do you think would improve your comfort?*

  - When answering this question, the tenants mentioned rather small improvements such as more space for meeting each other or moving the trash bins from the entrance to a more invisible spot. Another topic brought up was that a good renovation of the shower and the laundry area could improve their well-being. In addition, the need to exchange windows was mentioned, in order to have a better insulation from cold and from the traffic noise. Few and far mentioned a better ventilation, a separate sink in the shared toilets and the idea of using the old kitchen oven again.

- *What would you be willing to pay more for?*

  - In this question, the tenants had different preferences. One, for example, answered that more garden space would be a reason to pay more for. While others rather have a renovation of the windows;
  - One person pointed out that the money should rather be spent into the common laundry and a second shower, rather than having individual improvements in the apartments;
  - Another suggestion was fibre internet or someone coming to clean the staircases and common toilets.

- *How can you contribute to a more sustainable way of living?*

- The question generated many interesting ideas among the participants. The answers were related to physical changes in the building, but also to behavioural changes among the participants. Answers included the renovation of windows, a recycling station and replacing their old fridges with a modern one, that is more energy saving;
- Other comments were to continue having a small rent, to minimise the use of electricity and continue with the trading-table in the basement. Another suggestion was that the tenants could take over the management of the garden, meaning that they decide how much is going to be ordered and what get planted;
- One idea had a common interest was to use and see the building as a test bed, where new innovation can be tested. That way it can some kind of living lab and various companies or students could be part of it, to analyse energy savings and behavioural aspects, for instance.

After discussing the questions in smaller groups, they presented their ideas to the whole group and to one representative from the Property Management Administration, which has mentioned that the ideas generated in this workshop were very interesting and inspiring for them, as property owners. It could be observed that a lot of questions were asked to the property owner, where the participants specifically asked how the future perspective of the house looks like. It was pointed out by the tenants that they are much more attached to the house then only living there because of the low rent. The Property Management Administration then explained the further procedures, which many tenants appreciated since they claimed before that they have not been well informed about future renovation intentions.


Figure 25 Workshop with the tenants and the Property Management Administration (Source: personal archive)

Table 3 shows a summary of the written needs and what the tenants are willing to pay for, as a result of the group activity carried out in the workshop. The numbers that follow the ideas represent the amount of positive or negative votes they have received. This information can help to prioritise certain ideas and suggestions when developing a concept proposal. However, all the needs are important, and the voting had the purpose to rank after priority. Interesting is the gap

that exists between the expressed needs of the tenants and what they are in fact willing to pay more for.

Table 4 Summary of needs presented and voted by the tenants in the workshop

Summary of expressed needs by tenants	What they are willing to pay for
Environmental	
better insulation of the windows (5+ votes)	renovation/exchange of the windows
better insulation of the façade (1+)	hot water (2-, 1+ votes)
better ventilation	
recycling area	
hot water	
glass recycling station (4-)	
Social	
bigger garden, by moving out the fence (1+)	bigger garden (3+)
faster communication and service from the Property Management Administration (2-, 1+)	
self-management of the garden area	
more trees	
Economic	
keep the low rent (5+)	
Architecture and Historical	
	repainting the building with appropriate colour and quality (3+)
	maintaining the old character of the house
Well-Being	
better shower and laundry room, so it is easier to keep it clean (5+)	washing machine for carpets
improve the entrance (where the bikes and trash bins are located now)	cleaning of hallways and toilets (7-)
a guideline how to clean the hallways, the shower, the garden and other things (especially for new people) (1-)	

Besides gathering ideas for a concept to be used later on in the renovation process, the observation of the behaviour and the process of the participants and the workshop was an important part. As it was mentioned before, the location was chosen in order to be easily reachable for the tenants and encourage the participation.

When the first part of the workshop started, the authors mentioned explicitly the participation of the property owner for the second part, and the interest among the tenants seemed to increase.

During the check-in circle, the tenants supported each other by mentioning each other's name and support answers that other tenants had given before. Another observation was that many participants took notes of what was mentioned and one tenant asked the permission to record the whole workshop.

The discussions in smaller groups were interesting to observe, since everyone was asked and included in the discussion and the tenants made sure they understood the questions all in the same way. One aspect that could be observed in one group was that there were different interests among the participants and instead of finding a common ground, they agreed to write both ideas down. After the break and with presence of the property owner, it could be observed that the tenants directed their ideas and interests more towards the property owner rather than the authors.

After the presentation of the results, it was time for questions from the tenants towards the process and the property owner. It was noticeable that the atmosphere changed and there was some tension but also anxiety among the tenants. Questions were asked concerning the economic situation and rent level, and how this could be affected by the renovation. The property owner answered all the questions in a polite and explanatory manner and when the workshop ended, the property owner and the tenants mingled and had rather informal discussions and exchange of thoughts.

6. Discussion

This chapter aims to connect the research problem with the analytical framework and the findings and moreover discuss these in relation to each other. In addition, suggestions and recommendations will be given as well as the first ideas for a potential renovation concept.

6.1 Sustainable Renovation

Referring to Thuvander et al. (2012), a sustainable renovation is the ambition to fulfil the different dimensions of environmental, social and economic aspects. Kaklausas et al. (2008) summarized that renovating a building to become more sustainable means to make the building healthier and more energy and resource efficient. Previous research and through interviews, it became obvious that the goal of a renovation, depending whether the buildings is public or private owned, is often on the economic aspects, which often improve with rising the standard of a building (Interview Rotpartner, 2016).

In order to answer the research question "*How can a sustainable renovation be ensured from the inventory phase?"* and its sub questions *"What aspects need to be considered to ensure a sustainable renovation?"* and *"How can tenants be involved in the renovation process? In what way can they contribute to sustainable renovation?"* the authors summarise that a sustainable renovation project should not only improve the environmental impact of the building by making it more energy and resource efficient, but also involve the social aspects by including the users into the renovation process. The economic aspects need to be considered from the property owners but also from the tenants' perspective, meaning fair and gradual rise of the rent level. The well-being needs to be considered in a way that the human health is considered and a comfortable everyday life is possible. In addition, to the presented sustainability criteria in *Phase 1*, in order to achieve well-being, there needs to be a balance between the other presented sustainability aspects. This can be achieved when balancing the aspects of economic, social and environmental sustainability and causing a good indoor environment or a more functional everyday life for the users.

Two other aspects that usually are not included in concepts of sustainability (Thuvander et al.,2012), yet are important to consider in a renovation process, are the architectural and cultural-historical aspects of a building. These aspects need to be considered especially when the building belongs to a cultural heritage and represent architectural characteristics that need to be preserved for the culture and history of society.

The following will present the relation between different sustainability. The categorisation was given by importance in literature, likewise what the authors found out to be most relevant to be

considered. Since the well-being aspect is often not considered in the literature, it takes on a substantial part in the discussion.

Environmental-Economic Dimension

In order to increase the energy efficiency and respect the environmental sustainability dimension, it is necessary to apply new methods, tools and technology to make the building more energy efficient. Often these technologies are cost intensive and require a larger investment from the property owner's perspective. Besides raising the standard of the building, this can be a reason for an increasing rent level to the disadvantage of the tenants. In order to judge whether the investment in a more energy-efficient system is profitable, the property owner has to consider different time frames. The investment will most likely not pay off within a short-term perspective, but rather in the long-run. Therefore, different options regarding the energy system have to be considered and calculated before taking a decision in which one to choose. This, again, makes the inventory phase of a renovation important.

In the Case of Banérsgatan 6, the tenants have a considerable low rent, yet very high energy costs due to the inefficient energy system of the building. However, implementing a new energy system, including heating, ventilation, insulation, can reduce the energy costs and could justify a high rent, which after all makes the same total cost (rent and energy) as the tenants pay at the moment.

In addition, the certificates that can be acquired to prove a building's sustainability standard are less useful when it comes to the renovation process. Often, these consider the environmental and the economic aspects but have less value when it comes to the social, well-being, architectural and historical aspects of the building.

Economic-Social Dimension

Throughout the Case Study, it became clear that different stakeholders, such as the property owner and the users, have different interests in terms of the economic dimension. During the meetings with the Property Management Administration, it was pointed out that the goal of this renovation project, on their behalf, is to become more beneficial in the economic aspects. The motivation is the negative economic situation, where the rent of the tenants does not cover the expenses the property owner has with the building. Meaning, insurance for the building, electricity for common areas, maintenance, and others. Since the property owner is a public authority, expenses that exceed the earnings will be paid off by the taxpayers, which is not sustainable. Throughout the workshop and the interviews, it became clear that the tenants are not aware of the economic situation of the building, since the tenants appreciate the low rent and believe it can be kept at the same level. This is a conflict been pointed out in different research projects. The question is whether it is possible to convince the tenants to agree to a higher rent,

when being aware of the economic situation (Stenberg et al., 2009). The tenants mentioned that "there should be money reserve for the building, since we have paid rent over years, but nothing has been done with that (the money and the building)" (Workshop, 2016). However, since the building is owned by the municipality, there is no such thing as a "money reserved for the building" since the money is used for all buildings owned by the municipality. It is obvious that there is a misleading understanding of the economic aspects of the property, which can be traced back to communication aspects between property owner and tenants. Another possibility to improve the economic aspects in this case is to balance the probable raise in the rent level with the energy bill savings by improving the buildings' energy efficiency.

In order to understand the different economic needs and interests of the stakeholders in the Case Study, one question that was asked during the workshop was what the tenants would be willing to pay more for. The intention in this activity was to discuss on how to balance the property owner's requirement for a higher income, but at the same time considering the tenants need for keeping the rent low. Comparing the "wishes" and "complaints" the tenants have, with the aspects they are willing to pay more for, it shows a huge gap. Which raises the question of how to combine or balance these aspects. One way to approach a balance between these two interests is to raise the standard to a level and in a way that the tenants are willing to pay more or communicate the situation to the tenants in order for them to understand the necessity for the interventions that have to be made to reach a sustainable standard for the building.

In the case of Banérsgatan 6 one idea of the authors and the tenants was to make use of their abilities and interest to have workshop within the building. This could be in form of involving the tenants for smaller renovations of certain elements, as for example cleaning out the basement and restructuring the patio, as well as smaller renovations within the apartments. This could be guided by someone knowledgeable of renovation activities. It requires to gather the different competences the tenants have and their willingness to support each other. This process could improve the economic aspect in the sense of that less money has to be spent on contracting such services. Premise is that the tenants are interested and committed to this kind of process and that there are some existing skills. This goes along with what has been mentioned in the analytical framework under the social sustainable aspects and that the social aspects can be supported by making use of people`s experience and knowledge.

Environmental-Social Dimension

There are different ways to take the social dimension into consideration. One is to try to keep the rent level affordable. Another approach is the user behaviour that needs to be observed and taken into consideration. The users have a major impact on how efficient implemented energy systems are. In case of Banérsgatan 6, the tenants value environmental aspects. Ideas as "urban gardening", which has environmental and social importance, was mentioned as a possible idea

for a future concept. In addition, recycling stations seemed to be a desire among the tenants. Yet, this does not provide information on the actual behaviour of the tenants when it comes to energy savings in their everyday life.

Architectural/Historical-Economic-Environmental Dimension

When it comes to the architectural and historical values of a building, it is often difficult to balance these with the environmental and economic sustainability aspects. Buildings that are marked as cultural heritage and have important value for the architectural and historical heritage need to be renovated in a gentle way and with a certain expertise. The aim is very often to keep the "look" of the building and exchange certain parts such the windows. The replacement then needs to have the same characteristics, which can cause the renovation to become expensive since the market for these specific items might be limited. An expensive renovation then will collide with economic interests of different stakeholders.

In the case of Banérsgatan, one major complain was the poor insulation of the windows and the façade. However, applying additional insulation to the façade can either (applied inside) reduce the living space of the tenants, or (applied outside) destroy the architectural characteristics of a Landshövdingehus. Another result from the workshop was that a few tenants find it special to live in a house with such old characteristics and that these characteristics should be kept and even lifted up during and after the renovation. Property owners might assume that its not appreciated to live in a building with these specific characteristics, yet some people live in these buildings especially because of its unique and old character. This can raise a sense of pride, which can enhance well-being but also makes the tenants more ambitious to take care and live in a building with certain consideration. Which in return makes it important to involve the tenants in the renovation process in order to be aware of what is needed.

Well-being

The Well-being aspects in a renovation has not given enough attention throughout diverse research. In order to fulfil the well-being dimension within a sustainability approach, the environmental, economic and social dimensions need to be in place and balanced in order to reach well-being. Regarding to a sustainable renovation, this means that the process, and how the tenants are informed and integrated, is as important as the outcome of the renovation.

As Acre and Wyckmans (2014) pointed out, is the key to renovation acceptance to secure people's well-being, meaning that disregarding non-technical effect on occupants is a mistake, especially in energy renovation projects. This goes along with what Graninger and Knuthammar (2010) point out, that stress and anxiety among tenants as common emotions associated with a renovation. This could also be observed during the workshop with the tenants. Repeating questions such as

“what are the next steps?”, “how does the timeframe look like?” and, in addition, the demand for better communication on the part of Property Management Administration was an indicator for stress and anxiety among the tenants. This is supported by the research of Graninger and Knuthammar (2010) that explains these emotions as common throughout renovation processes. Therefore, including the tenants throughout the renovation process in form of Dialogues or Workshops, can provide the feeling of being in control of the given situation and in return reduce the stress level.

Another perspective on well-being is the situation the tenants live before a renovation process. After the observation and the first interviews with the tenants in Banérsgatan 6, it could be concluded that there are several aspects that are concerning regarding the users’ health and safety. The detection and smell of mould was mentioned as well as a bad ventilation system. Another aspect were the very low temperatures inside the apartments especially in winter. Referring to the WBDG Productive Committee (2015) can mould and living in cold houses lead to a higher chance to illnesses like nose and throat infections.

Balance between the sustainability aspects

The optimal result in a sustainable renovation process is to reach a balance among the sustainability dimensions. Sometimes, if the efforts are given to reach one aspect of sustainability at its maximum, it is most likely to hinder achieving sustainability in the other dimensions. One example is the replacement of the energy system in a building by the most efficient one existing. It may happen that the costs to implement and run this system will not be paid back during the life cycle of the building. Yet, it will lead to an extensive increase in the rent at a point that the actual tenants cannot afford to stay in their apartments. In addition, using new and innovative technology can affect the unique architectural characteristics that should be preserved. The improvement of the insulation can affect the characteristics of unique facades and windows, which should be avoided in case the architectural characteristics are preservable. But even though the building is running with a good and efficient energy system, does not guarantee the best results, due to the fact that user behaviour is as important as efficient energy systems. Therefore, it is not only necessary to consider the tenants in a renovation process but in addition, consider their behaviour and mind-set when it comes to sustainability.

In case of Banérsgatan 6, involving the tenants to achieve a sustainable renovation concept seems necessary. The tenants asked specifically for options like a recycling station or exchange old freezers for new ones with a better environmental standard. They further stated that they prefer to continue sharing the bathrooms in the stairwells and the shower in the basement, since adding bathrooms in all apartments would take out considerable space and likewise it would have a higher cost than only renovating what exists. This solution can be more sustainable from the environmental and economic dimensions, and it is the opposite idea that the property owner had

in mind. Before the dialogue with the tenants carried out by the authors, the property owner thought that keeping such spaces shared was not an option. Knowing that the tenants claimed for keeping these functions shared, they agreed that this idea is indeed the best for all, especially for the economic aspects.

Another important aspect in order to balance the different sustainability aspects is to involve the stakeholders that will be involved and affected by the renovation process. Especially in the inventory phase, involving different stakeholders, especially experts, property owner, users and contractor and cosultants can decide the outcome of a renovation process. Early involvement can ensure that different perspectives and options on the renovation project are recognized and considered. In addition it can ensure a more holistic and comprehensive analysis for the building, which in return ensure a proper strategy for the renovation project. One condition that needs to be dealt with is the different understandings of renovation throughout the mindset of the stakeholders. Meaning, the complexity of a renovation needs to be considered and the vision and goal with the renovation need to be communicated.

After all it is challenging to balance the different sustainability aspects. Research has approached environmental, social and economic sustainability, yet well-being is another important aspect that needs to be considered, as well as the architectural and cultural-historical value of the building. In order to find the most suitable strategy, balancing the different sustainability aspects, a comprehensive investigation throughout the inventory phase needs to be done. Based on this, individual decisions have to be taken, in order to balance the sustainability dimensions. Therefore, it is necessary to involve various stakeholders in order to make the right choices, that are in favour of the property owner, the users, society and the environment.

6.2 The Renovation Process - Inventory Phase

Revising literature on the renovation process and framework has shown that there is a big deficit on how to proceed with a renovation. In fact, there is no common renovation framework that is used within industry. The framework developed and presented by Boverket is rather general. This allows industry to interpret the single steps in their own terms and interests, which can result in an unsatisfying accomplishment of certain steps. In addition, it does not consider a sustainable renovation, which requires to involve the tenants in a much earlier stage then suggested, in order to balance the different sustainability aspects.

As it was published by Boverket (2006), has especially the inventory phase an important role not only for the property owner and contractor but also for the tenants. Being aware of a building and its characteristics can avoid unnecessary conflicts from the beginning of the renovation process and increase the acceptance for the renovation. Thuvander et al. (2012) state that more

emphasis should be put on time and resources in order to investigate the actual condition of the building and consequently reach better results in the following steps. Thuvander et al. (2012) concluded that it is frequent to renovation processes to start with insufficient documentation of building conditions. This could be observed in the case of Banérsgatan, where the property owner had prejudices on what the renovation concept should include, without having a proper investigation beforehand. However, reflecting on the structure and the separate steps of the inventory phase leaves room for a wide interpretation on how these should be put into practice. This has resulted from the interview with the renovation consultancy company Rotpartner, where it was pointed out that each contractor and consultant has its own structure and way to proceed with a renovation. Moreover, the renovation process, and especially the inventory phase, does not state how to proceed with the collected material in the up following process.

Construction projects, whether new or related to renovation, are unique. Therefore, it is necessary to have a renovation framework that is flexible and can be adapted to each project and building. This requires to bring various stakeholders from academia, public and private industry together and discuss such common renovation framework. One aspect that has to be considered is the emphasize on the involvement of the tenants.

6.2.1 Communication Between the Owner and the Tenants

One important aspect that the authors have come across during the literature review and the conducted interviews is the communication throughout renovation projects. When the first interviews with the tenants were conducted, complaints were made of the lack of communication between the property owner, Property Management Administration, and the tenants. The tenants would have liked to be informed about a possible renovation. Even though a letter was sent out to the tenants in advance, in order to explain the aim of this research, the information given was found to be not enough. Moreover, the authors are not working on behalf of the property owner, or represent their ideas and visions. On behalf of the authors, a request was sent to the property owner asking whether there is any information that shall be added to the first letter in order to confirm the property owner's involvement. However, no effort was made on the part of the property owner to include any.

Through the interview with Rotpartner, it was pointed out that the handling of the communication with the tenants is done very differently among property owners and contractors, which is not least because of the vague description of the renovation process execution. The renovation consultancy company Rotpartner has developed an own renovation process that strongly takes into consideration the communication with the tenants, called Tenants' Dialogue, which runs parallel with the technical/building process. These two processes are usually contracted together, but there is the option to contract them individually. Asking whether their

clients make use of the Tenants' Dialogue, the answer was vague. At first, the clients are very interested, but often they say their own project leader shall take on this part and assume that an extra process for the communication is not needed (Interview Rotpartner, 2016). Yet, there have been cases where property owners wanted to be in charge of the communication with the tenants independently. This caused, in many cases, bigger problems and more expenses due to the lack of experience in communication processes in a renovation.

If the tenants' opinion is taken into account, it is most likely to increase the satisfaction among them and reduce resistance against the project. Having a transparent process where the tenants are informed and included in each step will increase the awareness of the process and the value of the change that they might be afraid of, and it can strengthen the relationship between the housing owner and the tenants. The tenants can highly contribute to identify the needs and requirements for the buildings they live in. Further, people are most likely to care about and maintain things that they had participated and designed. In addition, when it is the case, they also need knowledge of the architectural and cultural heritage in order to know how to take care of it.

A recently published document by Boverket states that successful renovation projects are often connected to an effective tenant dialogue, which tends to lead to better results, and gives valuable information to the housing owner about their residences (Boverket, 2016). Moreover, Boverket (2016) recommends to housing owners to appoint a responsible person for the dialogue with the tenants, to capture their opinions, answer questions and keep them informed about the renovation process. This goes along with the findings from the workshop that was held with the tenants. Through the workshop, it was possible to connect property owner and tenants, and it was noticed that the tenants addressed many questions to the property owner, that could not have been answered by the authors.

When interviewing Rotpartner and how they proceed in the dialogue with the tenants, it was mentioned that it is always recommended to the property owner to be present in the first meeting. Not to discuss any changes or problems in the building, but to welcome the tenants and encourage them to participate in the process (Interview Rotpartner, 2016). This shows that in this case the consultancy company and the property owner work together and are both interested in the user recommendations and ideas. Many public housing companies have full-time employees taking care of the communication with the tenants not only in terms of renovation. Through the interview with Rotpartner, it was pointed out that it is not only important to have a strong communication process with the tenants but that it is important to point out one or two people that will be responsible for the communication throughout the whole process. This way a certain intensity of trust can be built up and give the tenants the feeling of being taken seriously.

6.2.2 Suggestions for the Inventory Phase

As it was mentioned above, it is necessary for various stakeholders to come together and agree upon certain aspects that need to be considered in a renovation process, and especially in a sustainable renovation. The inventory phase is the key to a successful renovation, therefore, the authors recommend to give special attention to this phase. Suggestions that need to be taken into consideration in this phase for a revised and general renovation framework are given. Such a common renovation framework is necessary and needs to be accessible to all stakeholders.

For the inventory phase, the authors suggest a general scheme (Fig. 26), where this phase is divided into "building analysis" and "user participation". Building analysis consists in collecting all necessary information for the inventory, and user participation consists in involving the users/tenants since the beginning, in parallel and connected to the building analysis. In addition, all sustainability aspects must be considered in the inventory phase, in both columns (building analysis and user participation). Taking into consideration the Tenants' Association framework, the authors suggest involving the tenants not only in the inventory phase, but throughout the whole renovation process, and that the negotiation happens throughout the whole process.

Involving the tenants since the beginning helps property owners to understand the main needs and requirements the tenants and the building have, to support future decisions on the project.

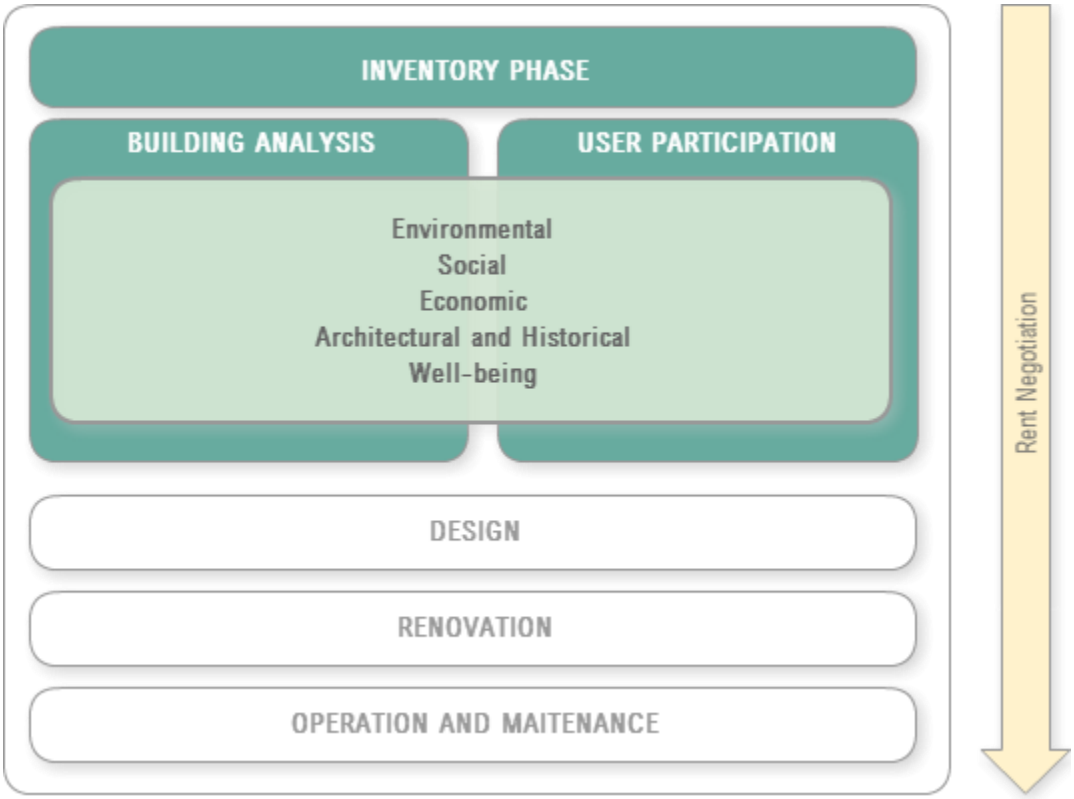


Figure 26 Suggested framework: Inventory phase

As it was done in this thesis, in the Case Study, these dialogues between the authors, property owner and tenants of Banérsgatan 6, in the form of interviews and workshop, together with the observations, helped to understand the main needs and requirements from the tenants for this multi-dwelling renovation project. However, the technical evaluation must be done properly by professionals and was out of the scope of this work. The information gathered in these events, together with the ideas generated in the workshop clearly helped to find a balance between the sustainability dimensions (one example is when it was decided that it is not necessary to add bathrooms in the apartments, since the tenants claim to not need or require it, even though it was the main idea of the property owner before starting this project).

Since each project is unique, such a common framework must be flexible in a way that property owners and construction companies can chose the most suitable way to perform each step (e.g. how to carry out technical analysis of a building, or how to handle the communication with the tenants), yet it must be clear and act as a guidance for renovation processes.

6.3 Banérsgatan 6: to proceed further

To make use of the information gathered in the research, investigation, interview, and workshop, the authors were asked to make suggestions to the Property Management Administration regarding the renovation of Banérsgatan 6, in the form of a preliminary concept. By involving the tenants and being in a neutral position between them and the property owner, the authors could gather valuable information to understand the needs and requirements for this building from both mentioned stakeholders.

One important aspect to meet sustainability goals, especially regarding environmental (material use) and economic, it is recommended to do minimal intervention. According to the actual regulations (BBR 19), when changing a building, it must follow the same rules as new constructions, (for example, if renovating the bathrooms, they need to meet today's standards in size, functions and accessibility, or even adding bathrooms to the apartments). However, if the building will be indeed protected *(k-märkt)*, it might be possible to have an exception, in order to keep its original architecture and form, and therefore, the authors recommend to intervene minimally (for instance, to keep the shared bathrooms and shower and only renovate them).

Proper technical evaluation of the building' systems were out of scope of this thesis, since the authors do not have the required tools and knowledge for such analysis. It is recommended to carry out a technical evaluation of the building by professionals, and take into consideration the needs presented by the tenants in the workshop, seeking for balance between the sustainability aspects. It is important to continue communicating with the tenants during the whole process, and to start, to make them aware of the negative economic situation of the building, as well as its bad technical conditions, to increase the awareness of the need for a renovation.

6.4 Challenge Lab

This thesis was developed and written in the Challenge Lab, which has supported the whole process of finding the research question and defining the scope and the system in which one has to analyse the problem. The methods used in the Challenge Lab helped to understand the urban development system in Gothenburg as a whole and see the problems from different and unusual perspectives. The first step was to envision a sustainable future and set sustainability criteria that support this vision. This step was rather general, and the vision will look different depending on the projects. However, it laid a foundation for a fundamental thinking about the environment, economy, society and well-being. Discussing important terms like circular economy or if mankind wants equity rather than equality ensures that all have a common understanding of certain terms and theories. The different stages of narrowing down within certain topics, but at the same time zooming out and seeing the challenges on a wider scale, helped to understand that the challenges and problems mankind faces are anchored on different analytical and heuristic levels and within various social groups. In addition, the method of Backcasting helped to connect the research problem to other problems and sociotechnical systems, and in that way shaped the interconnection and correlation the different systems and challenges have.

One important step in the Challenge Lab and within the Backcasting method, was the stakeholder meetings in order to analyse the present situation of Gothenburg, regarding sustainable urban development, and intervene in certain projects that were ongoing. In that way, it could be ensured that there are potential stakeholders interested in the research problem and that there are stakeholders that are willing to drive forward these developments.

After all, the Challenge Lab is an arena to teach and rethink society in a sustainable context. The terms of sustainability and sustainable development have been present and discussed the last years, yet, it has not put into practice as it is needed to face the global challenges. The Challenge Lab is an important setting, where students, irrespective of their cultures or educational backgrounds, get taught to think ‘outside the box’ and work in collaboration, to tackle the global challenges. What has not been so clear is how the mind-set will be carried on after leaving the University. The students, or change agents as they are called, have learned a lot and developed personal skills that need to be implemented in their future workplace. In the role of a student, it is possible to stay neutral between academia, public and private sector, but that might not be possible once losing the status of student. It is most likely to see the change agents as raw seeds when leaving the Challenge Lab. Raw seeds that need to be watered with knowledge, curiosity and the boldness to think ‘outside the box’ in order to make a difference in society.

A representative from the Property Management Administration stressed the importance for the authors to be students and in a neutral position, affecting the outcome in a way where gathering sensitive information was easier, since mostly interviewed tenants and companies do not feel

threatened by students and usually feel more comfortable to collaborate with. In addition, the same representative from the Property Management Administration showed interest in taking the suggestions further on to test how the involvement of tenants can enhance sustainability, and affirmed that they are willing to apply in other projects. It goes along with one of the purposes of this thesis, which is to raise awareness about sustainable renovation in an organisation that can influence a great amount of multi-dwellings in need for renovation in Gothenburg.

7. Conclusion

In times, where the challenges of climate change are undeniable, it is important to reflect on everyday practices. The built environment has a enormous impact on our climate, especially what has been built many years ago. Even more important is to consider what we build nowadays and how it can affect our future. Yet, the building stock from past decades has to reach the same standard as new construction. The approach of renovation is therefore an important topic. However, the main focus of renovation of multi-dwellings nowadays is to achieve more energy efficiency and raise the standard of the apartments, which in return influences the economic aspects and can negatively affect the social aspects, when tenants cannot afford to stay in their renovated apartments. Nevertheless research has shown that the social aspects are equally important, and that the inventory phase of a renovation is significant for the outcome of a renovation. Taking the users of a building into consideration right from the beginning can spread awareness and acceptance among them for eventual changes and an eventual rise in the rent level.

The aim of this thesis is to spread awareness of the need for transformative and integrative solutions in order to tackle sustainability challenges. Research among the approach of sustainable renovation has shown that it is long necessary to rethink the structure and process of a renovation. Boverket has a framework for renovation, but there is a lack of information on how and in what way to implement this framework.

It is important to balance the different sustainability dimensions in a renovation project, as well as balance the views and interests from different stakeholders. When efforts are made to reach one sustainability dimension at its highest level, other dimensions can be negatively affected, hindering the overall sustainability. One example is when investments are made in the most efficient energy system to meet environmental sustainability criteria, at a cost that it would not pay off during the building's operational life, thus affecting the economic sustainability.

In a rental multi-dwelling, involving the tenants in the beginning of a renovation project can help to do it in a more sustainable way. In the Case Study, by facilitating the communication between the tenants and property owner, and by enabling them to understand what are the needs and requirements for the renovation concept of this building, a few ideas emerged showing that it is possible to agree on solutions that can balance the sustainability dimensions.

In order to get a full picture of the Case Study, up following research is necessary. It is important to analyse what happens after the renovation, what impact the inventory phase and guidelines had for the overall outcome on the renovation process. In this way, the suggested framework can be improved according to that. However, less successful renovation projects in Gothenburg and the Case Study has proven that the inventory phase, and especially the communication between

property owners and the tenants, is essential for the outcome of a renovation project. The suggested inventory framework shall spread awareness and draw attention to that important phase in a renovation process.

This thesis was written in the Challenge Lab, a hub for rethinking mankind business as usual practices. The focus of this work is on renovation of multi-dwellings, but rethink people's behaviour and put sustainability into proactive action should be present in every discipline and in the everyday life. Citizen and tenant participation in planning and design can contribute to systemic change and thus, help producing systems (renovation processes, in this case) that are relevant in the society we have, and the one that will be developed in the near future.

7.1 Contribution to further research and practice

One aim of this thesis was to motivate for further research, which can be related to following topics:

- Investigation of the inventory phase with more stakeholders involved, and how decision-making is done in renovation processes;

- Evaluation of the suggested renovation framework by the Tenants Association, in the inventory phase, applied to different cases, with different characteristics;

- Follow up research on how the Tenants Association's framework can be put into practice and whether it is easy for companies to implement it;

- Investigation and evaluation of the importance of the architectural and culture-historical characteristics and how they can be better handled in renovation projects;

- What are the challenges within property owners to establish dialogue with tenants in renovation processes?

References

Acre, F. and Wyckmans, A., (2014). Improving people`s well-being - the key to renovation acceptance. *ZenN spatial quality.*

Anand S. and Sen A., (2000). Human Development and Economic Sustainability. *World Development,* 28(12), pp. 2029-2049.

Anon., (2014). *The Challenge Lab - Where master students take on global challenges.* [Online] Available at: www.challengelab.org/ [Accessed 25 February 2016].

Anon., 2009. *Promoting Sustainable Urban Development in Europe - Achievements and Opportunities,* Belgium: s.n.

Atanasiu, B. et al., (2013). *Boosting building renovation. An overview of good practices.* Brussels: BPIE.

Bagge, H. and Johansson, D., (2013). Prediction and Verification of Energy Performance in Energy Efficient Multi-Family Dwellings. *2013 ASHRAE Transactions,* 119(2), pp. 1-8.

Baker, N., (2009). *The Handbook of Sustainable Refurbishment. Non-Domestic Buildings.* London: earthscan and RIBA Publishing.

Botta, M., (2005). *Towards Sustainable Renovation. Three research projects,* Stockholm: PhD Dissertation.

Boverket, (2006). *Boverket.* [Online] Available at: http://www.boverket.se/globalassets/publikationer/dokument/2007/allmanna_rad_om_andring_av_byggnad_bar.pdf [Accessed 28 March 2016].

Boverket, (2016). *Boverket.* [Online] Available at: http://www.boverket.se/sv/boende/for-dig-som-bor-i-hyresratt-eller-kooperativ-hyresratt/boendeinflytande1/pdf-generering/ [Accessed 27 April 2016].

Chinowski, P. et al., (2001). Project Network Interdependency Alignment: New Approach to Assessing Project Effectiveness. *Journal of Management and Engineering,* 27(3), pp. 170-178.

Creswell, J., (2014). *Research Design.* 4th ed. United Kingdom: SAGE Publications, Inc..

Cruz, I. et al., (2009). Towards a systemic development approach: Building on the Human-Scale Development paradigm. *Ecological Economics,* 68(7), pp. 2021-2030.

Dreborg, K., (1996). Essence of Backcasting. *Futures,* 28(9), pp. 813-828.

Femenias, P. et al., (2013). *Integrated Strategies for Sustainable Renovation of Early Post-War Housing: The Case of Torpa, a Housing Area and National Heritage Asset in Sweden,* Italy: s.n.

Flood, R. L., (1998). Fifth Discipline: Review and Discussion. *Sztemic Practice and Action Research,* 11(3), pp. 259-273.

Geels, F., (2005). Processes and patterns in transitions and system innovations: refining the co-evolutionary multi-level perspective. *Technological forecasting and social change,* 72(6), pp. 681- 696.

Gluch, P. and Gustafsson, M., (2013). The acceptance and use of Life Cycle Costing (LCC) as decision support tool for renovation investments. *2015 International Conference on Construction and Real Estate Management*.

Gluch, P. et al., (2013). Knowledge sharing and learning across community boundaries in an arena for energy efficient building. *Journal of Cleaner Production,* Volume 48, pp. 232-240.

Häkkinen et al., (2012). *Methods and concepts for sustainable renovation of buildings,* s.l.: Espoo: VTT Technology, 26.

Hällgren, I., and Xygkogianni, M., (2015). *Cross communication among stakeholders and organisational learnings on renovation projects - a case at housing district in Gothenburg, Sweden,* Gothenburg: Chalmers Univeristy of Technology.

Higham, A. et al., (2015). Life cycle costing: Evaluation its use in UK practice. *Structural Survey*, p. 73.

Holmberg, J. and Robért K.-H., (2000). Backcasting from non-overlapping sustainability principles - a framework for strategic planning. *International Journal of Sustainable Development and World Ecology,* Issue 7, pp. 291-308.

Holmberg, J. et al., (1996). Socio-ecological principles for sustainability. In: R. Constanza, ed. *Getting Down to Earth - Practical Applications of Ecological Economics.* Washington DC: Island Press, p. International Society of Ecological Economics.

Holmberg, J., (1998). Backcasting: A Natural Step in Operationalising Sustainable Development. *The Journal of Corporate Environmental Strategy and Practice*.

Holmberg, J., 2015. *Transitions,* Chalmers University of Technology: s.n.

Hyresgästföreningen, 2015. *Hållbar ombyggnad – enda vägen framåt.* [Online]
Available at: https://www.hyresgastforeningen.se/globalassets/globalt-innehall/rapporter/ombyggnad_7juli_bra_utskrift.pdf
[Accessed 30 May 2016].

Isaacs, W., (1999). Dialogic Leadership. *The system thinker,* 10(1), pp. 1-5.

Jackson, T., (2005). *Motivating sustainable consumption: A review of endance on consumer behavior and behavioural change,* Surrey, United Kingdom: Center for Environment Strategy, University of Surrey.

Janson, U., (2008). Passive houses in Sweden: Experiences from design and construction. *Energy and Building Design.*

Kaklauskas, A. et al., (2008). *Knowledge base model for sustainable renovation,* Vilnius Gediminas Technical University. Vilnius: Modern Buildings Materials, Structures and Techniques.

Kåwert, J., 2016. [Interview] (29 April 2016).

Kohler, N., & Hassler, U. , (2002). The building stock as a research object. *Building Research & Information,* 30(4), pp. 226-236.

Learning Lab Hammarkullen, 2016. *Learning Lab Hammarkullen.* [Online]
Available at: http://learninglabhammarkullen.se/wp-content/uploads/2016/02/151117-

Presentation-alla.pdf
[Accessed 20 May 2016].

Liabäck, M. et al., (2014). *Sustainability indicators for redevelopment: Assessing the long-term effect of different strategies used in two housing areas.* Gothenburg, World Sustainable Building Conference 2014.

Lind, H. et al., (2014). *Sustainable renovation strategy in the Swedish Million Homes Programme: A Case Study,* School of Architecture and the Built Environment KTH: s.n.

Ludvig, K. et al., (2010). Life cycle costing in construction projects - A Case study of municipal construction client organisation. *Third International World of Construction Project Management Conference 2010*, pp. 1-8.

Mickaityté, A. et al., (2008). The Concept Model of Sustainable Buildings Refurbishment. *International Journal of Strategic Property Management*, 12, pp. 53-68.

Mjörnell, K. et al., (2014). A Tool to Evaluate Different Renovation Alternatives with Regard to Sustainability. *Sustainability,* Issue 6, pp. 4227-4245.

Nordling, L. and Reppen, L., (2000). *Ombyggnad: Varsamhet vid Ändring. En Handbok i Anslutning Till Boverkets Allmänna råd om Ändring av Byggnad.* Solna, Sweden: Svensk byggtjänst.

Pisano, U., (2012). *Resilience and Sustainable Development: Theory of resilience, systems thinking and adaptive governance,* s.l.: ESDN Quarterly Report N°26.

Rawls, J., (1971). *A Theory of Justice.* Cambridge: Harvard University Press.

Raworth, K., (2012). A safe and just space for humanity: can we live within the doughnut. *Oxfam Policy and Practice: Climate Change and Resilience,* 8(1), pp. 1-26.

Rockström, J. et al., (2009). A safe operating space for humanity. *Nature 461,* pp. 472-475.

Sandow, D. and Allen, A.M., (2005). The nature of social collaboration: how work really gets done. *Reflections: The SoL Journal,* 6(2-3), pp. 2-3.

Simmie, J. and Martin, R., (2010). The economic resilience of regions: towards an evolutionary approach. *Cambridge Journal of Regions, Economy and Society*, pp. 27-43.

Smedby, N. and Neij, L., (2013). Experiences in urban governance for sustainability: The Constructive Dialogue in Swedish municipalities. *Journal of Cleaner Production,* Volume 50, pp. 148-158.

Söderberg, Ö., (2014). *Challenge-lab compendium.* Gothenburg, Sweden: s.n.

SOU, (2005). *Nationellt Program för Energieffektivisering och Energismart Byggande (National Programme for Energy Efficiency and Energy-Smart Construction,* Stockholm, Sweden: Government Official Reports.

Stenberg J. et al., (2009). Linking Social and environmental aspects: a multidimensional evaluation of refurbishment projects. *Local Environment*, pp. 541-556.

Swedish Energy Agency, (2015). *Energy in Sweden.* [Online]
Available at: https://www.energimyndigheten.se/globalassets/statistik/overgripande-rapporter/energy-in-sweden-till-webben.pdf
[Accessed 22 April 2016].

The European Portal For Energy Efficiency in Buildings, (2016). *Build Up.* [Online]
Available at: http://www.buildup.eu/en/news/building-renovation-contributes-occupants-health-and-well-being
[Accessed 24 05 2016].

The International Wellbeing Group, (2013). *Personal Wellbeing Index-Adult.* 5th ed. Deakin University: The Australian Centre on Quality of Life.

Thomsen A. and van der Flier K., (2010). Replacement or renovation of dwellings: the relevance of a more sustainable approach. *Building Research and Information*, pp. 649-659.

Thuvander, L. et al., (2009). *Miljöanpassat byggande Göteborg,* Gothenburg: Program för bostäder.

Thuvander, L. et al., (2012). Unveiling the Process of Sustainable Renovation. *Sustainability*, pp. 1188-1213.

Thuvander, L. et al., 2016. *Renoveringsbarometern: Omfattning och karaktär av renoveringar i bostadshus.,* Gothenburg: s.n.

United Nations, (2016). *17 Goals to Transform Our World.* [Online]
Available at: http://www.un.org/sustainabledevelopment/
[Accessed 10 March 2016].

Wahlström, Å. el al., (2013). *Cost optimal energy efficiency in multifamily house.* CIT Energy Management, Chalmers, Gothenburg, Passivhus Norden 2013.

WBDG Productive Committee, 2015. *National Institute of Building Science.* [Online]
Available at: https://www.wbdg.org/design/promote_health.php
[Accessed 19 May 2016].

Westin, S., (2001). *"… men vart ska ni då ta vägen?" Ombyggnation ur hyresgästernas perspektiv. (…but where then will you reside? The Tenant's Perspective of Renovation),* Uppsala: Report nr 57, Institute for Housing and Urban Research, Uppsala University.

Willmot, Dixon, 2010. *The Impacts of Construction and the Built Environment,* s.l.: WD RE-Think Ltd.

World Commission on Environment and Development, (1987). *Our Common Future,* s.l.: Oxford University Press.

Yang, H. et al., (2014). Thermal comfort and building energy consumption implications - a review. *ApplEnergy,* Issue 115, pp. 164-173.

Yin, Robert K., (2008). *Case Study Research: Design and Methods.* 4th ed. Thousand Oaks: Sage Publications Incorpotated.

Appendix A – Challenge Lab

Theoretical Background

The theoretical background gives a short introduction to relevant theories that support the Backcasting method which is the main method used in Challenge Lab. Important theories supports this method, such as system thinking, the multi-level perspective, including societal systems and organisational learning. Starting with a short introduction to Backcasting which will be then further elaborated in the "Methodology *Phase 1"* chapter.

Backcasting

Backcasting is a relatively new approach and has been discussed from different perspectives (Holmberg, 1998). Holmberg (2015) mentions that there exist three different ways of approaching Backcasting:

- Expert Backcasting;
- Participatory Backcasting;
- Backcasting guided by principles.

The Expert Backcasting compares the feasibility of different normative future options and their policy implications while the Participatory Backcasting emerged after "Our common future" and the UN conference in Rio 1992. This type of Backcasting focuses on involving various stakeholders within a sector to address future options to meet sustainability challenges (Dreborg, 1996). The third approach, developed by Holmberg and Robért (2000), emphasises Backcasting guided by principles which can act as a shared mental framework for many possible futures. For this thesis, Backcasting guided by principles is essential. Therefore, any further theories and information are related to this type of Backcasting.

Backcasting is a method to analyse future options. Unlike forecasting where the steps are a continuum of present methods extrapolated into the future, Backcasting generates a desirable future using creating guiding principles. Thereafter, it takes a step back and analyses the present situation, which makes it possible to determine the physical feasibility of the described future and helps to identify the missing links from the present situation to the future.

Backcasting is particularly useful when the problem to be studied is complex and uncertain when one has to move within a dynamic system, when dominant trends are part of the problem and when the scope and the time horizon are long enough to leave considerable room for deliberate choice. It is a method to get early warning signals for when long-term investments based on today's structure can lead to dead ends and when punctual changes are not enough (Holmberg, 1998; Holmberg and Robèrt, 2000). Moreover, can Backcasting be applied for foreseeing certain

changes in legislation or on the market, thereby being helpful in avoiding risks and find business opportunities (Holmberg, 2015). The method of Backcasting and each step in detail will be explained in the chapter “Methodology *Phase 1.”*

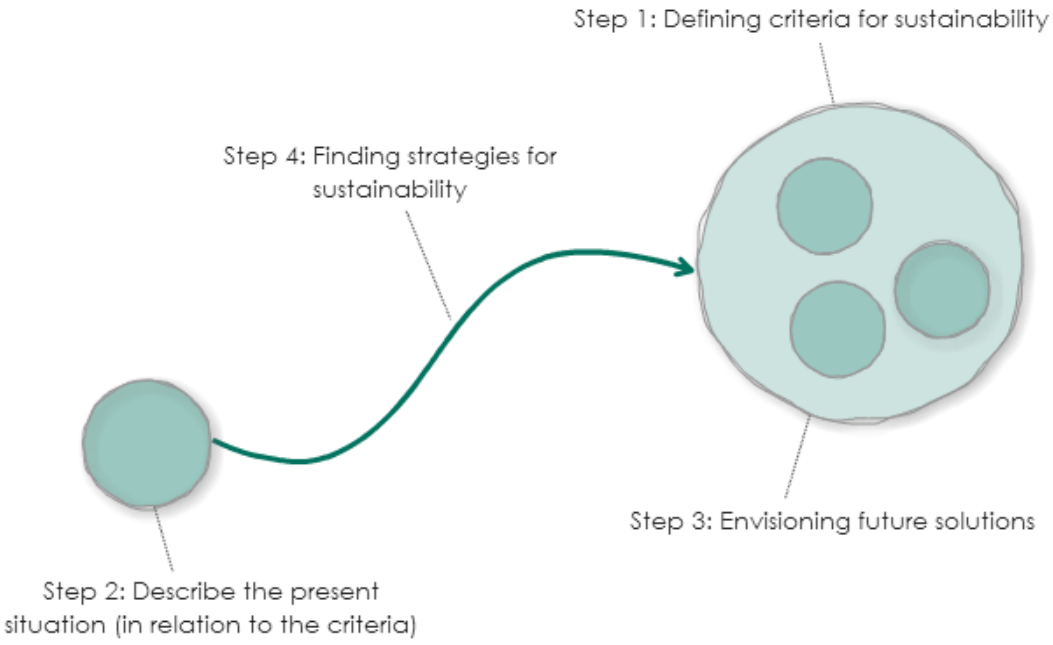


Figure 27 Backcasting (adapted from Holmberg, 2014)

System Thinking

One important theory to understand, in order to get the idea of the Backcasting method, is system thinking analyses things, systems, products and strategies as wholes rather than certain parts of it. Flood (1998, p. 260) explains that "people are taught from an early age to make complexity apparently more manageable by breaking wholes into parts. This makes understanding wholes impossible since one no longer can appreciate results of actions because the whole is stripped of an essential quality - interrelatedness". Therefore, one has to explore the system in order to discover the interconnection and relatedness.

An important aspect, is to identify the overall principles of how each system works, and develop the ability to see oneself, or an organisation, as part of the problem and the solution within a bigger and complex challenge, rather than as an isolated system on its own. This makes the process of system thinking increasingly complex (Flood, 1998). The system can be seen as a box, which is shaped by legislation, the current market, policies, culture and norms, knowledge and technology. The aim is to challenge the box and the system to find innovative solutions. When it comes to sustainability challenges, Holmberg (1998) affirms that established systems commonly endure punctual rather than radical changes, and such changes are not enough to cope with these

challenges. A transition towards sustainability is necessary for all systems, in a local and global perspective, and they require wise decisions in a complex, dynamic and uncertain system. Such decisions require systemic thinking; therefore, this approach was throughout the whole thesis process indispensable.

Multi-level Perspective

In order to understand the different systems that have been mentioned previously, Geels (2004) presents the Multi-level perspective, which recognizes three analytical and heuristic levels: Macro-, Meso- and Micro-level. Along with this approach go sociotechnical systems, that are actively created and maintained by various social groups. Geels (2005, p. 681) describes sociotechnical systems as "a cluster of elements including technology, regulation, user practices, markets, cultural meaning, infrastructure, maintenance networks, and supply networks" and that transitions are conceptualised as system innovations or change from one sociotechnical system to another.

On the macro-level the sociotechnical system is presented as landscape (system) which refers to a wider environment and is often beyond the direct influence of actors and can therefore not easily be changed at will. The meso-level is formed by sociotechnical regimes which are made of the rule-set that is mostly embedded in the knowledge base of the society. Therefore, regimes account for stability within sociotechnical systems. However, the system is more dynamic than the landscape system, and innovations of incremental nature still occur (Geels, 2004). Within the micro-level, one finds technological niches which are, as Geels (2004) presents, the locus for radical innovations and variations. They provide space to build the social networks which support innovations and learning processes which occur in many dimensions. The three concepts of landscape, regime, and niche systems are interrelated and linked, meaning that regimes are embedded within landscapes and niches within regimes (Fig. 27).

Changes on the sociotechnical niches can be traced back to problems of existing regimes, meaning that niches can create novelties that can be used in the regimes or even replace these (Geels, 2005). Niches provide the seeds for change. However, it is not easy to intervene in the regimes and even more challenging to intervene within the landscape system. Looking at the idea-driven innovation, a push factor is given, trying to challenge and change the system. When looking at demand-driven innovation, there is a design process that is pushing the system from the inside, creating change from within.

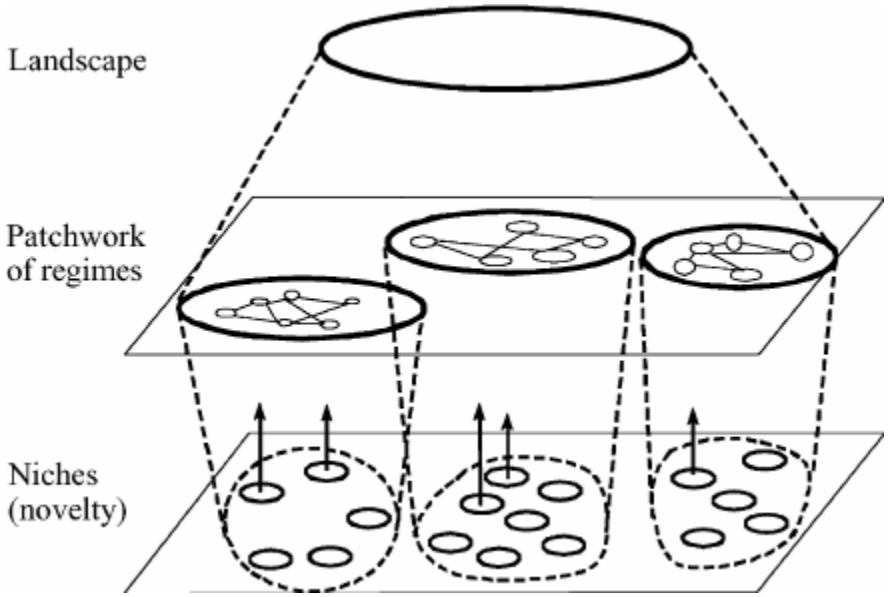


Figure 28 The Multi-Level Perspective (Geels, 2005)

When looking at the sustainability challenges we are facing, Holmberg (1998) states that society is often locked-in within these sociotechnical systems and that transitions are conceptualised as system innovations in order to change from one sociotechnical system to another.

Dialogue and Organisational Learning

One important theory used in the Challenge Lab is the Organisational learning and the tool of the dialogue. When it comes to tackling sustainability-related challenges, it is about understanding the system and how to break out of the above-mentioned lock-ins. This is necessary to overcome business as usual strategies and solutions. Therefore, one important part is to collaborate and to learn. Collaboration can be initiated in many ways; one way is through dialogue. Referring to Issacs (1999), dialogues create a setting in which people can allow a free flow of meaning of the collective background of their thoughts. In order to gain the most of collaboration in dialogues, active listening is essential (Sandow and Allen, 2005).

In addition, dialogues and especially the active listening enables learning. Learning from and with each other through communication and a non-pressure environment, which allows for trying out and making mistakes. Sharing collective knowledge and listening increases mutual trust and respect among the participants, which increases participation, enables creativity, innovation, and support. As can be seen in Figure 28, in a double-loop process, the various aspects involved are all tightly connected and interrelated. Trust and understanding, practiced in open dialogues, lead to collaboration, which in turn enhances participation, creativity and excitement, ultimately creating human energy (Sandow and Allen, 2005).

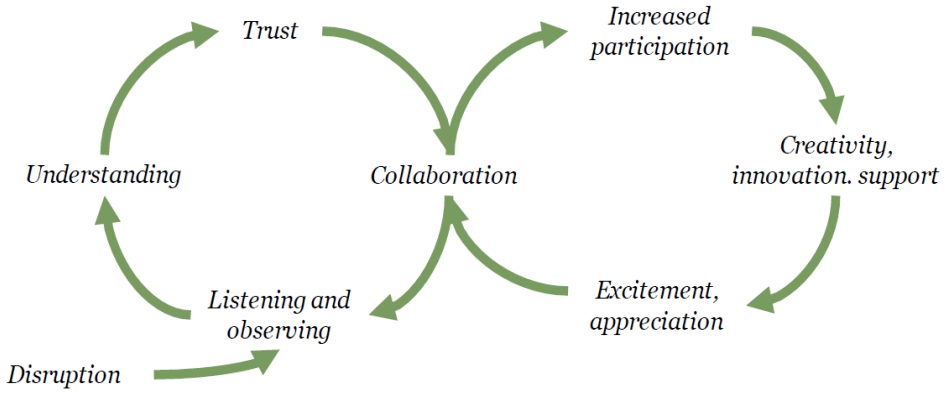


Figure 29: The double-loop benefits of listening (Sandow and Allen, 2005)

Sandow and Allen (2005) bring attention to the adverse fact that having open dialogues in a group or organisation might not be easy. Dialogues, if not held properly, can be disturbing and create tension, generating separation instead of participation. Those involved must be conscious that they can disagree on others' opinions and the other way around. Therefore, the precondition for such dialogues is an environment built on understanding and trust.

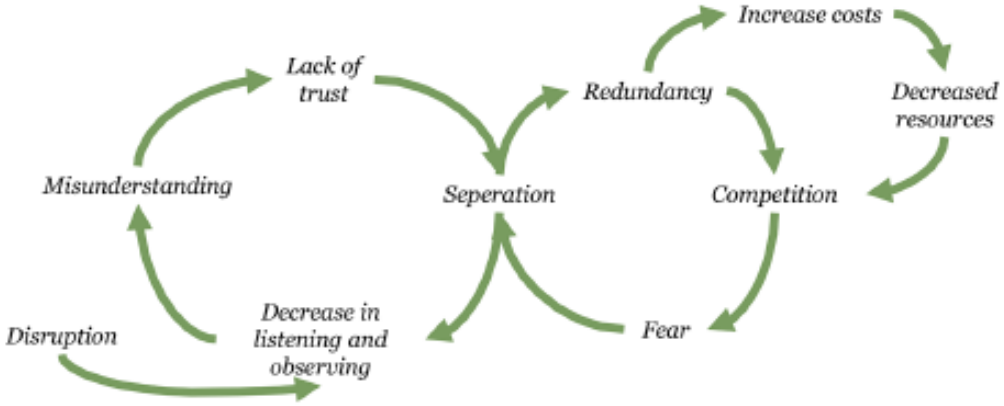


Figure 30 The double-loop effect of decreasing dialogue (Sandow and Allen, 2005)

Isaacs (1999, pg. 3) uses the term *dialogic leadership* and describes it as a way of leading that has four distinct qualities to support this process: "(1) the abilities to evoke people's genuine voices; (2) to listen deeply; (3) to hold space for and respect as legitimate other people's views; (3) and to broaden awareness and perspectives". When dialoguing people learn to use the energy of their differences to enhance their collective knowledge (Isaacs, 1999).

Methodology

Phase 1 of this master thesis has been supported by the Backcasting method, its tools and was materialised collectively by all Challenge Lab team members during four weeks, where the aim was to explore ongoing trends, challenges and needs regarding the urban development in Gothenburg and Western Sweden Region, to further narrow down to the students' areas of interest and generating ideas for their projects. In this section, the tools inside each step of Backcasting is explained, before presenting the *Results* of each step. The aim of *Phase 1* is for all students to find their thesis partner and to propose research question.

The Backcasting method from guided principles was used in designing this paper and finding the research question. Therefore, the following will explain the different steps of Backcasting and how it relates to this work, further in depth. Backcasting guided by principles builds on four steps (Holmberg, 1998):

- Define a framework or criteria for sustainability;
- Describe the current situation in relation to the set criteria or framework;
- Envision a future situation or solution;
- Find strategies for sustainability.

There are different tools, methods, and perspectives when it comes to the different steps (Fig. 30). These are the so-called Inside-out and Outside-in approaches. Whereas the Inside-out perspective focuses on understanding oneself, the inner values and own strengths. In order to get a better understanding of one's own values, the Self Leadership Workshop was held, that confronted the Challenge Lab members with their individual and inner values. In complement, the Outside-in approach aims to understand global challenges and the processes and patterns behind it. Moreover, the emphasis is on the transitions and system innovations. It focuses on spots where to intervene in the system.

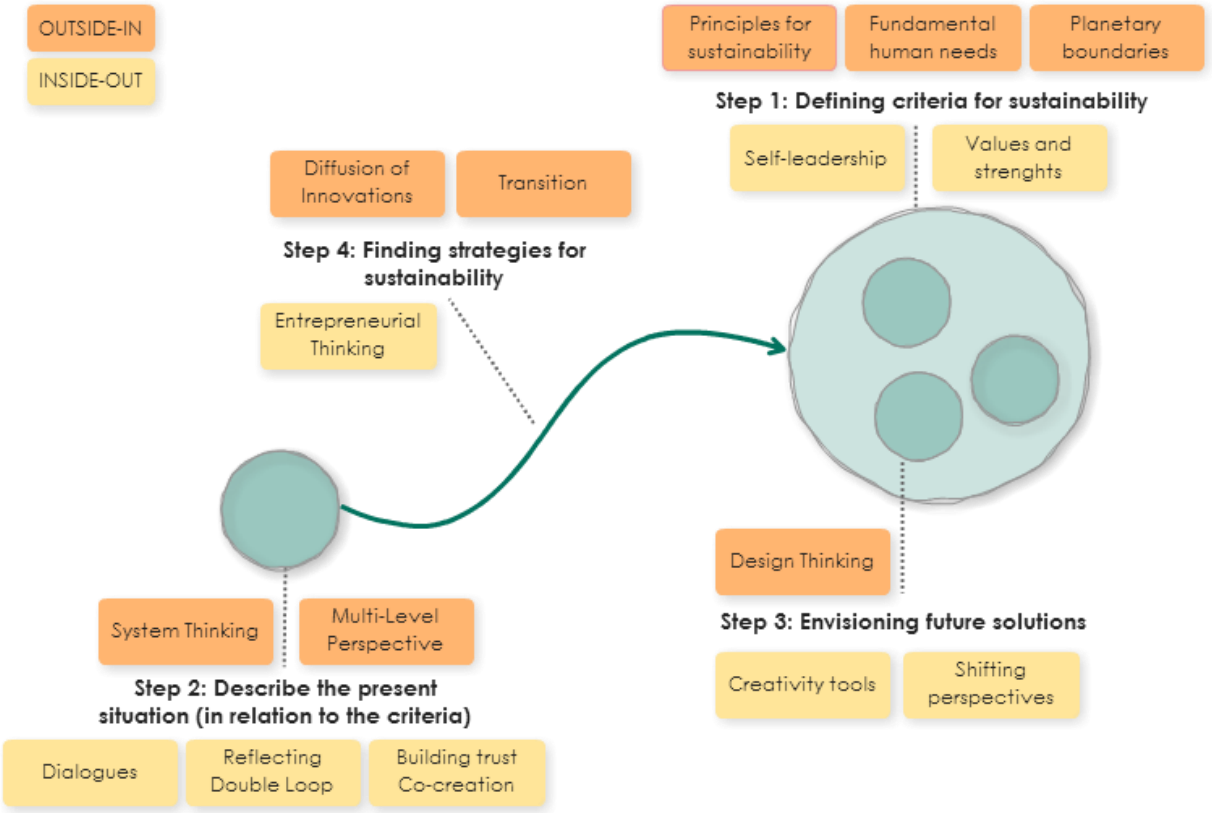


Figure 31 Backcasting and its supporting tools (Holmberg, 2015).

Step One: Principles for a Sustainable Future

The starting point of Backcasting is to envision a future state, generating principles for a sustainable future. This gives room for flexible strategies towards integrative transition. For that reason, it becomes essential to not only take current trends into account, because there is a risk for rather reactive than proactive strategies (Holmberg, 1998).

When defining the principles for a sustainable future, Holmberg and Robèrt (2000) have developed four principles for a sustainable development, based on the Brundtland report "Our Common Future" to "meet the needs of the present without compromising the ability of future generations to meet their own needs" (WCED, 1987).

The four principles describe how society can develop within the planetary boundaries described by Rockström (2009) and become system conditions, which creates a safe operating space for humanity with respect to the Earth system and the planet's biophysical subsystems (Rockström, 2009). The principles are within four pillars, such as Nature (ecological conditions), Social, Economic, and Well-Being. Whereas the Nature pillar builds the bottom foundation, the Social and Economic pillar build the support and conditions in order to achieve Well-being.

Often the system conditions are designed as restriction and minimum requirement, for instance, determining what human activities must not be done, in order to prevent destruction of the ecosphere and its ability to sustain us (Holmberg and Robèrt, 2000).

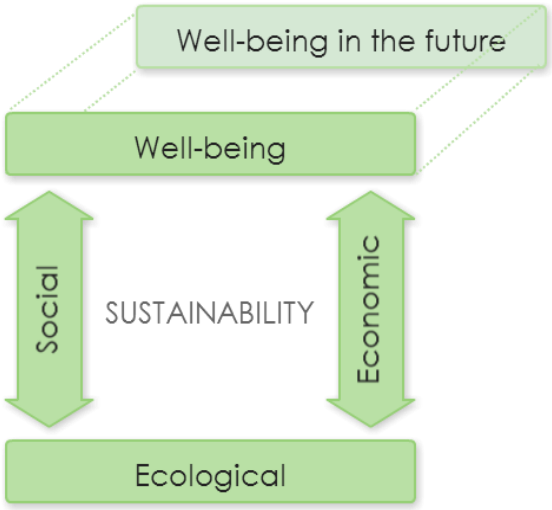


Figure 32 Pillars for sustainable development (adapted from Holmberg, 2014)

Holmberg and Robèrt (2000) have developed the system conditions to be used in Backcasting, and they argue that the principles must pursue the following aspects:

- *simplicity without reduction*, aiming to make it simpler to deal with complexity, without disconsidering any aspect of the complexity;
- *valid at various scales,* to counterpart different aspects to meet the principles;
- *shared mental framework,* to ease groups of people to share the principles of a vision, instead of sharing detailed pictures of the vision;
- *non-prescriptive,* where creativity is supported when experts in various fields share the framework for planning on a principle level but are allowed to handle the concrete details within that framework;
- *thinking upstream in causal chains,* claiming that upstream causes of any problem can often be easily understood and addressed than downstream.

Step one of the Backcasting method is often held in workshops, and the challenge is to make a group of individuals in the form of an organisation, a municipality, or a country, operate with a shared mental framework (Holmberg and Robèrt, 2000).

Step Two: Understanding the Present Situation

In step two, the current situation is analysed in order to identify the gaps between the present and the desired future. This will help in step three when designing strategies in order to meet the guiding principles.

Holmberg (1998) describes the double challenge the world is facing today, where on one side there is an increasing demand for energy and materials, and an increasing population. On the other side, we see increasing pressure on natural systems regarding their assimilation capacity, resource availability and land use. Together they visually symbolise the narrowing window of opportunities for humans to live sustainably.

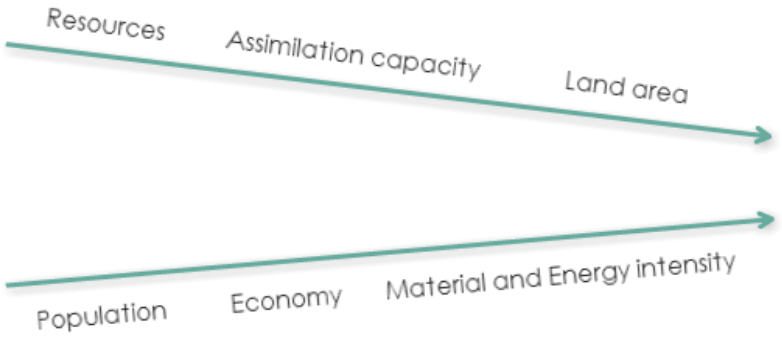


Figure 33 The funnel of resources (adapted from Holmberg, 1998)

In order to get a full picture and understanding of the present situation, various tools and approaches can be used, such as system thinking, dialogues, and double-loop reflection. The present situation relates to the overall ongoing global challenges, the analysis of existing systems, and where there are possible lock-ins within the system, which keeps society from moving towards more sustainable thinking and solutions. Step three and four focus on designing strategies to break out of these systems and overcome lock-ins. Therefore, it is essential to understand and stay within the present situation and not quickly move forward into finding solutions, as it often happens.

Step Three: Envisioning a Future Situation or Solution

Incorporating step one and two, in step three of Backcasting method the future will be elaborate and different solutions and strategies are then designed and tested, in order to fill the gaps between the present situation and the principles for a sustainable future. It is important to focus on the vision, and mission one has so that the strategies align with this vision. Within a global perspective, the vision could be seen as the definition of sustainability, to meet our own needs without compromising future generations to meet their own.

Holmberg (1998) points out that the future possibilities are envisaged in the light of the principles of a future sustainable society, and that these principles set restrictions as well as possibilities. Often there is a variety of future options, and the aim should be to think broad instead of detailed and static. The challenge is to free the mind of restrictions set by present circumstances. In order to develop different solutions, the multi-level perspective of design thinking comes into place.

Design thinking is a non-linear process that includes different methods of problem-solving strategies, expressed visually, in order to create new ways and methods to solve problems and create opportunities. It begins with pre-studies, which include matrixes and documentation, before starting to generate ideas and develop concepts, and trying them as prototypes, models or simulations. Each part of the process was supported by different tools (e.g. Gantt Chart, SWOT Analysis, Literature Studies, Study Visits, Interviews, Scenarios, Stakeholder Maps, Cognitive Walkthrough, Persona, Function Analysis, etc.) (Söderberg, 2014).

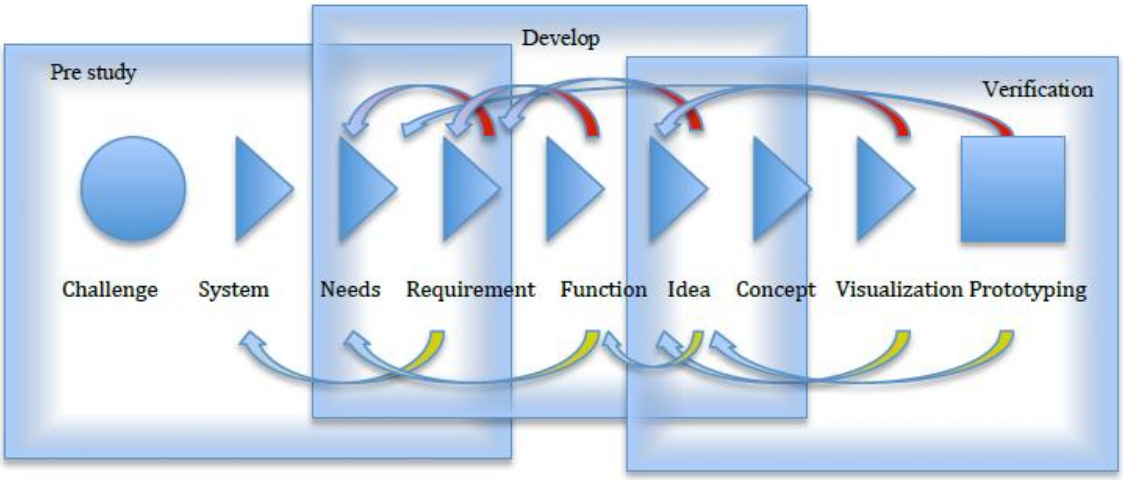


Figure 34 Design Thinking process (Söderberg, 2014)

Söderberg (2014) states that solutions must be function-focused, seeking to satisfy needs, rather than specify technical terms. He affirms that usually there is a gap between what people want and what people need, suggesting that semi-structured interviews with end-users and main stakeholders might enable disclosing important information that could not be foreseen.

Step Four: Finding Strategies for Sustainability

The fourth step of Backcasting method is to analyse which projects that have been developed in step three can have an impact on society and lead towards a more sustainable future. Holmberg (1998) points out the importance that the strategies have to link the current situation with the future sustainable situation. Four points are mentioned to be considered:

1. *Will each measure bring us closer to sustainability?* - As "measure" one understands a product, design, or investment and whether it will reduce our dependence on dissipative use of scarce elements;
2. *Is each measure a flexible platform for the next step towards sustainability?* - is it possible to go from the investment to another that will bring us even closer to sustainability?
3. Will each measure pay off soon enough?

4. Will the measures taken together help society to make changes at a sufficient speed and scale to achieve sustainability without too many losses for humans and other species during the transition?

The idea is to combine these points in order to reach sustainability and to analyse if the measures will pay off soon enough. If this is not the case, the risk of actors running out of money is too high (Holmberg, 1998).

Process and Results

This chapter describes the process and results of the first four weeks of the Backcasting method used by the Challenge Lab team. Challenges and possible solutions regarding sustainable development in the city of Gothenburg and the Western Sweden Region were envisioned. The major outcomes are the sustainability principles, understanding the present situation of urban development in Gothenburg and a research proposal for *Phase 2* of this thesis. Another outcome of *Phase 1* are the thesis pairs which were formed based on the personal interests in specific topics.

Results Step One: Principles for a Sustainable Future

The first step in the Backcasting method is to define the principles of sustainability based on the four sustainability pillars Nature, Social, Economic and Well-being. The first activity to agree on the principles was called World Café, where different tables represented the four pillars. The idea was that one facilitator would stay at each table while the others rotate and discuss towards the different pillars. The task was to envision a future state and how the different pillars are addressed in this future state. The groups could pick up some ideas from the previous discussion, which was documented by the facilitator. The discussions were supported by a literature review carried out in groups of 3 to 4 people beforehand. The literature was chosen by the Challenge Lab support team and built a ground for group discussions. Each group developed criteria related to their pillar and later presented the ideas to the rest of the group, where the principles were discussed and revised with the 17 UN Sustainable Development Goals and the last year's Challenge Lab criteria. The Challenge Lab agreed upon criteria for a sustainable future are the following:

Nature

For Nature (environmental) dimension, it was decided to inherit Holmberg et al. (1996) and Holmberg & Robèrt (2000) suggestion:

Human activities affecting nature's function and diversity are done in such a way that they:

- do not increase the concentration of substances from the lithosphere in the ecosphere;
- do not increase the concentration of human-made substances in the ecosphere;
- do not systematically deteriorate the resource base; such as fresh water, fertile land, and biodiversity through manipulation, mismanagement, or over-exploitation.

Social

The societal system is an instrument for individuals to live together within the other criteria with respect to the following conditions:

- it enables the well-being, empowerment, and productiveness of every individual while adhering to the ecological principles by:

a. equitable accessibility to education and health care;
b. gender and social equity;
c. equal human rights;

- its governing mechanisms (and societal institutions) are built on transparency, accountability, mutual trust, adaptability and recognition of diversity.

Adopted and inspired by Raworth (2012), Pisano (2012), Post-15 Goals, Criteria by Challenge Lab (2015).

Economic

The economic system is an instrument that enables individuals to meet the other criteria (society, well-being, nature) efficiently and effectively, as such:

- the function of the economic system is driven by the other criteria and not the other way around;
- it enables further use of resources and avoids dissipative use of materials;
- it assures an equitable distribution of resources;
- it has an inherent mechanism of maintaining and serving societal infrastructure and institutions that permits human well-being to be met over time;
- it has the ability to change and to adapt when facing shocks and disturbances.

Adopted and inspired by Sen (1999), Anand and Sen (2000), Simmie and Martin (2010), Post-15 Goals, Criteria by Challenge Lab (2015).

Well-being

The well-being pillar includes what contributes to humans' individual well-being. First, it was presented the basics for survival, followed by components supporting self-fulfilment and self-realisation.

The goal of the society and economy, lying on nature as its fundament, is to serve the human well-being, where:

- everyone has the right to basic human needs; health, security, future security, food, water, sanitation, recreation, shelter, energy;
- human life includes subsistence, protection, affection, understanding, participation, idleness, creation, identity, freedom;
- everyone should have access to the same opportunity and the freedom to build a meaningful life;
- everyone should have access to the same opportunity and freedom to explore and express your" inner-self" and to be your values without limiting others' freedoms or harming others;
- social and economic inequalities are not justified unless they are to the greatest benefit to the least-advantaged members of society.

Adopted and inspired by Rawls (1972), International wellbeing group (2013), Cruz et al. (2009), Post-15 Goals, Criteria by Challenge Lab (2015).

The principles were used as a framework and guidance for the next steps of Backcasting. Especially for step two, it is essential to have well-defined principles in order to analyse the present situation and find the gaps and the energy within the system.

Results step two: Understanding the present situation

Step two focuses on understanding the present situation. Besides the global challenges, there are many small-scale challenges to tackle in order to contribute to the global challenges. In this year's Challenge Lab case, the focus was to understand challenges on the regional and local level and to gather information whether there are ongoing urban development projects in Gothenburg and Western Sweden Region. In order to gain an understanding of ongoing projects and the challenges specifically related to Gothenburg, various transition dialogues on different topics took place:

- Understanding the concept and idea of the Areas of Advance;
- Mobility and Urban Development;
- Transition Dialogue Johanneberg Science Park;
- Sustainability driven Innovation for Urban Development;
- Areas of Advance – Energy;
- Integration and Social Innovation;
- Urban agriculture.

All the dialogues have been well prepared beforehand, by reading project and stakeholder-related literature and discussing in the Challenge lab team what is seen as challenges and opportunities among these stakeholders. The dialogues here represent a unique situation, where stakeholders that have never been discussing or worked together sit in a neutral arena, the Challenge Lab space, to open up their views and engage in collective discussions. This offers various opportunities and vibrant dialogues when the right questions are asked. As the most appropriate set-up, the Challenge Lab team decided to have a closed *fishbowl layout* circle, that is often used when discussing in bigger groups. In the *fishbowl layout*, there is an inner and an outer circle, whereas the outer circle has a more observative roll, the inner circle has an open and organic dialogue which can be steered by questions that have been prepared beforehand.

The dialogue that was most important for this thesis was “Sustainability driven Innovation for Urban Development”. Among other stakeholders, two representatives from the Property Management Administration where part of the inner circle, as well as Chalmersfastigheter and representatives of HSB Living Lab and the Innovation Roof Project. Referring to the authors’ personal interests, the expectations towards this dialogue were quite high, and many questions were asked in order to understand the urban development regarding the built environment in Gothenburg. Many urban development projects are happening in Gothenburg. One that has been

often mentioned was the development of the Frihamnen area, and related to that, the project DenCity, that aims to develop the area as a dense urban environment, with increased number of buildings and decreased number of vehicles per square meter, for a more efficient use of infrastructure.

The Property Management Administration, for instance, mentioned that one big challenge for the city is the actual need to build a large number of apartments in a short period of time. Chalmersfastigheter pointed out that the built environment has often less research function than other industries, since the construction sector is very rigid, and introducing new techniques and challenging the status quo is tough. In addition, the construction companies are often very much focused on individual projects and that there is often a lack of collaboration between different actors. Another topic mentioned was the social integration and who is taking responsibility for that. The Property Management Administration mentioned that for the properties that are located on their lands, a large number in the city of Gothenburg, they have the power to influence and set standards regarding energy efficiency, material use, etc., but they are rarely making use of it. They mentioned that they have an interest in having a better look on that.

Out of this dialogue, one central question arose referring to why it is often only considered to build new rather than preserving the existing and make it more efficient. Especially when it was often spoken about making the city denser, it needs to be mentioned that nowadays not many cities have the opportunity to construct new buildings as close to the city centre as Gothenburg has it in Frihamnen area. And many existing buildings are inefficient when it comes to energy standards.

In respect to the defined sustainability criteria, one has to look closer towards the environmental and economic principles and how materials are used and reused and how efficient they are used. Replacing old buildings with new ones might raise the energy efficiency, but it does not relate to handling material in an effective way therefore that most of the material from demolition is not recycled or “naturalized” in a proper manner.

Results Step Three: Envisioning a Future Situation or Solution

After understanding the present situation in light of the defined principles for sustainability, the Challenge Lab team had a workshop in order to find the so-called “Hot-spots,” meaning which challenges and topics are stakeholders interested in working with, and where can we connect these to perhaps already ongoing projects. The Challenge Lab team defined main topics that they found interesting. Based on that, a brainstorming session started in order to broaden up the perspectives to see possible connections between the topics, that have not been as obvious on a narrow base. With this, the iteration phase began by zooming in and out and by defining and

summarising smaller topics to bigger headlines. The result was three topics that were then analysed further in depth:

- Dense city: comprises the idea of making the city denser and mixed, connected to that the Frihamnen development;
- Transportation Strategy: involves scaling up electro-mobility, decreasing the number of parking spots to a 0.1 parking norm, how can Gothenburg prepare for that and become a city with fewer cars and fossil fuels free;
- The value chain of materials: covers materials and industry, especially in the construction sphere.

As mentioned in chapter two and three, sociotechnical systems are much essential for the Backcasting method. In the Challenge Lab, the design process can take place on different levels of sociotechnical systems and the multi-level perspective. It depends on how and where in the system one aims to intervene. After defining the three different "Hot-spots", a deep analysis was executed by answering different questions:

- *Stakeholders:* Is there stakeholders interest around this topic? Who are they?
- *Transformative and Integrative*: What can be the integrative and transformative aspects of this topic?
- *Multi-level Perspective Analysis*: Where in the system can one intervene to achieve positive changes (Landscape, Regime, and Technological Niche levels)?
- *Sociotechnical System Analysis:* How things are and where it can be changed in these systems (Technology, Knowledge, Market, Legislation, Policy, and Culture)?
- *Dimensions of Sustainable Development:* Will these interventions be aligned with our vision (Nature, Social, Economic and Well-being)?
- *Value Chain:* Where in the value chain can one intervene?

After analysing and presenting these aspects for each topic, each student had to reflect and decide individually which topic was the most interesting to work with. Each student then had to elaborate why this specific topic was chosen and in which direction we could imagine a possible research. Based on that, the students formed smaller groups around the topics to do further research on, and eventually pair up.

At the beginning of this thesis, three main topics were interesting (related to the construction sector):

- Supply chain in the construction industry;
- Reuse of material;
- Test beds and trying innovations in practice.

The line between step three and four is vague and can be different for each thesis' pair. Therefore, some students were already quite clear on their topic at this point, while others had to do a wider

research on the topics, and especially stakeholders and supervisors that could be interested in these areas.

Results Step Four: Find Strategies for Sustainability

The fourth step was different for each group, dependent on how much research around the chosen topic had to be done in order to formulate a research question, and on the areas of interest and education of each group. A strong focus was given to connect the different evolving research questions, therefore, different pairs connected, to find eventual common ground for projects (master theses). Mutual interest to write this thesis was the idea to explore possible ways of using existing residential buildings in Gothenburg more efficiently, rather than focusing on new buildings to suppress the need for new housing.

After the stakeholder dialogues, the Property Management Administration was the one of the relevant stakeholders to engage with. The Property Management Administration owns nearly 50% of the land in Gothenburg and in addition, but to a far smaller extent, some buildings on their properties. They offered the possibility to develop a renovation concept for a property owned by them, in Gamlestaden, a multi-dwelling in need of renovation. This opportunity brought up the idea of using this project as a “test-bed”, mentioned in step three.

Research Question and Analysis of the System

After using the Backcasting approach, the Challenge Lab students defined the sustainability criteria and gained an understanding of different problems, and on emerging projects within the city of Gothenburg and the Western Sweden Region. Especially after the dialogues and the interaction phase, various questions evolved and a research topic crystallised. After analysing the topic in depth in step four and getting feedback from various stakeholders, the following research question evolved:

How can a sustainable renovation be ensured from the inventory phase?

This research question is formed and guided by following sub-questions:

- *What aspects need to be considered to ensure a sustainable renovation?*
- *How can tenants be involved in the renovation process? In what way can they contribute to sustainable renovation?*

The research question was stated after an analysis of different keywords such as “sustainable renovation” and “stakeholder involvement in renovation processes.” Moreover, were various information and aspects of the “renovation system” collected to understand and get an idea of the scope of the system. Many existing regulations and norms refer to new buildings and new construction rather than buildings that have to go through renovation. But old buildings have different aspects to consider and cannot be treated the same way new construction is. Often these buildings have a history and eventually tenants that need to be considered. Therefore, the challenge is to take into account these aspects, yet with respect to the four sustainability dimensions.

Appendix B – Interviews

Tenants:
Fredrik - 2016.02.24
David - 2016.02.24
Saga - 2016.02.29
Åsa - 2016.02.29
Anisa - 2016.03.02
Roger - 2016.03.02
Ingela - 2016.03.04
Stina - 2016.03.04.

Pernila Gluch, Professor at Chalmers - 2016.03.13
Economic calculations for renovation projects.

Anders Svensson, Professor at Chalmers - 2016.04.14
Workshop methods for urban development projects.

Tobias Matsson and Olle Björquist, Project Managers at Fastighetskontoret - 2016.04.15
Economic aspects of the property and what Fastighetskontoret wants for the multi-dwelling, as owners.

John Kåwert, Uppdragansvarig at Rotparner (Renovation Consultancy Company) - 2016.04.29
About how they carry out renovation processes.

Appendix C – LCC on building cost estimation and decision making in Gothenburg

Älvstranden Utveckling AB in Gothenburg, in 2007, used LCC to analyse three alternative designs of a multi-dwelling to support the decision-making process on cost efficiency, especially focused on energy systems. They conducted fifteen LCC calculations with up to eight comparative options in each calculation. It gave a very good decision-making parameter and changed the design of the building during its early phases (Thuvander et al., 2009). Table 4 shows the compared building designs of the multi-dwelling, their main characteristics, and their calculation of returns over 10 years:

Table 5 Three design options for LCC calculation by Älvstranden Utveckling AB (adapted from Thuvander et al., 2009)

Name	Main Characteristics	Return (10 Years)
Normhuset F-system	designed according to the Swedish Building Standard, with traditional exhaustion systems (F-systems) and radiators;	between 5.7% and 7.1%
Höghuset F-system	designed under Älvstrandens building standard "High-rise Standard" with traditional exhaustion systems (F-systems) and radiators;	between 5.8% and 7.2%
Hamnhuset FTX	designed under the passive principle with a well-insulated building envelope without thermal bridges, an exhaustion and ventilation system (FTX system) with good energy recovery and solar panels for hot water production on summer, without radiators.	between 5.8% and 7.3%

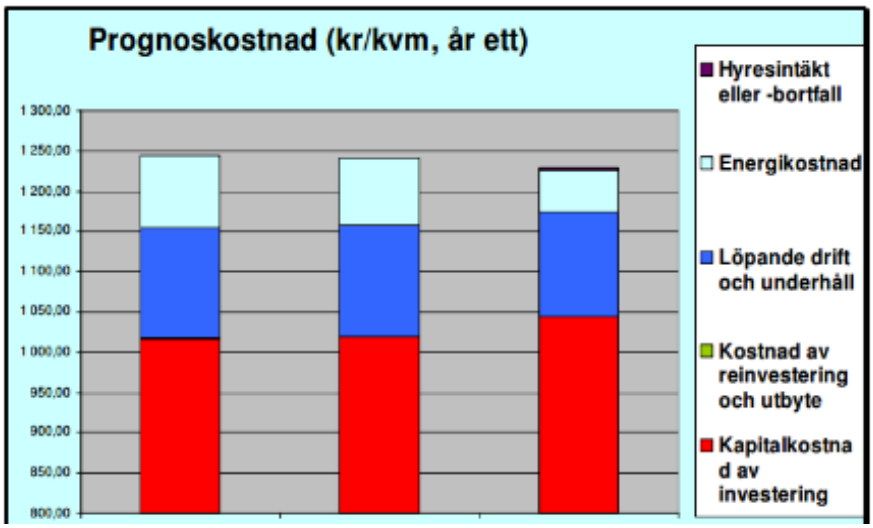


Figure 35 LCC estimation on three design options by Älvstrand Utveckling (Thuvander et al., 2009)

The most energy-efficient house was Hamnhuset and was considered a better option despite an additional investment of 4% on its construction, compared to the other two options, according to Swedish standards. It consists of 115 apartments, and its energy use is 60 kWh/m2 per year, whereas the other

two options' energy use are 129 kWh/m2 and 116kWh/m2 per year. In addition, passive houses usually emit one-fourth of CO2 that a house built according to the building code does, and have lower operating costs (Thuvander et al., 2009).

Figure 36 Hamnhuset is Gothenburg's first apartment blocks built as a passive house (White Arkitekter, 2008)

Appendix D – Interview guidelines and observation tenants

1) How long have you been living here?
2) How is it to live here?
3) What do you appreciate about your apartment?
4) What's the most important aspect to consider when doing a renovation?
5) Anything else you would like to ask/mention?

Observation

1) Type of apartment:
2) Situation/position:
3) Major changes:
4) Defects/Shortcomings:

Appendix E – Interview Questions Rotpartner

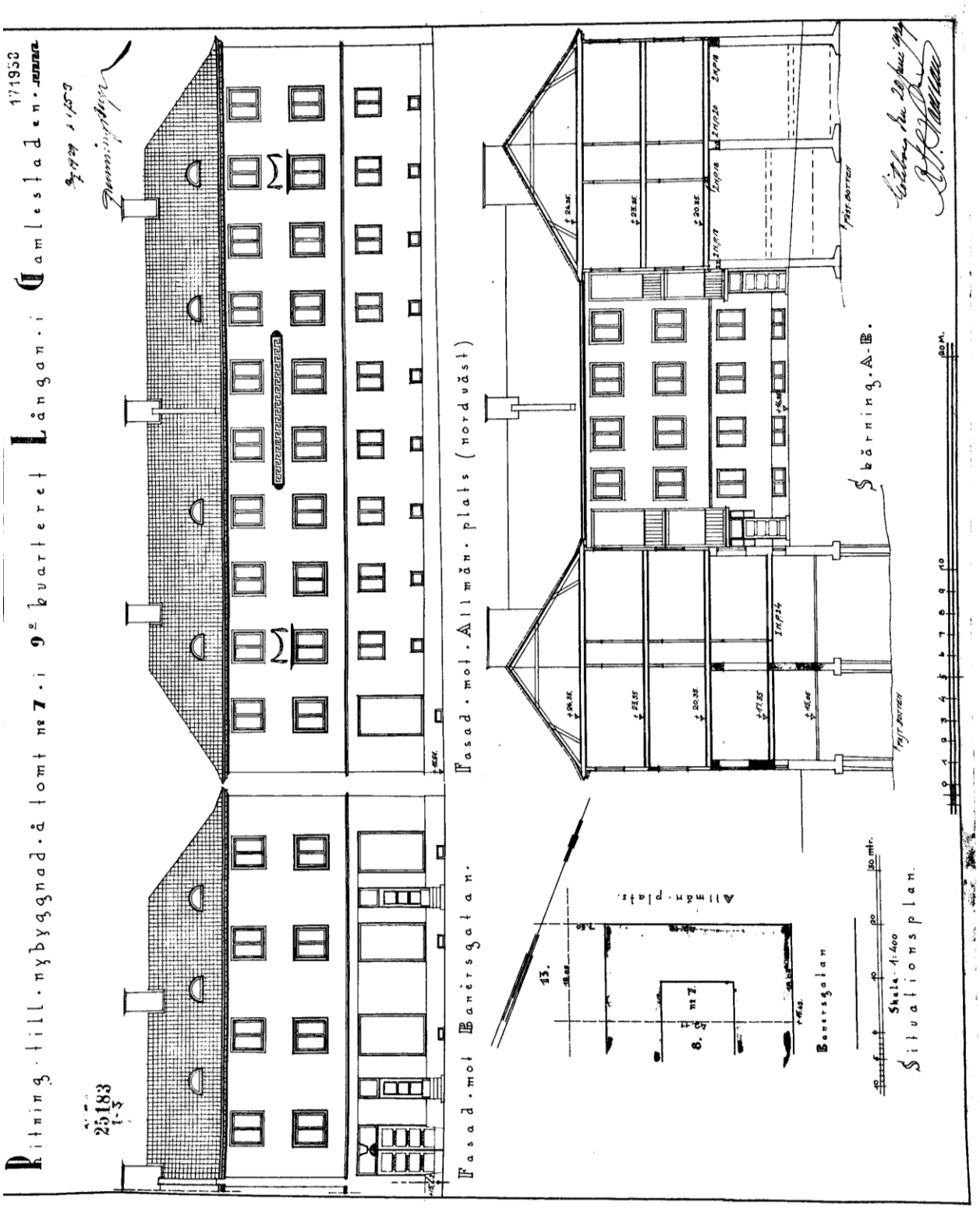
1) Could you describe how you proceed/which steps you follow in a typical renovation process of a multi-dwelling, with tenants?
   a) What would you see as your major task?

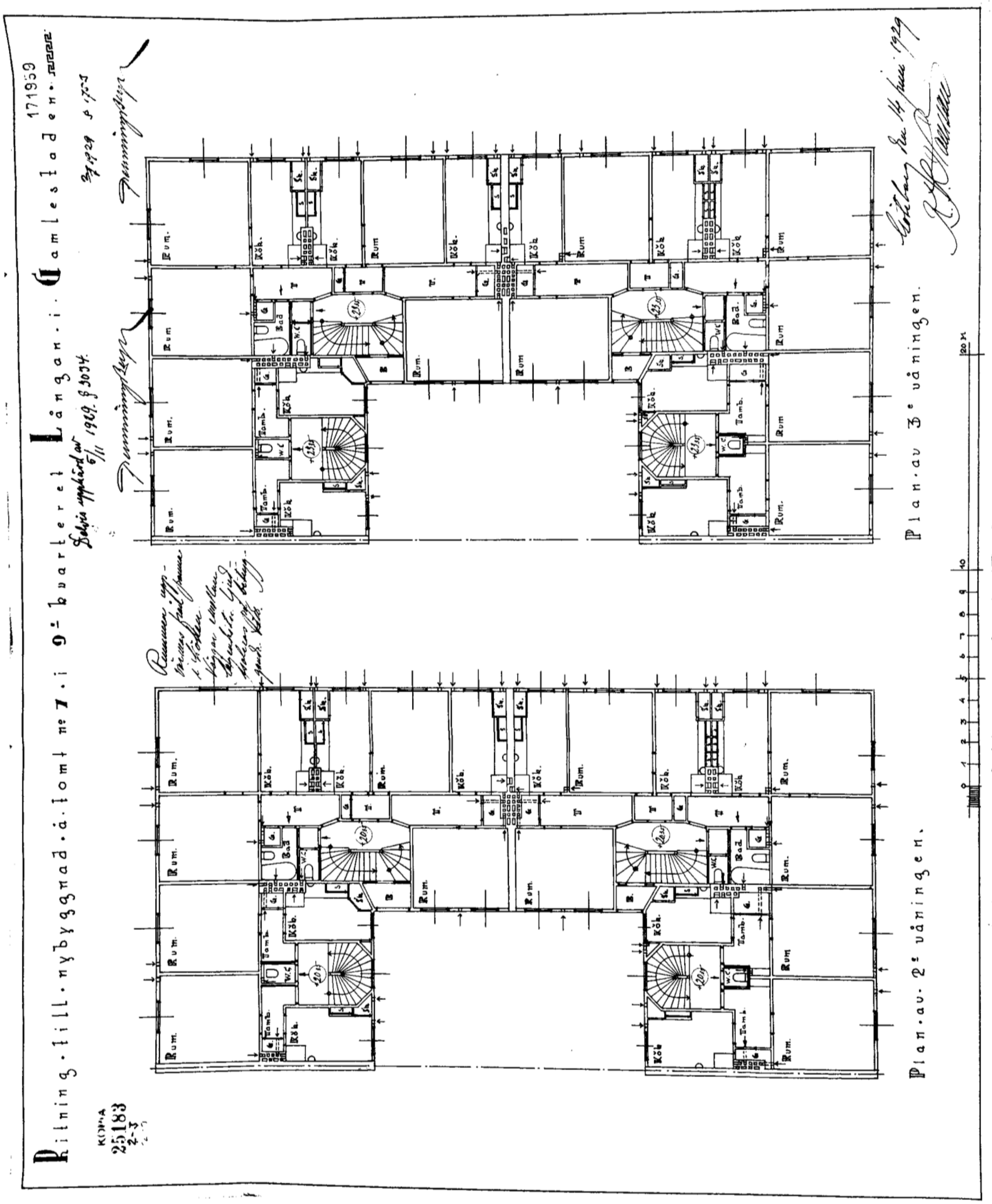
2) Is a sustainable renovation process/concept important to you?
   a) And if yes, how do you approach this?
   b) Where do you see the biggest conflicts?
   c) Related to your own experience, are the three sustainability (social, environmental, ecological) dimensions equally important?

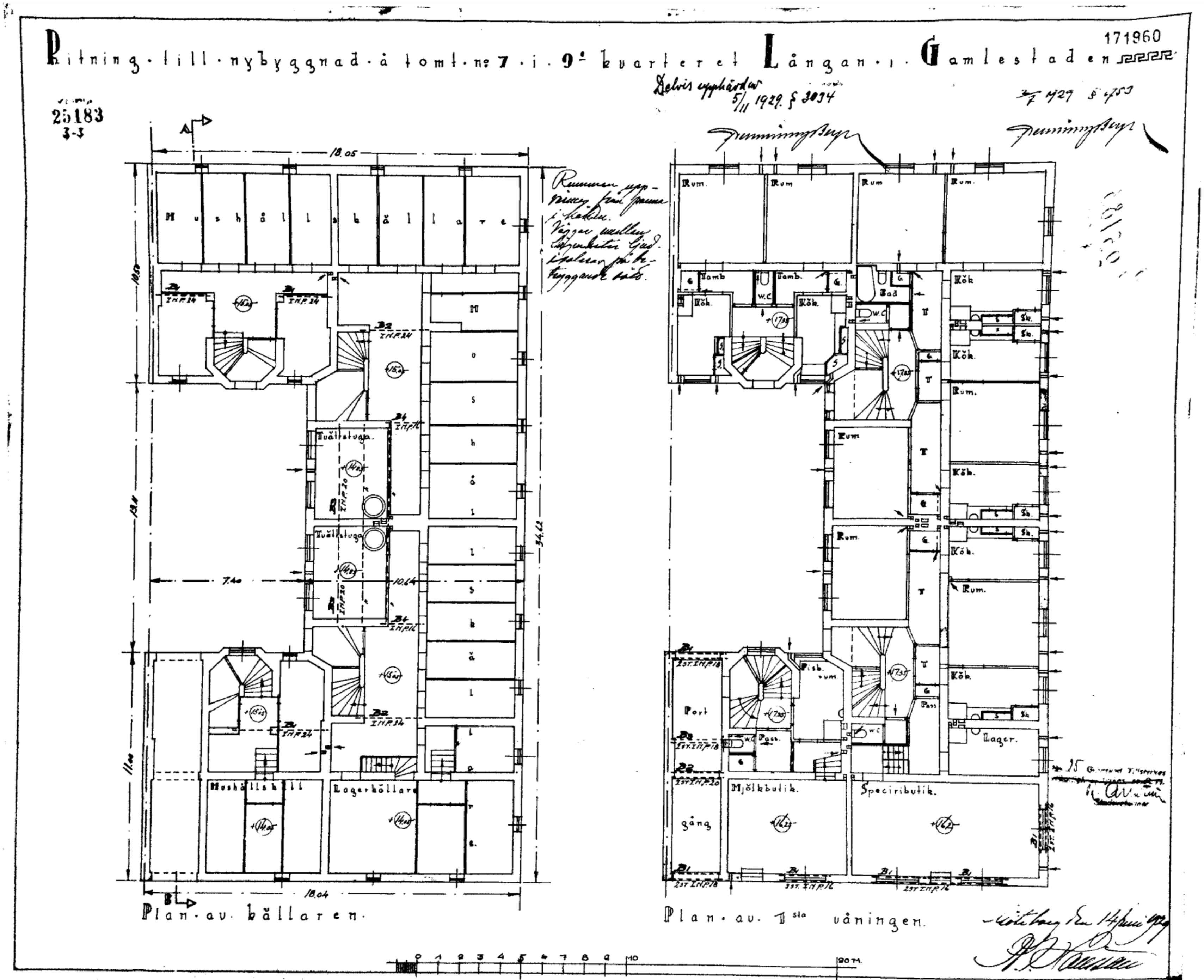
3) How have you experienced the owner/tenant relationship?
   a) Are there any special forms of dialogues?
   b) At what point do you usually involve the tenants?
   c) How much power do the tenants have analysing the needs for a renovation?

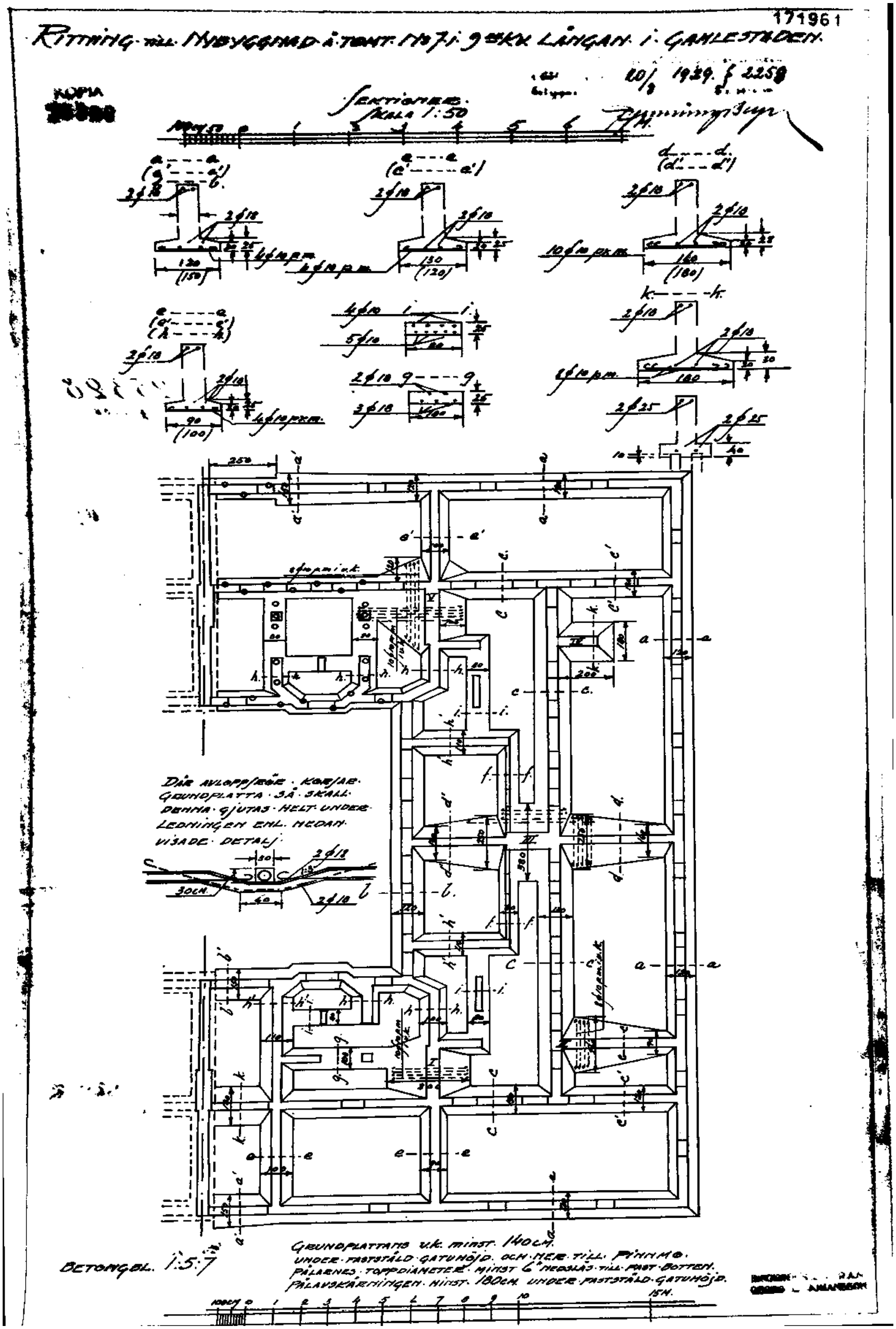
4) How do you proceed in the inventory phase of a renovation?
   a) Have you developed your own framework? owner?
   b) What documents do you collect?

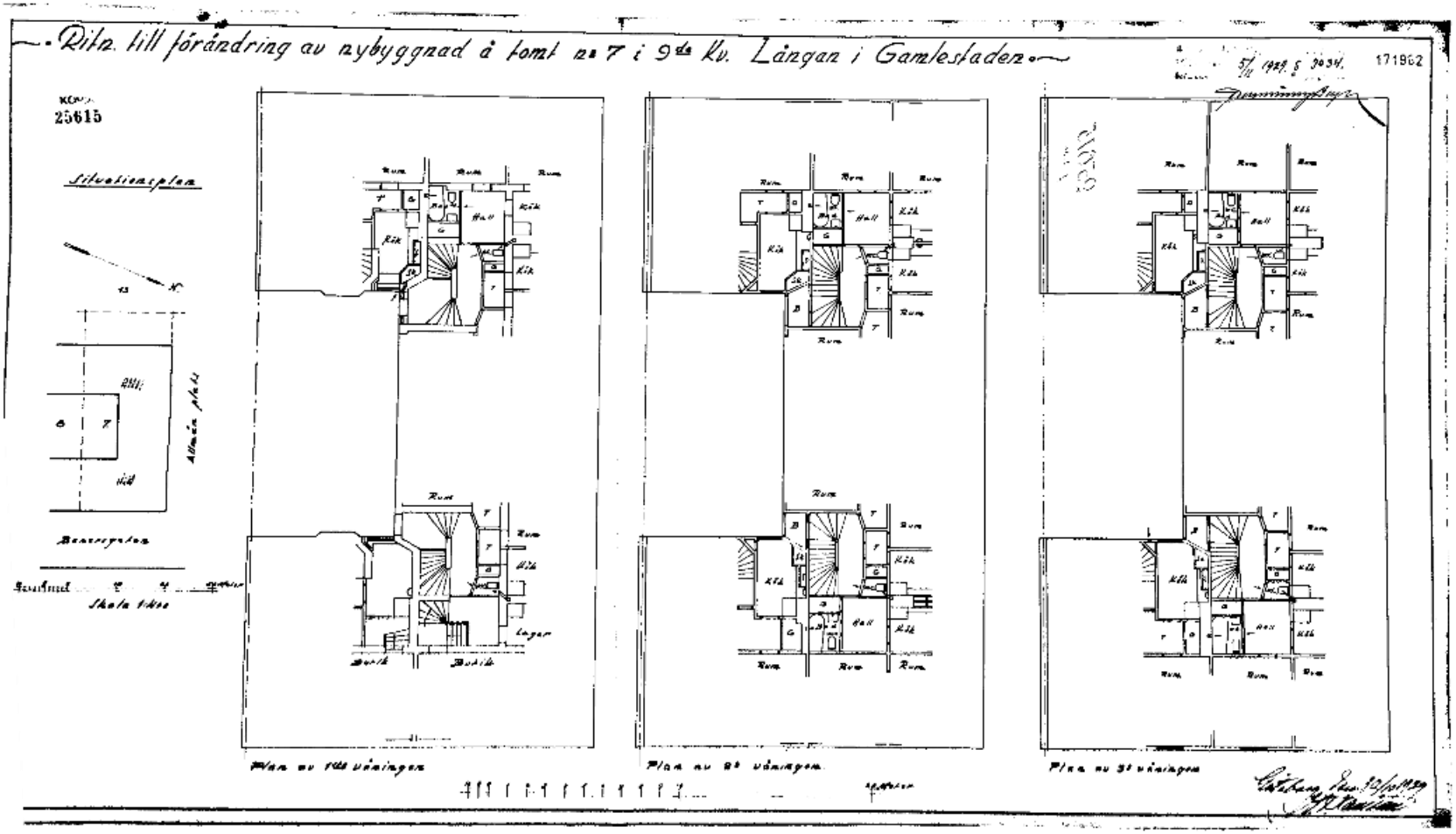
Appendix F – Archive Documents

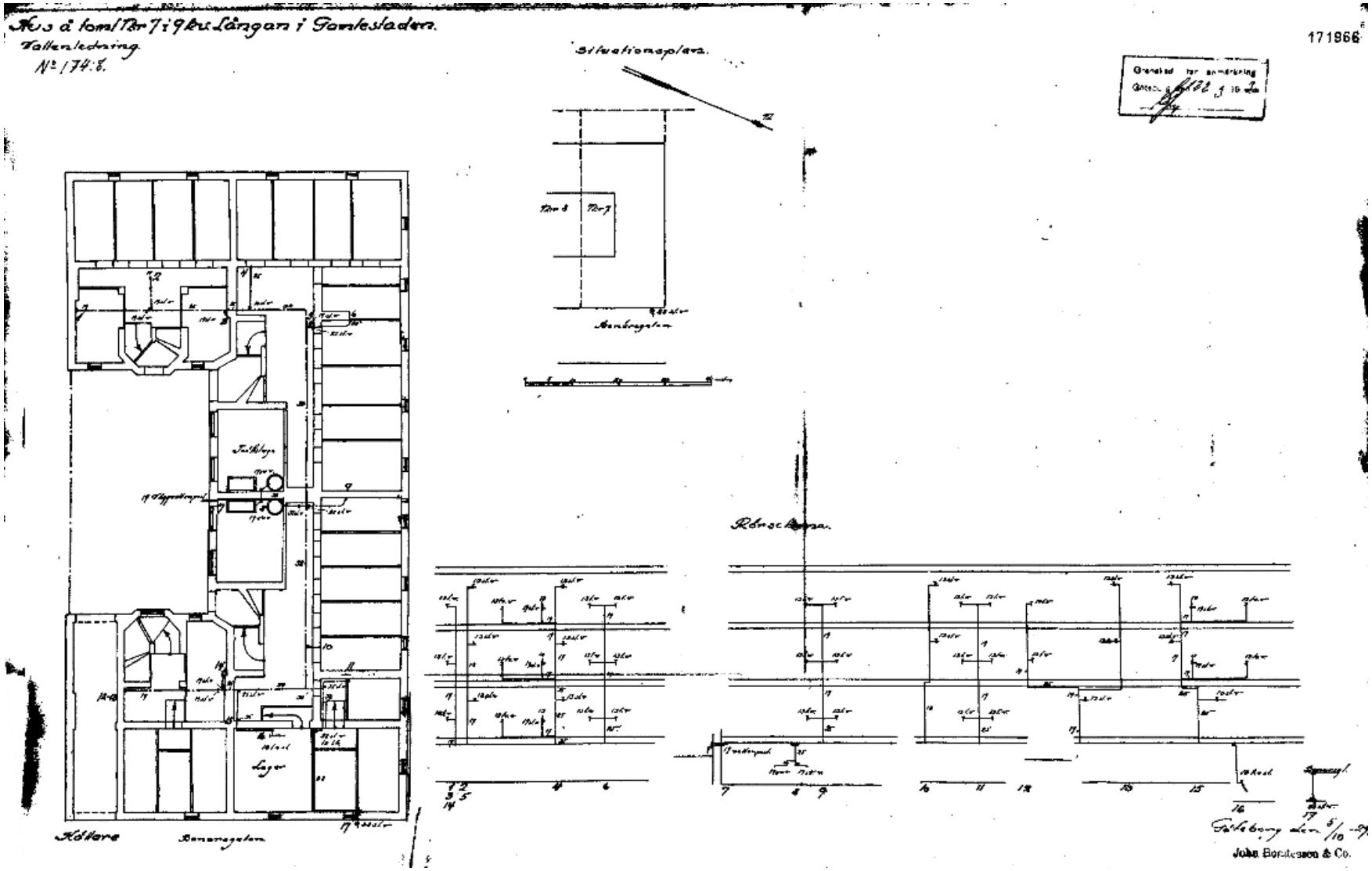


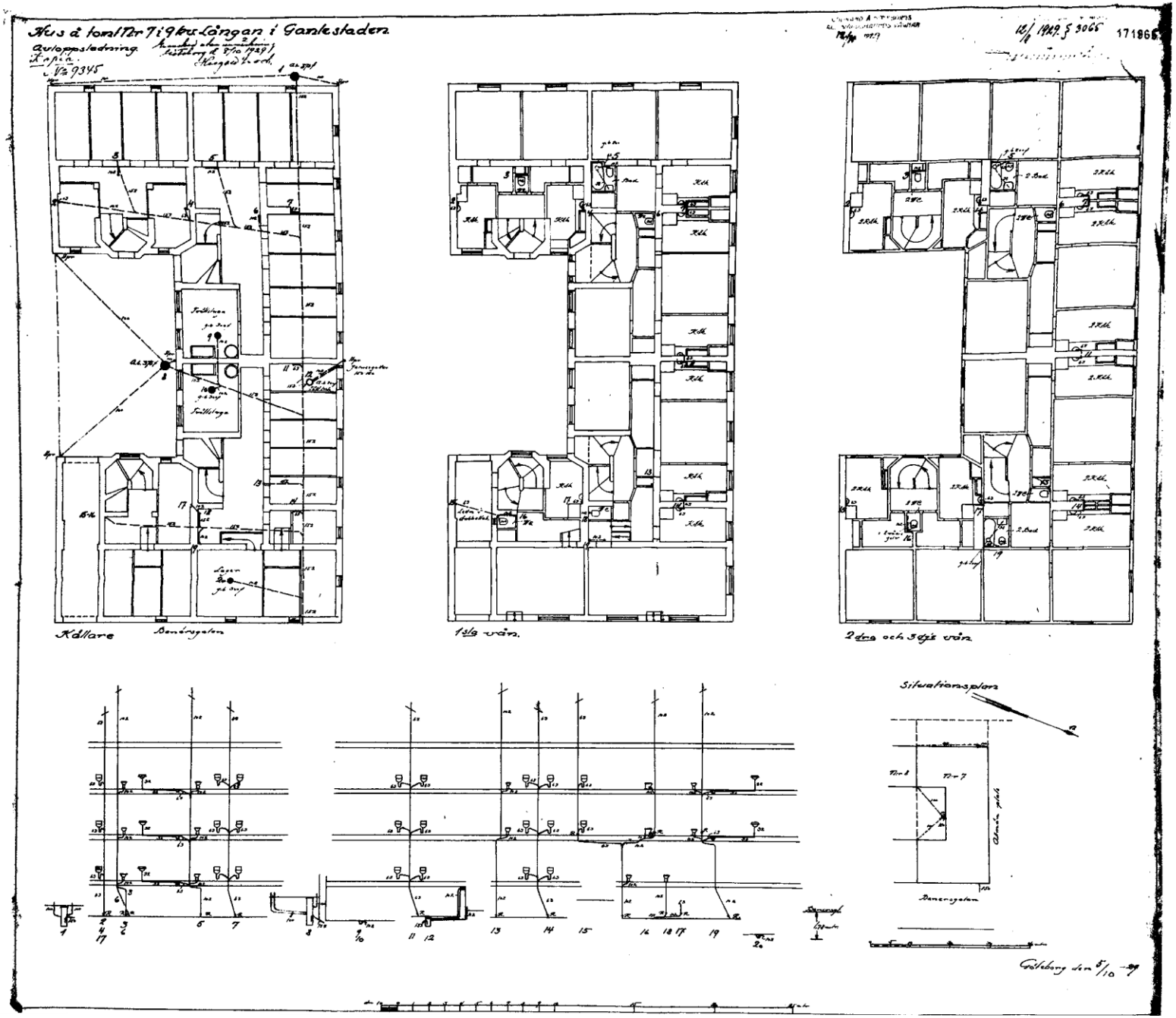

Ritning · till · nybyggnad · å · tomt · no 7 · i · 9e kvarteret · Långan · i · Gamlestaden
Plan · av · 2e våningen.
Plan · av · 3e våningen.
Rum
Kök
Bad
Tamb.
W.C.
171959
25183

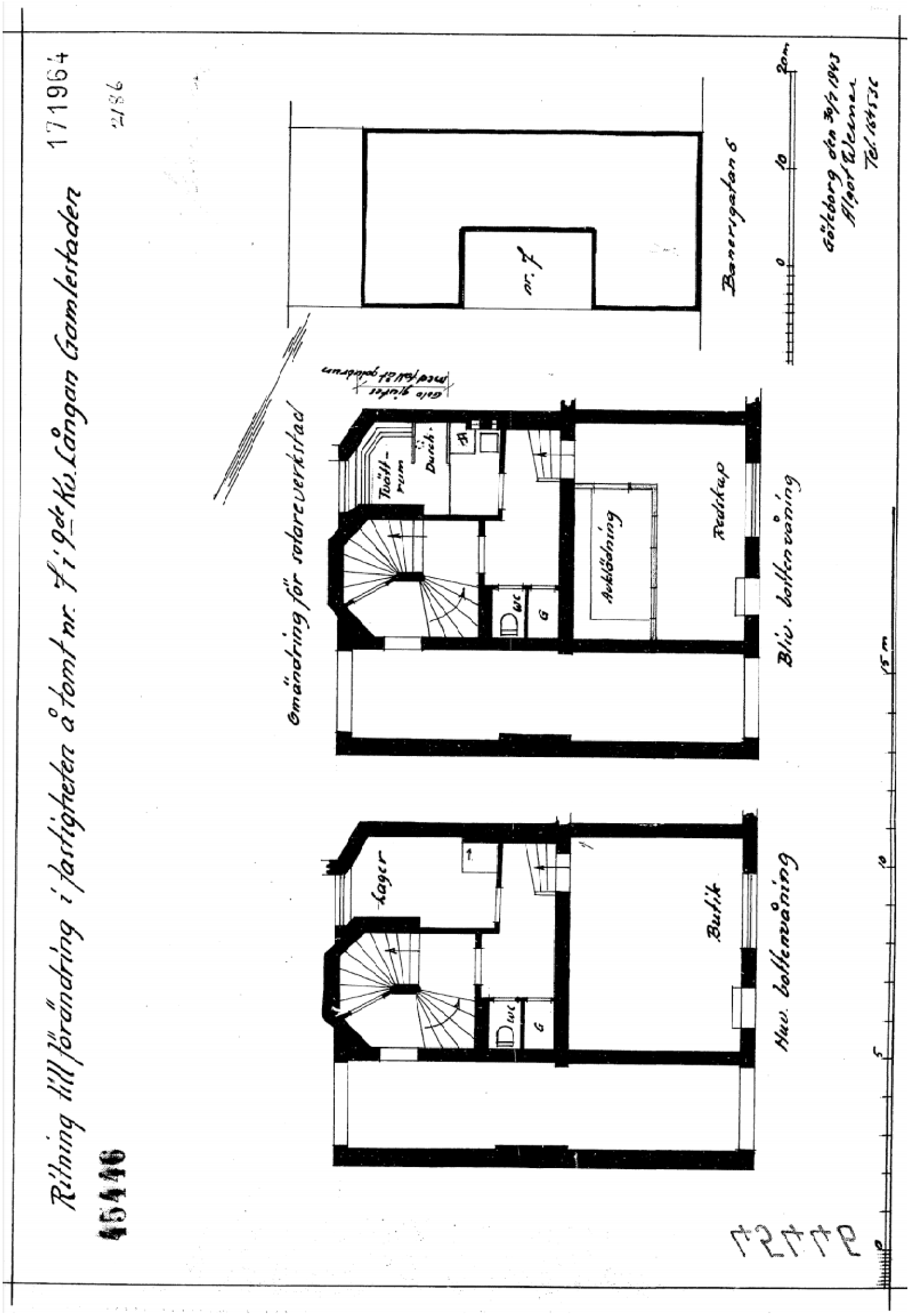

Ritning · till · nybyggnad · å · tomt · no 7 · i · 9e kvarteret Långan · i · Gamlestaden
171960
25183
3-3
Delvis upphävd 5/11 1929. § 3034
3/7 1929 § 4753
Hushållskällare
Tvättstuga
Lagerkällare
Plan · av · källaren
Rum
Kök
Tamb.
Bad
W.C.
Port
gång
Mjölkbutik.
Speceributik.
Lager.
Pass.
Plan · av · 1sta våningen
0 1 2 3 4 5 6 7 8 9 10
20 M.

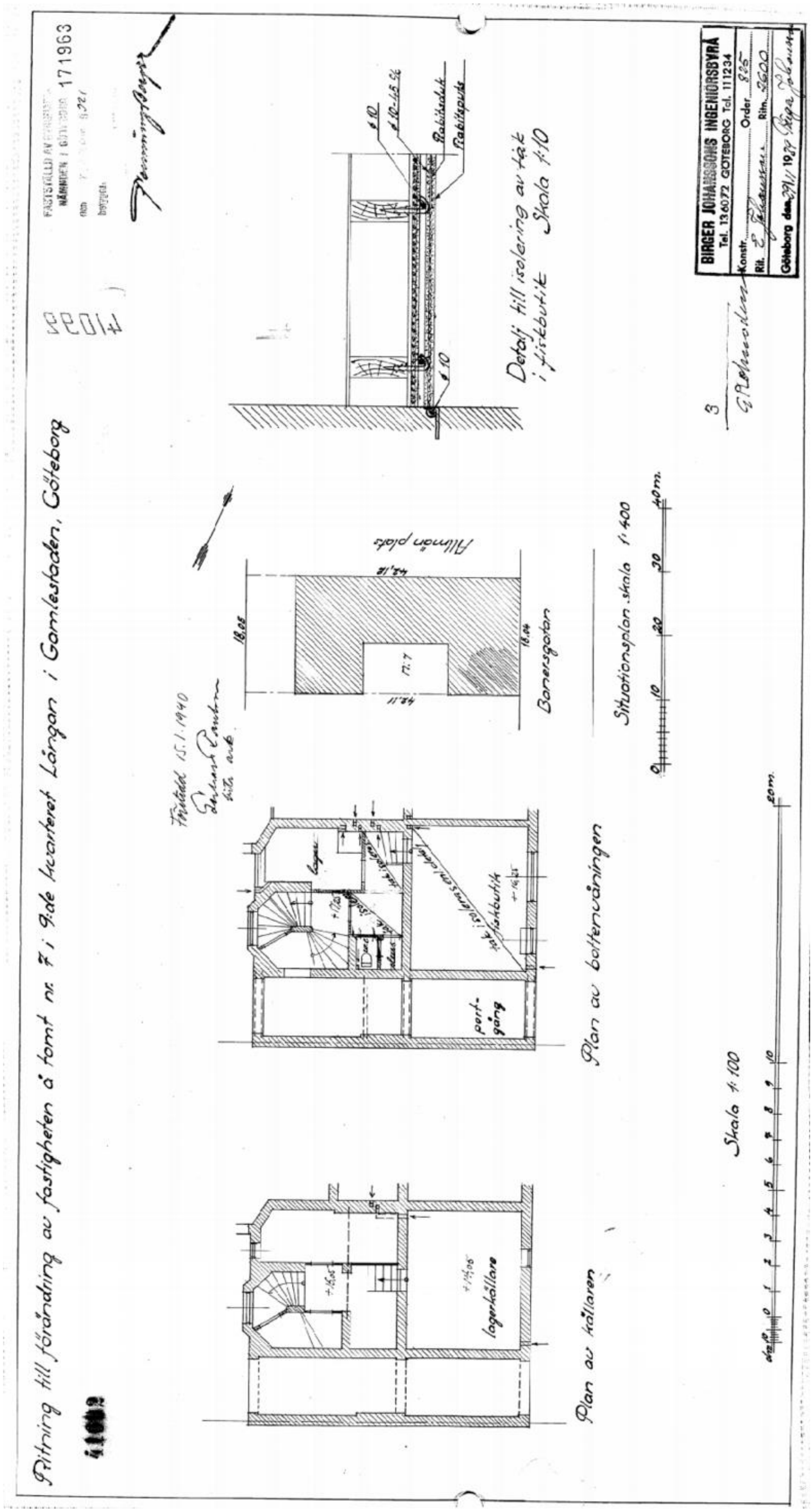

171961
RITNING TILL NYBYGGNAD Å TOMT N:o 7 I 9:de KV. LÅNGAN I GAMLESTADEN.
20/9 1939. § 2258
KOPIA
SEKTIONER. SKALA 1:50
DÄR AVLOPPSLEDN. KORSAR GRUNDPLATTA SÅ SKALL DENNA GJUTAS HELT UNDER LEDNINGEN ENL. NEDAN VISADE DETALJ
BETONGBL. 1:5:7
GRUNDPLATTANS U.K. MINST 140CM. UNDER FASTSTÄLD GATUHÖJD. OCH NER TILL PINNMO.
PÅLARNES TOPPDIAMETER MINST 6" NEDSLAS TILL FAST BOTTEN.
PÅLAVSKÄRNINGEN MINST 180CM UNDER FASTSTÄLD GATUHÖJD.


Ritn. till förändring av nybyggnad å tomt nr 7 i 9de kv. Längan i Gamlestaden.
171962
25615
Situationsplan.
Plan av 1ste våningen
Plan av 2a våningen
Plan av 3e våningen


Hus å tom/Nr 7:9 Kv Långan i Gamlestaden.
Tallenledning.
№ 174:8.
171966
Granskad för anmärkning
Situationsplan.
Nr 8
Nr 7
Bangatan
Tvättkök
Lager
Källare
Bangatan
Rörschema.
Fastebrev den 5/10 -9
John Bordeaux & Co.


Hus å tomt Nr 7 i 9 te Längan i Gamlestaden.
Avloppsledning.
Kopia.
1/2 9345
Källare
Benärsgatan
1 tr
2 tra och 3 dje vån.
Situationsplan
Gothenburg


Ritning till förändring i fastigheten å tomt nr. 7 i 9de Kv. Långan Gamlestaden
171964
45446
2/86
Omändring för sotareverkstad
Lager
Tvätt-rum
Durch.
Golo giutes med fall åt golvbrunn
WC
G
Avklädning
Butik
Redskap
nr. 7
Banersgatan 6
Huv. bottenvåning
Bliv. bottenvåning
0
10
20 m
5
15 m
Göteborg den 30/7 1943
Algot Wenner
Tel. 164536


Ritning till förändring av fastigheten å tomt nr. 7 i 9:de kvarteret Längan i Gamlestaden, Göteborg
171963
41098
Plan av källaren
lagerkällare
Plan av bottenvåningen
port-gång
fiskbutik
Skala 1:100
Situationsplan skala 1:400
Allmän plats
Banérsgatan
Detalj till isolering av tak i fiskbutik Skala 1:10
Rabitzduk
Rabitzputs
BIRGER JOHANSSONS INGENIÖRSBYRÅ
Tel. 13 60 72 GÖTEBORG Tel. 111234

INTYG
FUNKTIONSKONTROLL
Ventilationssystem (enligt SFS 1991:1273, 1994:1216)

GÖSAB
Ventilations AB
Jons väg 19
433 75 JONSERED
031-847575

Göteborgs Stad
Fastighetskontoret
Box 2258
403 14 GÖTEBORG
2010-07-05

Beteckning (kvarter/fastighetsnummer etc)		Adress
Gamlestaden 740:117		Banérsgatan 6
Byggnadsår	Ombyggnadsår	Använd som
		Lägenheter

☐ Ventilationssystemets funktion är godtagbar t.o.m

☒ Ventilationssystemets funktion är ej godtagbar med hänsyn till brister och fel.

Brister och fel ska vara avhjälpta senast 2010-11-24

Besiktningsdatum	Nästa besiktning	Besiktningsman	Behörighet
2010-05-24	2010-11-24	Jonas Hjärne	K-Riks 1856

Underskrift: Jonas Hjärne

FUNKTIONSKONTROLL
Ventilationssystem (enligt SFS 1991:1273, 1994:1216)

2010-07-05

Datum	Diarienummer
2010-05-26	2388.800 - 109443

Anmärkningar

Pos	0 = Utan anmärkning 1 = Bör åtgärdas 2 = Åtgärdas	Bedömning
1.1	Imkanal kök: Balk mitt i kanal. 6B 1 vån höger.	2
1.12	Badrum: Badrumskanal plomberad. 6C 2 vån vänster.	2
1.19	Vardagsrum:De flesta utsug ioensatta genomgående hela huset.	2
2.1	Yttervägg: Många intag gensatta, genomgående hela huset.	2
6.1	Okulärkontroll: Murfogar kraftigt urgröpta. Läckage finns.	2
7.1	Luktöverföring: Många klagar på rök och matos från grannar.	2

1824042

FUNKTIONSKONTROLL
Ventilationssystem självdrag (enligt SFS 1991:1273, 1994:1216)

Datum	Diarienummer
2010-05-26	2388.800 - 109443

GÖSAB
Ventilations AB
Jons väg 19
433 75 JONSERED
031-847575

Göteborgs Stad
Fastighetskontoret
Box 2258
403 14 GÖTEBORG
2010-07-05

Fastighet mm

Beteckning (kvarter/fastighetsnummer etc)		Adress
Gamlestaden 740:117		Banérsgatan 6
Driftansvarig	Telefon	Byggnadsår / Ombyggnadsår
Ärende		
Lägenheter		

	0 = Utan anmärkning	1 = Bör åtgärdas	2 = Åtgärdas					
1.0	FRÅNLUFTSKANAL				3.1	Spisfläkt	0	
1.1	Imkanal kök			2	3.11	Våtrumsfläkt typ Pax	0	
1.11	Imkanal pentry	0			3.12	Våtrumsfläkt	0	
1.12	Badrum			2	3.13	Kanalfläkt	0	
1.13	Dusch	0			3.14	Fläkt	0	
1.14	WC			2	4.0	ÖVERLUFT		
1.19	Sovrum 1	0			4.1	Badrum	0	
1.16	Sovrum 2	0			4.11	Duschrum	0	
1.17	Sovrum 3	0			4.12	WC rum	0	
1.18	Sovrum 4	0			6.0	KANAL TÄTHET		
1.19	Vardagsrum			2	6.1	Okulärkontroll		1
1.2	Tvättstuga	0			6.11	Rökstryckpovning	0	
1.21	Soprum	0			7.0	BRUKARSYNPUNKTER		
1.22	Garage	0			7.1	Luktöverföring		2
2.0	UTELUFTSKANAL				7.12	Fukt/mögel	0	
2.1	Yttervägg			2				
2.11	skatten	0						
2.12	Kök	0						
2.13	Badrum	0						
2.14	Duschrum	0						
2.15	Annat Våtrum	0						
2.16	Sovrum 1	0						
2.17	Sovrum 2	0						
2.18	Sovrum 3	0						
2.19	Sovrum 4	0						
2.2	Vardagsrum	0						
2.21	Tvättstuga	0						
2.22	Soprum	0						
2.23	Garage	0						
3.0	FLÄKTAR							

Besiktningsdatum	Besiktningsman	Behörighet
2010-05-24	Jonas Hjärne	K-Riks 1856
☐ Godtagbar	Nästa besiktning senast	Påbörjande besiktning
☒ Ej godtagbar	2010-11-24	
Tekniker		Underskrift
Jonas Hjärne		Jonas Hjärne

Appendix G – Invitation for interview with tenants

Vi vill lära känna dig! Vilka förbättringar vill du ha i denna byggnad?

Vi heter Elisabeth och Maria Julia, vi är Stadsplanerare och studerar Projektledning inom byggindustrin vid Chalmers Tekniska Högskola. I vårt examensarbete kommer vi att utveckla ett koncept för renovering av denna byggnad tillsammans med Fastighetskontoret. Vi vill lära känna just dig, den viktigaste användaren av denna byggnad. **Vi vill höra vad du vill** och att ta en titt inne i byggnaden. Om projektet blir verklighet är fortfarande okänt, men vi vill föreslå vad som är **bäst för dig**, staden och miljön.
Låt oss veta när vi kan komma att besöka dig och ställa några frågor. Det tar inte mer än 30 minuter. Ju tidigare desto bättre. Vi vill gärna träffa dig **senast 29 februari**. Vi kommer också att vara öppen för andra möten under utvecklingsprocessen, för att visa vad vi skapar för dig och byggnaden.

För det första besöket, skicka ett e-post eller sms och uppge ditt namn, ditt lägenhetsnummer och ett datum som passar för dig.

bober@student.chalmers.se
mariaju@student.chalmers.se

Med vänliga hälsningar
Elisabeth and Maria Julia


Appendix H – Invitation for the workshop with tenants

Banérsgatan 6 Workshop
Renoverings Koncept

Hej!

Vi har äntligen blivit klara med första fasen av vårt projekt och vill tacka alla som har öppnat sina dörrar för oss och delat med sig av sina tankar om boendemiljön. Eftersom vi har fått så många frågor och inbjudningar har vi tyvärr inte kunnat svara eller komma till er alla. Men vi har tagit upp de idéerna med Fastighetskontoret och de har visat stort intresse.

Nu: Vi skulle vilja bjuda in er till den andra fasen, en workshop.

Tillsammans vill vi diskutera med er, Fastighetskontoret och andra hyresgäster, under 2 timmar, hur framtiden i huset på Banèrsgatan 6 ser ut och hur ett koncept för renovering skulle kunna se ut.
Workshopen kommer att hållas på engelska och svenska. Vi kommer att erbjuda fika.
Vi vill att du tar med, om möjligt, en elräkning så att vi får användning och kostnadsinformation för framtida beräkningar.

Var?
Gamlestadens Medborgarhus
Brahegatan 11a
A-Salen

När?
Måndag den 2 Maj, kl 17.30

Vi ser fram emot att träffa er!
Låt oss veta om ni har möjlighet att komma senast 1 vecka innan.

Med vänliga hälsningar
Elisabeth
bober@student.chalmers.se
Maria
mariaju@student.chalmers.se

Appendix I – Banérsgatan 6 Economic Information

Table: Economic information in 2015 (Adapted by the authors, provided by Fastighetskontoret).

GROSS INCOME	**583000 SEK**
COSTS (MAINTENANCE + OPERATION + TAXES)	-437000 SEK
DEPRECIATION (*AVSKRIVNINGAR*)	-69000 SEK
NET INCOME (INCOME – COSTS)	77000 SEK
DECLARED CONTRIBUTIONS (*NÄMNDBIDRAG*)	-264000 SEK
INTEREST (RÄNTEKOSTNADER)	-46000 SEK
RESULT	-233000 SEK (what the building costs for the owner)

Appendix J – Banérsgatan 6 Energy Consumption

Apartment 1: 30 sqm
January 2016: 719 kWh ≈ 23 kWh/day (31 days)
February 2016 : 604 kWh ≈ 21 kWh/day (28 days)
Average during all months of the year: (23+11,5) ÷ 2 = 17,25 kWh/day
17,25 kWh x 365 days = 6296 kWh/year
6296 kWh/year ÷ 30 sqm ≈ **210 kWh/year/sqm**
Energy consumption is **280% higher** than asked by Boverket*
*Maximum energy that new and renovated residential buildings (with electric heating, in climate zone 2, middle Sweden) must use in one year is 75 kWh/year/sqm (Boverket, 2013).
Price: according to the tenant's bill, the price paid for kWh, including taxes is 70,45 öre + 240 SEK per year of service.
240 SEK + (6296 kWh x 70,45 öre) = 4432 SEK/year
Price of rent (energy not included): 1400 SEK
Electricity is ≈ 27% of the rent's value.

Apartment 2: 60 sqm
February 2016: 1170 kWh ≈ 42 kWh/day (28 days)
March 2016: 828 kWh ≈ 26 kWh/day (31 days)
Average during all months of the year: (42+(42/2)) ÷ 2 = 31,5 kWh/day
31,5 kWh x 365 days = 11497 kWh/year
11497 kWh/year ÷ 60 sqm ≈ **192 kWh/year/sqm**
Energy consumption is **256% higher** than asked by Boverket*
*Maximum energy that new and renovated residential buildings (with electric heating, in climate zone 2, middle Sweden) must use in one year is 75 kWh/year/sqm (Boverket, 2013).
Price: according to the tenant's bill, the price paid for kWh, including taxes is 60 öre + 240 SEK per year of service.
240 SEK + (11497 kWh x 60 öre) = 6900 SEK/year
Price of rent (energy not included): 2400 SEK
Electricity is ≈ 24% of the rent's value.