Challenges in Open Innovation

A case study of Positive Footprint Housing

Master's thesis in the Master´s Programme Design and Construction Project Management

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ABSTRACT

In order to be able to meet the demands of a growing population, organizations must review their ways of working if they are to prevent increased climate change and the depletion of natural resources. Thus, to account for the need of sustainable development, organizations must foster innovative solutions and find new ways to operate. By using the approach of open innovation, and thereby go beyond the organization's own boundaries, organizations can obtain external resources to stay competitive and innovative.

This thesis aims to contribute to the literature on open innovation by investigating the approach in a new context - the Positive Footprint Housing context (PFH). PFH is a cross-sectional research platform between academia and industry, with the purpose to generate new and more sustainable ways of designing housing projects. The platform's outputs are currently being realized in three housing projects, which thereby function as full-scale laboratories for implementing sustainable housing. In particular, the study aims at identifying and analyzing the challenges the PFH platform has encountered, from a management point of view. To be able to achieve the purpose of the study, an inductive and qualitative research strategy have been used, and data collection has been made through interviews, observations and documents. Furthermore, a literature review was undertaken in order to form a theoretical framework related to the research problem, which was used to support and enhance the analysis.

The findings of the study show that the greatest challenges from a management point of view in the PFH platform are concerned with how to lead and organize a group with various actors involved, coming from widely spread organizations and having different goals and ways of working. Moreover, the literature shows that specific context characteristics have an impact on open innovation collaborations. In the construction industry, the high complexity as well as the high variety of actors, constitute as factors that bring difficulties for innovation in the industry. The analysis shows that the PFH platform have been a successful project in the sense that it has been a functional collaboration that have resulted in several sustainability-oriented solutions. Although it can be hard working with open innovation due to the variety of the actors involved, the PFH collaboration seems to have benefited the members of the group. It seems as there are some factors that function as enablers for the platform, namely innovation broker, management engagement, demonstration projects etc., which therefore could be considered to be critical for the future of the PFH platform.

The findings of this thesis could contribute to the literature on open innovation by filling the gap of case studies on open innovation within the construction industry, in the context of sustainability, and thereby provide new insights of how innovative and sustainable solutions can be implemented in a construction project.

Key words: Open innovation, Construction Industry, Sustainable innovation, Project management, Innovation broker

Utmaningar med Öppen Innovation
En studie om Positive Footprint Housing

Examensarbete inom masterprogrammet Design and Construction Project Management

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SAMMANFATTNING

För att kunna möta kraven från en växande befolkning, och samtidigt förhindra klimatförändring och utarmning av naturens resurser, måste organisationer granska sina arbetssätt. Således, för att ta hänsyn till behovet av en hållbar utveckling måste organisationer främja innovativa lösningar och hitta nya sätt att arbeta på. Genom att använda sig av tillvägagångssättet öppen innovation och därmed gå utöver organisationens egna gränser, kan organisationer erhålla externa resurser för att vara konkurrenskraftiga och innovativa.

Denna avhandling syftar till att bidra till litteraturen inom öppen innovation genom att undersöka tillvägagångssättet i en ny kontext - Positive Footprint Housing (PFH) kontexten. PFH är en tvärvetenskaplig forskningsplattform mellan akademi och industri, med målet att skapa nya och mer hållbara sätt att utforma bostadsprojekt. Plattformens utfall förverkligas för närvarande i tre bostadsprojekt, vilka därmed fungerar som fullskaliga laboratorier för genomförandet av hållbara bostäder. I synnerhet syftar studien till att identifiera och analysera de utmaningar som PFH plattformen möter, ur ledningssynpunkt. För att uppnå syftet med studien, har en induktiv och kvalitativ forskningsstrategi använts, och datainsamling har gjorts genom intervjuer, observationer och dokument. Vidare genomfördes en litteraturstudie för att bilda ett teoretiskt ramverk relaterat till forskningsproblemet, vilken användes för att stödja och förbättra analysen.

Resultatet av studien visar att de största utmaningarna, ur ledningssynpunkt, i PFH plattformen är att hantera och organisera en grupp med olika aktörer involverade, som kommer från brett spridda organisationer och har olika mål och sätt att arbeta. Dessutom visar litteraturen att specifika kontextegenskaper påverkar öppna innovationssamarbeten. I byggbranschen är den höga komplexiteten och den stora variationen av aktörer faktorer som leder till svårigheter för innovation inom industrin. Analysen visar att PFH plattformen har varit ett framgångsrikt projekt i den meningen att det har varit ett fungerande samarbete som har resulterat i flera hållbarhetsinriktade lösningar. Även om det kan vara svårt att arbeta med öppen innovation med alla berörda aktörer, verkar PFH samarbetet ha gynnat gruppens medlemmar. Det verkar som det finns några faktorer som fungerar som möjliggörare för plattformen, nämligen innovationsmäklare, ledningsengagemang, demonstrationsprojekt etc., och kan därför anses kritiska för PFH plattformens framtid.

Resultaten av denna avhandling kan bidra till litteraturen om öppen innovation genom att fylla klyftan av fallstudier om öppen innovation inom byggbranschen, inom ramen för hållbarhet, och därigenom ge nya insikter om hur innovativ hållbarhet kan genomföras i ett byggprojekt.

Nyckelord: Öppen innovation, Byggbranschen, Hållbar innovation, Projektledning, Innovationsmäklare

Contents

Preface

This Master of Science thesis covers 30 credits and has been conducted during the spring of 2018 as the final part of the master program Design and Construction Project Management at Chalmers University of Technology in Gothenburg, Sweden. The thesis has been made jointly by the authors, which have been equally involved in all parts of the thesis.

Taking part of the PFH platform has been an extremely exciting and educational work in which we have had the opportunity to weave together much of the knowledge we gained during the master program. We would like to thank our PFH contact Peter Selberg at Johanneberg Science Park for supporting us with guidance and contacts throughout the project and letting us be a part of PFH during the spring. Moreover, we also wish to thank the participants in Positive Footprint Housing group for interesting discussions and thereby giving us valuable insights and ideas. Finally, we would like to thank our examiner and supervisor Martine Buser at Chalmers University of Technology for her permanent support and encouragement. Thank you for your always valuable advice.

Olivia Nilsson & Lina Royson

Gothenburg, June, 2018

List of Figures, Tables and Notations

List of Notations:
JSP   Johanneberg Science Park
PFH   Positive Footprint Housing

Dictionary

Accommodation	Boende
Apartment	Lägenhet
Boom	Högkonjunktur
Bust	Lågkonjunktur
Case study	Fallstudie
Condominium	Bostadsrätt
Cooperative housing association	Bostadsrättsförening
Cooperative tenancies	Kooperativa hyresrätter
Design	Projektering
Designer	Projektör
Industry	Bransch
Real estate company	Bostadsbolag
Recession	Lågkonjunktur
Residential unit	Bostad
Specifications	Förfrågningsunderlag
Tenancy	Hyresrätt
Tenant	Hyresgäst
Tender	Anbud
Upfront	Insats

1. Introduction

In this chapter, the reader will be given a background for the study of the open innovation platform, Positive Footprint Housing. Furthermore, the study's purpose and research questions are presented. The chapter concludes with a brief description of the delimitations made, as well as with a thesis outline.

1.1 Background

The world is facing a growing population, increasing industrial production and a rising consumption (Melander, 2017). Challenges such as depletion of natural resources and the critical issues of the climate change have caused a new demand for sustainable development. This has influenced firms to develop new innovative sustainable solutions by require external knowledge beyond the firm's boundaries (Goodman, Korsunova & Halme, 2017). Besides this, growing complexity of technologies and changing requirements of consumers, firms have to obtain external resources for innovation activities in order to stay competitive. Because of global professional mobility, the traditional innovation model has become an outdated strategy in our current era and evolved from closed independent innovation to open innovation (Chan, Chen, Hung, Tsai and Chen, 2017). Open innovation emphasizes the fact that valuable ideas can arise from both internal and external resources of the firm. The approach stresses the importance of firms collaborating with other organizations and acquiring external knowledge and ideas, in order to stay innovative (Chesbrough, Vanhaverbeke & West, 2006). The concept is today widely used in academia, business and policy making (Bogers, Chesbrough & Moedas, 2018).

Even though this research area is gaining more attention there is currently a gap in the existing research about open innovation approach in the construction industry. Therefore, this thesis aims to investigate this topic further by studying an innovation platform called Positive Footprint Housing. Positive Footprint Housing started in 2011 and is a cross-sectional research platform between academia and industry. Riksbyggen, a large cooperative real estate developer, is the initiator and main stakeholder of the platform and collaborative stakeholders are Johanneberg Science Park, Chalmers University of Technology and University of Gothenburg to mention a few. The purpose behind the platform is to generate new, more sustainable ways of designing housing at the international leading edge of innovation, supporting a joint transdisciplinary knowledge project between academia and industry. The sustainable ways comprise the three fundamentals of sustainability; social, environmental and economic sustainability. The project's outcomes are currently realized in three housing projects, Brf Viva, Bfr Slå Rot and Lindholmshamnen, which constitutes as full-scale laboratories for implementing sustainable housing.

This thesis will describe and reflect upon experiences from taking part in the PFH platform, with focus on the management perspective and the sustainability outcomes. The study aims to fill the gap of literature and by, introduce the PFH platform, also present how one can work with innovative sustainability in the construction industry.

1.2 Purpose and Research Questions

The purpose of this thesis is to contribute to the literature on open innovation by investigate the approach in a new context - the Positive Footprint Housing context. Hopefully, the findings will provide new insights of implementation of open innovation in a construction project with high sustainable objectives, as Positive Footprint Housing is. Moreover, the study aims at identifying and analyzing the challenges the Positive Footprint Housing platform encounters from a management point of view. Based on the background and the purpose of the research, one main question and three sub-questions have been formulated, which follows:

- What are the challenges, from a management point of view, of the open innovation platform Positive Footprint Housing?

  - *What is Positive Footprint Housing?*

  - *What are the challenges of sustainable open innovation in the construction sector according to the literature?*

  - *According to the literature, how can Positive Footprint Housing continue to work as an open innovation platform?*

1.3 Delimitations

The master thesis will consider one single case study, namely the open innovation platform PFH, which means that the results of the study can consequently not be generalized on the construction industry as a whole. Similar apply to the challenges being studied, as the majority of the empirical data will be collected from individuals in the management of PFH, no general picture from the actors will be obtained but rather a management's point of view. More specific, focus will lay in challenges that can arise in the meeting of the PFH, and only some in the activities around. The choice of mainly interviewing managers of PFH is based on the fact that they are the ones who most closely monitor the platform, who have implemented it, manages it, as well as has to deal with the challenges that arise in the platform, between actors, regarding project selection and so forth. It is therefore likely, that these people can provide the best information regarding the PFH platform, how the projects and meetings work, what challenges and difficulties that have existed, and exists, in the group - as well as those who are able to actively make improvements within the project. Furthermore, PFH is a very extensive project with many various outcomes. Therefore, the authors have chosen to delimitate the scope by focusing on how the process have been managed rather than the outputs. However, the different outcomes such as sub-projects have been used to strengthen the empirical part.

1.4 Thesis Outline

The structure of the thesis is aligned with the master thesis directions at Chalmers University of Technology. The structure that have been used can be seen in Table 1 below, followed by a brief description of each chapter's content.

Table 1   Thesis outline.

Chapter 1:	Introduction
Chapter 2:	Methodology
Chapter 3:	Theoretical Framework
Chapter 4:	Empirical Findings
Chapter 5:	Analysis and Discussion
Chapter 6:	Conclusion and Recommendations

Chapter 1: This chapter constitutes of an introduction of the study, in which one can read about the background to the study, its purpose and objective, as well as the delimitations made.

Chapter 2: The methodology used in the study is described in this chapter. The research strategy, research design as well as the research methods and processes used are described in great detail. At the end of the chapter the research quality is discussed based on the three criteria´s reliability, replicability and validity. Lastly, some ethical considerations are considered.

Chapter 3: In this chapter the theoretical framework is presented, which was realized through data collected via books and scientific articles. The focus of the theoretical framework is mainly on the area of open innovation and how it can be implemented in the construction industry with high level of sustainable factors.

Chapter 4: The results of the empirical findings are presented in this chapter, in which the data is based on interviews, internal documents, as well as observations of meetings within the PFH platform. The focus is on the PFH platform, its origin, participants, projects, as well as challenges the group have encountered over the years.

Chapter 5: In this chapter the authors make an analysis and discussion of the empirical material and whether it relates to the theoretical framework, combined with own reflections of the study.

Chapter 6: This chapter presents the main conclusions that can be drawn from the study, as well as recommendations for future researchers within the subject.

At the end of the thesis, a list of the references used have been added as well as some appendices to give additional information about some parts of the study.

2. Methodology

In this chapter, the methodology of which the master thesis is built upon is described in detail. Through a systematic description of how the research was conducted, the idea is that the reader should be able to reproduce the master thesis with this chapter as a guideline. The chapter starts by introducing the research strategy, followed by the research design. Furthermore, the research methods and process are presented, including data collection, data analysis and a literature research. Finally, a discussion of the chosen methodology and some ethical considerations are provided.

2.1 Research Strategy

When talking about the relationship between theory and practice, one often refers to deductive and inductive research strategy (Bryman & Bell, 2011). In this study, an inductive research strategy has been used. Unlike a deductive research strategy, where the researcher deduces a hypothesis based on known theory, that later must be subjected to empirical review, the inductive research strategy works the other way around. In an inductive research it is not the theory and the deduced hypothesis that drives the process of collecting empirical data, rather it is the collection and analysis of empirical data that drives the theory research, see Figure 1 below. The empirical data may consist of analysis of focus groups, interviews or similar, used to develop a theoretical understanding of the subject being studied. In this study an inductive research strategy has been chosen since it fits nicely with the authors' process of first collecting empirical data, to later strengthen with a theoretical framework. The process of this thesis started with an interest of the chosen case study, the PFH platform, in which the authors wanted to examine the platform and their way to work. Later, open innovation as theory was chosen, which makes the choice of using an inductive approach clear.
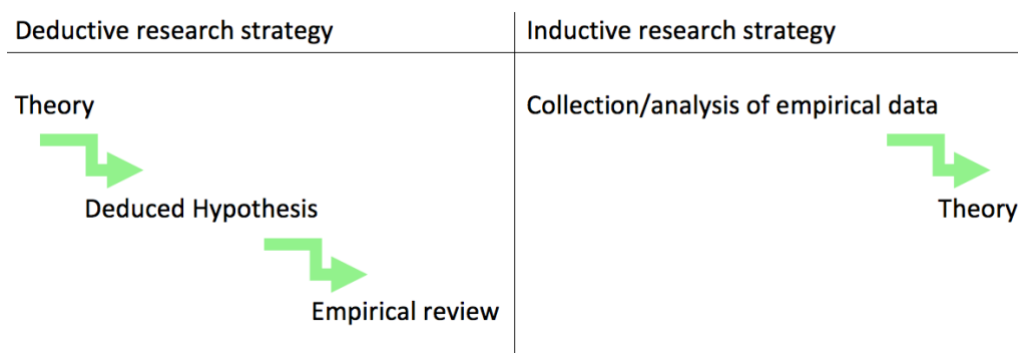
Figure 1   Deductive vs Inductive Research Strategy (Made by the authors).

In research strategy, one usually distinguishes between quantitative and qualitative research (Bryman & Bell, 2011), in which the latter one has been used in this study. The major difference between quantitative and qualitative research is that, within quantitative research researchers employ measurement while in qualitative research they do not. In quantitative research, emphasis is placed on quantification when collecting and analyzing data. Moreover, this type of research generally entails a deductive approach in the relationship between theory and research. Qualitative

research on the other hand, emphasizes words rather than quantification of numbers, and consequently entails an inductive approach in the relationship between theory and research. Ergo, in a quantitative research, the theory is driving a hypothesis, that in turn drives data collection and analysis. This, unlike a qualitative approach, in which the theory is rather the result of an empirical study.

In addition to an emphasis on words, qualitative studies have a participant's points of view (Bryman & Bell, 2011). This means that the researcher normally strives to have a close relationship with the participants, to be able to see the world with their eyes. Unlike quantitative studies, which gives a static picture of the social world, qualitative studies are process oriented and dynamic. Since they are adapted to how things change over time it means that the process is always open to new directions. Additionally, qualitative researchers do not strive to generalize. Instead they normally have a micro perspective, striving to get an understanding of the values and behaviors that take place among a certain group of people in a certain type of context. The researcher thus always tries to study the participants in their natural setting. Furthermore, the data in these kinds of studies are often considered as rich and deep as it has grown from long relationships with the participants. Unlike, quantitative studies which focus on people's behavior, qualitative studies focus on what this behavior holds - the meaning of the behavior.

The reason why a qualitative research strategy has been chosen, is first and foremost because it fits nicely with the process of the study (Bryman & Bell, 2011). The qualitative way of first doing an empirical study, to later base the literature research on, was suitable for this type of study, aiming at examining the open innovation platform Positive Footprint Housing. In order to understand how the participants within the group interact, how they collaborate and share knowledge it felt important to have a "participants point of view" and therefore the choice of a qualitative study. Furthermore, it was necessary to build some kind of relationship with the participants to be able to "see the world with their eyes" and to understand how they view and interpret things happening within the group. Beyond any doubt, a qualitative strategy was needed since the study of PFH is a dynamic and unstructured process, requiring the research to adapt to changes happening during the course of the study.

2.2 Research Design

Research design aims at explaining the framework(s) used when collecting and analyzing data, at a first glance research design can easily be confused with research method, see Chapter 2.3, although it is important to distinguish the two (Bryman & Bell, 2011). While research methods refer to the methods used when collecting data (i.e. observations, interviews etc.), research design refers to the structure that governs how the methods are used and how the data is being analyzed. Case study is a common example of a research design, often misunderstood as a research method. Doing a case study is not a method but rather a way of doing a detailed study of a certain group of people, organization or industry. Bryman and Bell (2011) points out the fact that by simply determining which research design to use, e.g. to do a case study of a certain organization, the study will not generate any data. Hence, studying the entire organization will not provide any answers. Therefore, it is necessary to decide which questions are important to answer, and whether to answer them by interviews, observations or any other methods.

One of the most popular and commonly used research designs is *Case study design*, which is also the research design used in this thesis (Bryman & Bell, 2011). Case study design involves studying one, or a few, cases of a phenomenon in detail (Given, 2008). A case can be anything from a single organization, a single location (workplace, office building, factory, production site), a person and/or a single event. However, the most common type of case is the one that associates with a geographical location, such as an organization or workplace (Bryman & Bell, 2011). What differences a case study from other research designs is that a case study focuses on a limited entity or situation, to see how just that entity or situation works in reality.

One of the fundamental issues regarding case study analysis is to determine which case(s) to study (Bryman & Bell, 2011) and whether to use a single case study or multiple case studies (Ellram, 1996). According to Bryman & Bell (2011) the choice of case study/studies should primarily be based on the ability to learn and one should therefore choose the case study/studies in which one think the learning will be the greatest. If one should study one or multiple cases depends on the goals of the research (Ellram, 1996). Multiple cases are either used to predict similar results or to show contrasting results among the cases. Such type of study often provides a richer theoretical framework compared to a single case study and consequently allow for a more generalizable result. A single case study on the other hand is appropriate when a very unique or extreme case is to be studied, when a case is used to test a well formulated hypothesis or when studying a case which have not existed before and/or reveals a whole new phenomenon. As mentioned earlier, this thesis constitutes of a single case study design for which the open innovation platform PFH have been chosen. PFH is a platform initiated by Riksbyggen in cooperation with Johanneberg Science Park, Chalmers University of Technology, University of Gothenburg, Göteborg Energi, City of Gothenburg, Research Institutes of Sweden (RISE) and many more (Riksbyggen 1, n.d.) The project's initial phase started in 2011, with the aim of finding new, more sustainable ways to build and take care of housing, see Figure 2 below, and has now grown into the three pilot housing projects: Brf Viva, Brf Slå Rot and Lindholmshamnen.

Figure 2   The Positive Footprint Housing Platform (Riksbyggen 1, n.d., Edited).

The authors knew early on that the main focus would be on the case study, and the case study only, since PFH is such a unique and different project. The case study was therefore determined early on in the process, along with the supervisor at Chalmers University of Technology. Of course, other case studies could have been chosen but since the authors had contact with people in the PFH project through their supervisor, the choice was easy. Furthermore, through their supervisor the authors got access to previous collected information which meant they did not had to start their research from scratch but could build on previous research and learn more. In addition, by choosing this case study, the authors were given the opportunity to attend meetings with the PFH group, which resulted in a better picture of the project and the actors involved. Not least, according to Bryman and Bell (2011), a single case study is the research design that conforms best to a qualitative method, as it allows for an extensive and detailed data collection (Bryman & Bell, 2011). Moreover, it provides the opportunity to use several different qualitative methods (observations, interviews etc.), which means the risk of being too reliant on a single method decreases.

2.3 Research Methods and Process

This section describes how the research has been carried out. As stated above, the researchers have used an inductive strategy in order to collect qualitative data, analyze it and develop a theoretical understanding, which have been compared to the case study. Multiple research methods have been conducted simultaneously to generate relevant data and to approach the research questions from different angles. In parallel to the data collection, a literature review has been conducted, which has been a part of an iterative process, see Figure 3 below for the different steps in the process.
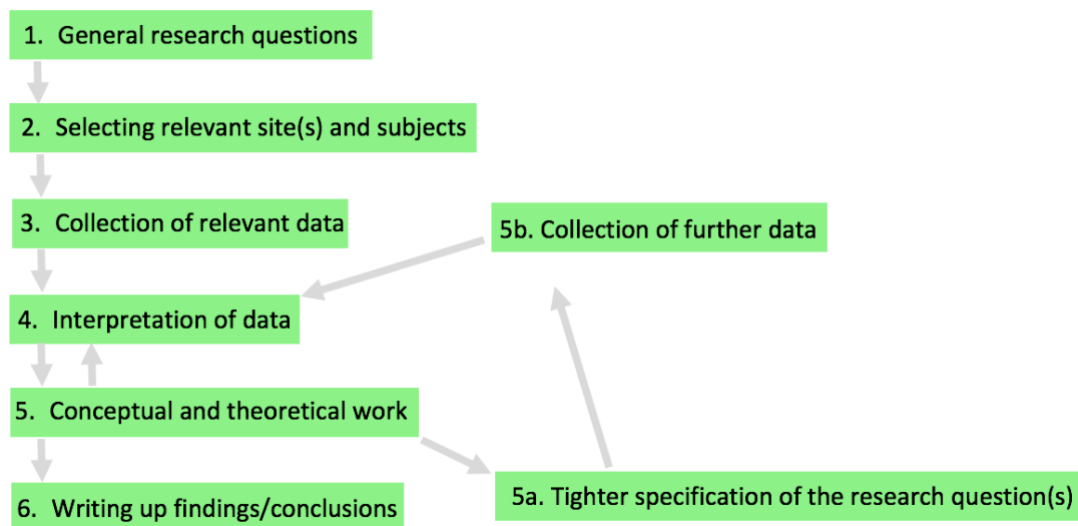

Figure 3   *Outline of the main steps of qualitative research (Bryman & Bell, 2011, p. 390, Edited).*

The figure shows the different steps in the process of writing the thesis, from the general research question to the conclusion of the thesis.

2.3.1 Data Collection

According to Given (2008), methods of obtaining data in qualitative research mainly involves a face-to-face communication between the researchers and the studied participants. In this thesis, the data collection consists of interviews and observations as qualitative research. In addition, information from both external and internal documents have been studied. The data collection process is further explained in the following sections.

In order to obtain qualitative empirical information, it was important to conduct semi-structured interviews. The semi-structured approach is adjustable and emphasizes on what the interviewee views as important in understanding of events, patterns, and forms of behavior (Bryman & Bell, 2011). When conducting the interviews, a range of questions of more or less specific topics was covered, but the interviewees had the possibility to be flexible in how to reply. According to Bryman and Bell (2011) this is a common way to conduct semi-structured interviews and implies that the interview may not follow exactly the layout that was determined prior to the interview. A total number of four interviews was made in order to collect all relevant data. The interviewees were chosen due to the individual's level of involvement in the PFH project, and thereby have the best insights of the process and the management. The interviews took place between February 7th and April 30th, 2018. All of the interviewees are involved in the cross-functional group and had been involved in the PFH project for different periods of time. Moreover, primary data from another researcher's semi-structured interviews have been accessed and then analyzed by the authors. Data from six interviews was collected and enabled the authors to collect more data in a shorter period of time. The data was exclusive and collected by a researcher with the purpose of studying the management issue in PFH. This means that the authors of this thesis were not involved in the collection of this data. In this case, the data collected from another research was in the form of records from the interviews, also called primary data, which means that it had not yet been analyzed by the researcher that collected the data.

A total number of ten interviews have been made, with seven individuals. The interviewees have dissimilar level of involvement and different roles, whereas one interviewee is the regional manager, two are project managers, one sustainability manager, one coordinator, one architect and one engineer. Four of the interviewees are from Riksbyggen, one from JSP, one from an engineering company and one from an architectural company.

In order to get an understanding of the PFH project and its context, participatory observations during PFH meetings with the cross-functional group were also performed. The term observation refers to a research method of obtaining data where the researchers immerses in a research setting to observe and perceive the dimensions in that specific setting (Mason, 2002). According to Bryman and Bell (2011) participatory observation refer to an observation where the observer is involved in the studied group for an extended period of time, observing both behavior and communication of the participants. There are different roles that the observer can adopt which are depending on the level of the researchers' involvement and detachment from the participants of the observation (Bryman & Bell, 2011). In this thesis, the level of the authors' engagement can be termed as *complete observers*. This mean that, during the observation, the authors did not interact with the group but only

observed the flow of events. The participants in the cross-functional group was aware of the authors and the purpose with the participatory observation.

During the interval of January 25th and May 16th, the authors attended a total number of four meetings with the cross-functional group. During the meeting, the authors gathered information by observing and collecting data, in type of field notes, that was of interest for the case study. This method of research was particularly useful in the beginning of the project and gave the authors a good insight of the organizational settings, culture and communication. The observation consequently entailed a better understanding of the case project and the context of which it was developed in.

In addition to the interviews and observations, and in order to study the project's earlier stage, exclusive documents from the case project was also studied. According to Mason (2002) analysis of documentary sources is a main method of qualitative research. In fact, many researchers see this as meaningful and appropriate in the context of their research strategy. Using this type of data alongside with other methods of data collection, information gathered from other methods can be confirmed or put into context. In fact, documents or visual data can provide access to situations or processes the researcher are not able to observe (Mason, 2002). In this case, this type of sources become useful to obtain data that have already occurred. For the purpose of this thesis, both visual and written texts are interesting in the process of how the project have developed the prior years until today. Therefore, documented information in form of former meeting notes, presentations and workshop materials have been considered. The majority of the obtained documents for this thesis are exclusive but some are official and have been published on the World Wide Web. The exclusive documents have been generated through a shared file which have been accessed by a majority of the actors in the cross-functional group.

2.3.2 Data Analysis

The inductive research strategy is usually iterative, which allow the researcher to weave back and forth between collecting empirical data and theoretical reflection (Bryman & Bell, 2011). Analysis of the thesis involved an iterative process of collecting data from previously mentioned sources, categorizing data, developing emerging ideas, relating them to theory, and selecting further empirical and theoretical data for developing the analysis. In this section, the analysis of the collected empirical data is described. The first step in analyzing the qualitative data from the interviews was to transcribe the recording files to text. In order to work efficient, the authors divided the transcribing-part. This was done to ease the analysis but also due to the fact that Bryman and Bell (2011) argue that transcribing interviews helps to counter allegations that an analysis might have been affected by the researcher's values or biases. The recorded data obtained from another researcher was also transcribed before the analysis. The transcribed data was later thematized and then divided into three categories - findings about (1) the process of PFH, (2) challenges of PFH and (3) the cross-functional group-processes. Furthermore, the data was placed in the context of relevant literature about open innovation in order to make a comparison between the theoretical framework and the empirical research.

2.3.3 Literature Review

A literature review was executed in order to form a theoretical frame related to the research problem and to support and enhance the analysis. According to Bryman and Bell (2011), a literature search is primarily based on the reading of books, journals, and reports. For this thesis, the literature research was realized through data collected via books and scientific articles. The primary focus was to study the concept of open innovation and how it can be implemented in the construction industry with focus on sustainable factors. Published literature was collected by searching in electronic databases such as Summon and Google Scholar.

2.4 Research Quality

Whether using a quantitative or qualitative study, the research design must be of high quality (Ellram, 1996). Within business and management research one usually measures the quality based on three criteria: *Reliability, Replicability* and *Validity* (Bryman & Bell, 2011). The three criteria will therefore be explained more thoroughly below, followed by a discussion regarding the choice of research strategy, research design and research method and process, as regards to their level of quality.

2.4.1 Reliability, Replicability and Validity

Reliability is about the degree of reliability, or consistency, of a test, measure or study (Bryman & Bell, 2011) and addresses the repeatability of that test (Ellram, 1996). In business research, high reliability is desirable, and means that the result of a test will be the same when repeated measures and regardless of who performs the test. *Replicability* is very close to reliability but is more about to which extent a study is replicable (Bryman & Bell, 2011). For a study to be replicable, the researcher must describe the test, measure or study procedure, in great detail, otherwise it will be hard for another researcher to replicate the process. Last but not least, *Validity* refers to the extent to which a test, measure or study measures what it is supposed to measure (also called measurement validity). However, it can also refer to the issue of causality (called internal validity) or the issue of whether the results from a study can be generalized outside the research context or not (called external validity).

Bryman and Bell (2011) states that although inductive studies tend to generate interesting and enlightening results, the theoretical meaning may not always be that clear, or there may even be a lack of theory. Further, they state that inductive studies often bring insightful generalizations. This is somehow a bit contradictory, as inductive studies often comes with a qualitative research strategy, which in turn is criticized for not being able to generalize.

Regarding qualitative studies there are many critics (Bryman & Bell, 2011). The most common criticism that quantitative researchers have on qualitative research strategy is that it is too subjective, that it is hard to replicate, that the findings generated are hard to generalize and that this type of research strategy often is insufficient in its transparency. Bryman and Bell (2011) mean that reliability is a difficult criterion to meet in qualitative research since a social setting is impossible to freeze, meaning one can never get exactly the same circumstances again, as in the original study. This study will probably be hard to repeat as the circumstances are so exceptional. The

PFH project is a very unique project and it will be impossible to find a project with exactly the same conditions to examine. Mason (2002) mean that a qualitative study can be rewarding, but also challenging in an intellectual, practical, social and ethical way. A researcher that collects and analyses qualitative data will continually make judgements during the research process. No matter how objective they try to be in their records, they will make assumption of what they have observed, heard or experienced, and interpret the data in their own way. In this study, the researchers have tried to be as objective as possible by leaving the results free from their own values and opinions. Moreover, they have tried to be as systematic as possible when collecting data. All data from the interviews was transcribed, in order to minimize the bias, although as Mason (2002) states, it is difficult to be fully objective when interpreting the data. The same goes for the observations, were the authors have tried to be free from own values and opinions. However, fully objective is hard to be as observations are always affected by the observers own interpretations.

When it comes to the choice of single case studies, the validity or generalizability is often questioned (Bryman & Bell, 2011). Bryman and Bell (2011) claim that single case studies come with the disadvantage of not being able to generalize, as the findings from a single case might not be representative for other cases. One should therefore not use single case studies if the purpose with the research is to generalize - but rather if the goal is to investigate a unique case and develop an understanding of its complexity. Ellram (1996) agrees and believes that case studies lack of generalizability is what the method is most often criticized for, and the validity is therefore something that needs to be addressed early on in the process (Ellram, 1996). Validity means that the test measures what it intends to measure, which brings generalizability of results. Therefore, lack of generalizability is best addressed by replicating case studies to be able to verify patterns. In order to get higher generalizability, multiple case studies could have been conducted for this thesis. However, since the time was short and more in-depth data was preferred, a single case study was chosen. Besides, a multiple case study would have led to more shallow data and weaker answers to the research questions.

2.4.2 Ethical Conduct

When doing research that involves people, i.e. by observations, interviews etc., ethical considerations must be taken into account (Saldana, 2011). Meaning, researchers cannot simply do what they want in order to achieve their intended goals, but there are some moral and legal codes that must be followed (Saldana, 2011). This master thesis will, like many others, be a subject-to-review and therefore the authors must act in such a way that none of the people involved come to harm or feel exposed in any way. The interviewees may provide private or in other way sensitive information through interviews, in meetings etc. and therefore, the authors must be careful about which information they spread, both in the thesis and elsewhere. According to Wiles (2013) the main principles of ethical conduct is voluntary informed consent, the confidentiality of information provided by participants, the anonymity of study participants and the avoidance of harm and researcher integrity. In this thesis the authors have relied on these principles by, making sure the audio-recording were approved by all the interviewees involved, as well as by making sure that no private or sensitive information about the Interviewees were omitted. In addition, all

interviewees have chosen to participate voluntary, and their names have been kept anonymous to not violate any ethical aspects.

Sustainability is another ethical dimension that is being addressed in this thesis. Becker (2011) mean that sustainability is an inherent ethical dimension which should be taken into greater consideration, as we have responsibilities and obligations towards future generations. With this thesis, the authors address sustainability issues, both as regard to open innovation as to the construction industry. They illustrate how the PFH platform, by working in an open innovation, has been able to come up with more sustainable ways to build and take care of housing. By highlighting this, the hope is that more people will be inspired to work in open innovation to come up with more innovative and sustainable solutions for the future.

3. Theoretical Framework

The following chapter includes theoretical findings from the literature review. The concept of open innovation is explained, as well as its relation to sustainability and the construction sector. Focus will be in challenges and enablers in open innovation, and further challenges and enablers that can affect the specific case study.

3.1 Open Innovation

The phrase open innovation was coined by Henry Chesbrough in 2003 (Chesbrough, Vanhaverbeke & West, 2006). Chesbrough is an Executive Director of the Centre of open innovation at Haas School of Business, University of California, Berkeley. His book *Open Innovation: The New Imperative for Creating and Profiting from Technology*, from 2003, has come to lie as a foundation for the research that accelerated as a result of him putting the subject on the map. Today, a search on the phrase *'open innovation'* in Google Scholar, generates more than three and a half million results and his books and articles on open innovation have been cited thousands of times (Google Scholar, March 2018). Although researchers like Huizingh (2011) argue that the foundation of open innovation has existed for a long time, and that the activities of using external knowledge and marketing methods have been implemented by many organizations over the years (Huizingh, 2011), it was Chesbrough that coined the expression and gave the phrase a definition (Chesbrough, Vanhaverbeke & West, 2006). In his book from 2006, open innovation is defined as:

> Open innovation is the use of purposive inflows and outflows of knowledge to accelerate internal innovation, and expand the markets for external use of innovation, respectively. Open innovation is a paradigm that assumes that firms can and should use external ideas as well as internal ideas, and internal and external paths to market, as they look to advance their technology (Chesbrough, Vanhaverbeke & West, 2006, p.1).

This definition has come to be one of the most frequently used on open innovation (Huizingh, 2011). It tells that open innovation is about how organizations, in their pursuit of competitive advantage, use both internal and external knowledge as well as internal and external methods to market their ideas (Chesbrough, Vanhaverbeke & West, 2006). Open innovation emphasizes the fact that valuable ideas can come from both inside and outside the organization and can reach the market by different paths. It stresses the importance of organizations collaborating with other organizations and acquiring external knowledge and ideas, in order to stay innovative.

Nonetheless, it has been a long time since Chesbrough coined the expression and gave it a first definition and a lot of things have happened since then (Chesbrough, 2017). Many books and articles have been written about the subject and the various researchers all describe the subject in their own way, which has led to some confusion. In order to embrace a new wider view of the subject, Chesbrough in 2017, with inspiration from his colleagues Dahlander and Gann, came up with a new definition of open innovation. In this new definition, he is taking pecuniary and non-pecuniary aspects into account, aspects that may be important to think of when dealing with open innovation. Chesbrough now define open innovation as "a distributed innovation process based on purposively managed knowledge flows across organizational boundaries, using pecuniary and non-pecuniary mechanisms in line

with the organization's business model" (Chesbrough, 2017, p. 30). In the definition Chesbrough describes that the innovation process should be based on "purposively managed" knowledge flows (Chesbrough, 2017). This means that the in- and outflows of knowledge should be well planned, unlike in unintended flows of knowledge, or spillovers, which unconsciously flows in and out the organization. In order to properly control the in- and outflows of knowledge and to avoid spillovers, it is of great importance to have a business model that is in line with the organization's core business. The business model should function as a basis when managing knowledge flows and handling important decisions. It aims at helping to figure out which knowledge is valuable, when to make use of external knowledge or disseminate internal knowledge as well as when the exchange will take place. Having the right business model is consequently a crucial part of the open innovation model.

3.2 Open Innovation Practice

Gassmann and Enkel (2004) calls for two key practices in open innovation, (1) *outside-in approach* and (2) *inside-out approach*. The outside-in refers to practices where a company acquire external ideas and technologies into their own innovation process, whilst inside-out refers to practices where a company export internal ideas and assets to the external environment. Both of the core processes represent an open innovation strategy and can differ in importance for different companies' innovation process. Each company generally chooses one primary core open innovation process but can also integrate elements from the other (Gassmann & Enkel, 2004). According to Gassman and Enkel (2004) a company that adopt outside-in approach as core open innovation strategy, invests in collaboration with suppliers and customers to integrate the obtained external knowledge. Besides the integration of customers and suppliers, this process can be accomplished by applying innovation across industries, acquiring intellectual property or investing in global knowledge creation. Chesbrough (2017) states that external knowledge can also be obtained from open-source software and outsourcing, but can also include cooperation with universities, research institutes or even non-profit organizations.

Integration of external actors can enable valuable sources of knowledge and capabilities that are required for product or project development. By letting suppliers contribute with their competence to innovate and develop new ideas, a company's product or project can be enhanced (Gassman & Enkel, 2004). Gassmann and Enkel (2004) claims that especially companies with products that are highly modular, benefits by having the outside-in process as key approach. Furthermore, companies with high knowledge intensity would also gain advantage by focus on outside-in processes, due to the need of knowledge which cannot be fulfilled by only using the internal knowledge. Furthermore, they found that it is mainly companies in low tech industries that choose to specialize in outside-in processes.

3.2.1 How to Manage Open Innovation in Practice

Wallin and von Krogh (2010) have developed a five-step model, see Figure 4, that managers can use to integrate knowledge in open innovation projects. The purpose of the model is to easily support managers in thinking more effectively when organizing open innovation projects. It is underpinned by the idea that management set the scope of innovation, by designing the organization in accordance to whether knowledge can

be find inside or outside of the company. Further below, the five different steps are explained in detail.
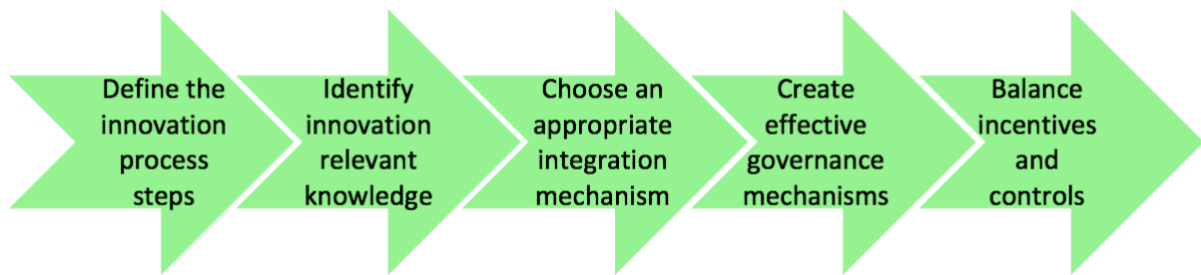
Figure 4   *Process model for integrating knowledge in open innovation (Wallin & von Krogh, 2010, p. 148, Edited).*

1) Define the innovation process steps
The process of moving from an initial idea to launching the innovation in the market requires specification of the different phases between, from the starting idea to the distribution of the product, and each phase contains a number of more distinct activities for which domain knowledge is needed. According to Wallin and von Krogh (2010), in the progress of the innovation process, it should be specified in detail what activities and tasks that needs to be performed and in what sequence. If the steps are not identified, issues caused by biases, legacy and political interests risk to form the innovation process negatively and affect its openness towards external knowledge.

2) Identify innovation-relevant knowledge
Wallin and von Krogh (2010) stated that domains, i.e. the areas of expertise that knowledge can be obtained from, should be identified, rather than identify individuals with capabilities that is known to the company. A starting point is to find where the best knowledge is located, to solve the tasks of the innovation process. Furthermore, collaboration, knowledge transfer or creation of new knowledge rely on non-technical factors such as a cooperative and positive climate, a mutual respect for expertise, a joint social practice and favorable governance.

3) Choose an appropriate integration mechanism'
Another factor for enabling an effective open innovation is to select a suitable integration mechanism. This by specifying how external and internal sources contribute to the innovation process. Wallin and von Krogh (2010) believe that most companies integrate external knowledge through one of four different types of mechanisms. Firstly, managers can formulate rules for integration. Secondly, integration can be done through sequencing of tasks where the phases of open innovation process are outlined ahead, based on when they occur along a timeline. The difference between rules and sequencing is that the first refer to an incident or situation that activates the need for acquiring outside knowledge, while sequencing is described in ahead of the innovation process. Thirdly, integration can be done through routines. For instance, patterns of behavior caused by tasks or problems that drive the organization to access external knowledge to solve them. The fourth mechanism is integration trough decision making and solving group problems, e.g. external sources not only contribute to solving pre-specified tasks but also contribute to defining the phases, tasks, issues, and processes of open innovation.

4) Create effective governance mechanisms
Wallin and von Krogh (2010) found that that governance is strongly related to the extent to which external organizations and individuals feel obligated to commit to open innovation. In an open innovation collaboration, both internal and external actors are involved, which means a number of difficulties related to governance of the projects results and assets may arise. Some issues to be dealt with is how to select participants, how are profits and losses distributed in the group and how to deal with conflicts. The responses to the questions depend on specific features of the open innovation. However, a manager of an open innovation group should make it easy for the external collaborators to be involved.

5) Balance incentives and controls
According to Wallin and von Krogh (2010), while benefits for firms engaging in open innovation is often highlighted in management literature, literature on rewards or incentives for external actors to contribute in open innovation is lacking, even though external knowledge is critical to the open innovation process. Organizations and individuals contribute to innovation by various of motivations, intrinsic like joy of achieving a task, or extrinsic like achieving the task for payment or improving career. Furthermore, as mentioned in previous part, Wallin and von Krogh (2010) points out that governance impacts on the motivation of the contributors. While a firm might want to control the work of external contributors by, for example, setting high requirements for quality and productivity, such actions might also weaken the external actor's motivation to commit for fun, learning, or recognition. Therefore, managers need to balance; between controlling the result and quality of the work of outside actors with giving enough incentives for actors to be involved in the open innovation process and for some to remain voluntarily (Wallin and von Krogh, 2010).

The incentives and structure of participants in open innovation process mean that these five steps of organizing for open innovation emerge to a cyclical process. The involved actors may change gradually and open up new possibilities for innovation, as well as the group will generate new ideas and add more knowledge, new requirements in market and so on. These changes cause managers to think through the steps of open innovation, identify relevant knowledge, choose integration mechanisms, change governance, and develop new incentives. Wallin and von Krogh, (2010) expect that, as companies experience these cycles, management learn to structure and lead open innovation projects more effectively.

3.2.2 The Importance of User Integration

According to Arnold (2017), open innovation is based on the requirements and co-creation activities of consumers and the consumers communities. The concept of user integration is described as, a method that, on a target basis, address co-creation approach that involves current and future users in the innovation process. This means that the user is involved from the starting idea, development process and to the last phase when the invention is implemented and diffused in the market. When users are involved in the innovation process, the possibility for a consumer's acceptance among broader segment of public increases, but also the awareness of the invention. Hence, the product may be more likely accepted and spread on the market. By using co-creation in the whole value chain, by integrating other stakeholders (for example

suppliers and consumers), negative social and environmental impacts can be minimized, and thereby sustainable development can be fostered.

3.3 Challenges and Enablers of Open Innovation

There are a range of challenges and constraints that limit firms' ability to make use of open innovation (Chesbrough, Verstegen, Biemans, Mulder & Omta, 2009). However, there are also enablers, that could, if used right, facilitate the open innovation process (Howells, 2006). According to van de Vrande, de Jong, Vanhaverbeke and de Rochemont (2009), each single open innovation project has its own specific difficulties and barriers to overcome. However, Du Chatenier et al. (2009) have discovered a variety of challenges that often arises in open innovation collaborations. If all challenges and enablers would be discussed, this thesis would be very long. Therefore, only the most important ones are selected and presented, based on what was found in the case study of PFH. The challenges and enablers discussed are based on various authors' articles within the field of open innovation, however with main focus on Du Chatenier et al. (2009).

3.3.1 Leadership

In an analysis made by Ollila and Yström (2015), it was found that, while both traditional internal innovation and open innovation have a high degree of uncertainty, sensemaking across organizational boundaries in open innovation increase the level of complexity. Therefore, when realizing open innovation, a different approach to leadership and organizing is required. Open innovation paradigm has entailed a shift in perspective on how innovation is managed and coordinated. Therefore, it is important to adopt new management strategies when working with innovation in discontinuous circumstances such as open innovation. Furthermore, to foster open innovation and to exploit the advantages that follows, coordination and management is central. A manager's capability to coordinate knowledge flows and relationships between the involved actors is crucial for successful collaboration in open innovation.

Du Chatenier et al. (2009) identify leadership as one of the key challenges in open innovation teams as it has been found that there is a close relationship between leadership style and innovation outcome. With leadership style the researchers refer to the way in which teams are managed, coordinated, and how responsibilities are shared within the team. Chesbrough (2017) agrees on the fact that leadership is a crucial factor in open innovation and states that top management support seems to be a boundary condition for open innovation to be successfully implemented. Furthermore, Chan et al. (2017) have studied the influence of open innovation archetypes and team managers' innovation characteristics, on team performance. Their study showed that leadership style, as well as leadership characteristics, are of great importance for open innovation projects. However, their study also showed that in most research the crucial role of the leader in integrating resources and connecting creative ideas in an open innovation project is being overlooked. Therefore, leadership style need to be addressed when implementing and leading open innovation. Du Chatenier et al. (2009) mean that a subtle leadership is preferable, as too little management and control tend to lead to untapped potentials and reduced productivity while too much management tend to lead to reduced creativity. The challenge is therefore having a

subtle leadership in which there is a balance between controlling and coordinating the actors involved.

Ollila & Yström (2015) embrace the fact that an open innovation process is not self-organizing and therefore there is a need for management for a successful collaboration. There is a need for a manager that can organize the complex social processes that exists in an open innovation with lots of actors involved. Furthermore, the manager need to have interpersonal and relational skills to be able to manage all challenges existing in an open innovation, not least to acquire trust and respect from the actors involved.

Facilitate Open Innovation Process by Innovation Broker
Not too seldom one often witnesses new types of actors emerging as a result of adopting open innovation practices (Petroni, Venturini & Verbano, 2012). The process of establishing partnerships in open innovations can be both a fundamental and a time-consuming issue, leading to the fact that many firms question if they should do the work themselves. Therefore, it is proposed for firms to have an innovation broker or intermediary, which organizes the network and builds trust between the networking members (Huizingh, 2011).

The actors emerging in open innovation practices are variously described as innovation brokers, integration experts (Petroni, Venturini & Verbano, 2012), third parties, intermediaries, bridges or change agents (Howells, 2006), although all are involving in supporting the innovation process. The innovation broker´s (as the role will be called from now on) main task is to ease the innovation process (Petroni, Venturini & Verbano, 2012) and the knowledge and technology transfer across people, organizations and industries (Howells, 2006). They therefore need to have the ability and knowledge to effectively acquire external knowledge and make it useful in new processes or products (Petroni, Venturini & Verbano, 2012). They must have a technical/scientific background as well as a thorough understanding of the organization and its strategies and challenges, enabling them to integrate technical/scientific knowledge that is in line with the managerial requirements. That is, the innovation brokers must be able to integrate technological knowledge, management systems and people. The innovation brokers are often found in intermediary organizations, bridging institutions or innovation communities (Howells, 2006). In these kinds of firms or communities, the intermediaries work to convey knowledge and adapt solutions to the market, as well as helping in developing and improving relationships in networks working with open innovation. They can also work to ease the dissemination of information to substructure firms, i.e. those firms producing the innovation from the first place.

3.3.2   Team Diversity

According to Chan et al. (2017) an open innovation group normally involves people from different disciplines that have different professional backgrounds. However, not all external collaborations, where members from different organizations collaborate, result in successful projects (Du Chatenier et al., 2009). In many cases, it might just be the fact that members come from different organizations that cause social and communicative conflicts - resulting in a failed project. Not least, it can make the process more complicated and expensive. Hossain, Islam, Sayeed and Kauranen

(2016) also acknowledge that although various skills and different insights improve a group's productivity, the members' diverse organizational backgrounds may hinder team performance. To avoid that the diversity of the individuals in open innovation cause difficulties, it is important for the manager to have this in mind and understand the interactions among the individuals in the open innovation process (Ollila & Elmquist, 2011).

When talking about team diversity, and whether it facilitates knowledge transferring and benefits team output or not, the researchers' opinions goes in different directions (Du Chatenier et al., 2009). To clarify, team diversity refers to the extent of demographic-, job-, expertise- and/or firm diversity within a team. In open Innovation teams, the degree of firm diversity if often high, unlike the degree of job-, demographic- and cultural diversity which may differ between teams. Accordingly, the diversity factors affect teams to different degree, and in different contexts. However, researchers agree that several factors of diversity, i.e. social, information, decision making, must be taken into account when examining how diversity affects team output. Some researchers within innovation management, believes that high diverse teams or heterogeneous teams, containing different actors, with different knowledge, skills and experience, tend to come up with more creative and innovative solutions. Others claim that homogeneous teams are more productive, as the members similar experience and skills provides a mutual understanding and attraction to each other. However, it is certain that team diversity and homogeneous teams require more work on sharing information, interpretation, negotiation etc. as diversity tend to increase the cognitive distance between the actors. So even though heterogeneous teams with high diversity may generate more ideas and creative solutions, such teams also place more demands on the actors - demanding that they dare to speak and express their opinions even though they might not think or feel the same way.

3.3.3 Cognitive Distance

To have a shared cognition, or if thinking the opposite, to avoid cognitive distance is another challenge for open innovation teams (Du Chatenier et al., 2009). Shared cognition refers to the extent different actors share mental processes, such as knowledge, thinking and interpretation of information. Du Chatenier et al. (2009) describes cognitive distance by *Differences in conceptualizations, Differences in goals* and *Differences in working culture.* Here, only a description of the latter two will be provided, as those are the ones identified in the case.

Differences in goals, refers to the will and commitment of the actors to achieve the same goal, a goal that requires everyone's effort. In an open innovation team, the actors may have similar as well as competitive goals, which can make the process more difficult to handle. An actor putting his/her goal in front of the group may even cause the project to fail. Ollila and Yström (2015) agrees with this and states that the competing demands or conflicting objectives of the members from different organizations is a challenge that an open innovation manager have to face. To mitigating the eventual dissension between collaborative parties, the manager has to identify and promote a unifying and motivating collaborative aim, which may be a challenging task. This also involves managing with organizational politics on multiple levels and requires managerial skills in negotiating as well as having patience when

dealing with extensive decision-making processes. As Du Chatenier et al. (2009) writes, balancing competition and cooperation is the challenge here.

Differences in working culture, or business culture, is about how organizations works and solves everyday problems. How they handle methods and processes and decides which information is relevant. In open innovation teams, actors from different organizations are probably used to work in different ways, which may cause problems and make it difficult to develop common plans. In short, the diversity of actors in open innovation teams can either inhibit or stimulate the knowledge sharing process. The biggest challenge therefore is to balance individual and common interests and create common goals and plans to reach them.

3.3.4 Team Stability and Group Efficacy

Team stability is another challenge in open innovation teams (Du Chatenier et al., 2009). It refers to the extent of entry and exit of actors within a team, in which one should always strive for a good balance. In a team that is too stable, implicit rules and habits tends to arise. Furthermore, there is a risk of groupthink, leading the members to value conformity higher than having a healthy and critical attitude towards each other, which in turn will impede new developments. This unlike an unstable team, where actors constantly flow in and out, in which there is a risk of losing the organizational memory. Furthermore, this can negatively affect the group as socialization in the team can slow down the search process (Dahlander and Gann, 2010). As open innovation teams consist of an ongoing mix of actors, the risk of groupthink is normally very small (Du Chatenier et al., 2009). The challenge here however, is to cope with the uncertainty that may arise when there is an in- and outflow of actors, as well as not to lose the organizational memory when actors only participate temporarily.

Group efficacy is another decisive factor for a successful open innovation collaboration (Du Chatenier et al., 2009). Group efficacy refer to the members faith in their ability to perform but also their belief of a high collective efficacy. A key factor for group efficacy is a mutual commitment among the members, meaning, as a member you have to give and take. Group efficacy is also about fair dealing, embracing the fact that the members act with transparency and respect for each other. Fair dealing does not necessarily mean that the inputs and outcomes are always equally shared between the members, however, it is important to be attentive to those members not contributing to the group but enjoying the outcomes of the collaboration. To be attentive to those taking advantage of the transparency among the members - the so called "free riders".

3.3.5 Power Distribution and Hierarchy

Power distribution is another challenge of open innovation teams, where the distribution is closely related to status, knowledge and position (Du Chatenier et al., 2009). Several studies have shown that knowledge sharing either takes place when there is no difference in power between actors or when there is a difference that is controlled. However, mutual power and influence between actors often equals better learning and knowledge transfer since high dominant actors and their presence tend to inhibit members in sharing information. Furthermore, it has been found that

interdependencies between actors is a decisive factor in reaching desired learning outcomes. Although there are often no hierarchical relationships in open innovation teams, there may be differences in power and dependence. For example, do suppliers often feel more dependent on their buyers than the opposite, and larger companies often feel that they have more power than smaller companies. The challenge here is therefore to balance power and dependence but also to find a good balance between influencing others and being influenced.

Hierarchy is another challenge in open innovation teams, that is closely related to power (Du Chatenier et al., 2009). Hierarchy refers to the positions the actors have in a particular team, what control they have, how the power distribution looks as well as how decisions are made. Studies have shown that in teams with high hierarchy, actors have difficulty in transferring knowledge and developing new ideas. This since they are inhibited by strong individuals with a high level of power. In contrast to this, teams with no hierarchical structure have easier to transfer knowledge. Du Chatenier et al. (2009), mean that interfirm alliances, such as open innovation teams, are facing the challenge of finding a good balance between being in control and being out of control. What they mean is that, although these teams have a flat structure, which benefits them in the knowledge creating process, they must have a plan for how the projects are managed and organized - activities that are more complicated in a flat team without hierarchical structures, as no one is obliged to lead or follow.

3.3.6 External Context Characteristics

As can be understood by now, after having discussed several challenges within open innovation, the context characteristics have great importance for open innovation and its effectiveness (Huizingh, 2011). With context characteristics Huizingh (2011) refers to the internal and external environment characteristics that affects performance. Internal environment characteristics have been discussed above and refer to the company specific characteristics like employees, location and strategic orientation. However, what have not been discussed is the external environment characteristics and its impact on the effectiveness of open innovation. Huizingh (2011) refers the external environment characteristics mainly to the industry, as the industry specific characteristics highly affect the adoption of open innovation, something that will be discussed more in Chapter 3.5. However, external environment characteristics can also have to do with market turbulence and competitive intensity. According to South East England Partnership Board (n.d.), market turbulence with its recessions and booms, have high impact on whether companies chose to focus on innovations or not. At the same time as a recession can make it difficult for companies (especially small companies) to finance innovations and high-risk projects, a recession can also force innovations as the competition between companies increases. That is, to compete for customers the companies must come up with more innovative solutions. The context characteristics, internal as well as external, are therefore something that should be taken into consideration when discussing open innovation, its adoption and effectiveness (Huizingh, 2011).

3.4 Sustainability in Innovation

With a growing population, rising industrial production and increased consumption, the world is facing greater challenges (Melander, 2017). The depletion of natural

resources and the critical issues of the climate change have caused a new demand for sustainable development and thereby led companies to look towards innovation for sustainability in order to develop new innovative solutions (Goodman, Korsunova & Halme, 2017). There is no united definition of *Sustainable Innovation* and therefore, Goodman, Korsunova and Halme (2017) have in their study defined the term as "a new or significantly improved product or service whose implementation in the market solves or alleviates an environmental or a social problem" (Goodman, Korsunova & Halme, 2017, p 732). Furthermore, Arnold (2017) states that sustainable development primary aim is to "..shape human systems, to economize, produce and live in a way the ability of the Earth's ecosystems to assimilate, buffer and regenerate is considered" (Arnold 2017, p. 179). Additionally, sustainability emphasizes the urgency for an establishment of resilient systems in regard to ecology, economy as well as society. This chapter will underline the different challenges that sustainability implies in bringing together the different stakeholders and aligning their motivation.

3.4.1 External Collaboration in Sustainable Development

External collaborations are not only favorable in the innovation process, but also important for successfully innovating sustainable-oriented products and services (Melander, 2017). According to Goodman, Korsunova & Halme (2017) organizations may require external knowledge beyond the firm's boundaries to be able to develop these products. Watson, Wilson, Smart and Macdonald (2018) states in their systematic review that environmental innovation is changing business and natural environment contexts and therefore, constant resource reconfiguration is crucial. Due to firms' inexperience in new technological frontiers that the evolution bring, external knowledge may be required. Compared to normal innovation process, sustainability-oriented innovation is usually more complicated and ambiguous due to the consideration of the wide extent of stakeholders that may have conflicting demands (Goodman, Korsunova & Halme, 2017). However, sustainability-oriented innovation groups possess likewise complex challenges of how to involve external stakeholders, as open innovation groups do. Melander (2017) found that it is argued that in environmental innovation, networking and collaboration activities with partners such as suppliers, universities, research institutions and competitors are even more important than in other innovation processes, since organizations that collaborate in environmental innovation obtain knowledge from a broader network of actors.

3.4.2   Drivers for Sustainable Development

Looking into motives of collaborative sustainable innovation, Melander (2017) found drivers like economic issues, regulations, customer demand and competitiveness. By investing in green innovation, companies can increase productivity and decrease environmental expenses and risks. Arnold (2017) showed in her review that most of the studied co-creation processes were used to legitimate corporate responsibility and improve business image or test new tools. Another motivation can be new business opportunities when developing these innovations and therefore, participating in sustainable product innovation needs to be economically advantageous, such as financial profitable or provide opportunities for entering new market or developing new technology (Melander, 2017). According to Arnold (2017), the costs, benefits and risks of interactive value creation have a strong impact on the development and subsidy of sustainability innovation. Therefore, when sustainability results are not

directly noticeable for the stakeholders, it may bring difficulties and risks for the firm to invest in these kinds of services or products.

3.4.3 External and Internal Challenges of Sustainable Innovation

As in the theory of open innovation, conflicting objectives between actors cause difficulties in sustainability questions as well (Melander, 2017). Therefore, as in an open innovation collaboration, alignment of objectives and shared goals are important for avoiding misunderstandings and increase opportunity to transfer knowledge. Furthermore, internal practices such as senior management support, clear goals and a strong company mandate, as well as consideration of long-term aspects and planning that leads to sustainability, is essential for succeeding in environmental innovation. Additionally, cross-functional collaboration which is established by employees being creative and flexible, and integrating knowledge between different functions are important. This however increases the demands on the employees and it is therefore advised that organizations employ persons with expert ability and educate employees on specific aspects of environmental sustainability issues. Watson et al. (2018) state that some companies have a centralized functional team (CSR, environment, or sustainability team) and other companies have a distributed competence which is located within several departments. These capabilities can take the lead of sustainability steering groups composed of representatives from various functions. Further, the researchers suggest that sustainability specialists are well suited to support the development of stakeholder engagement capabilities. The researchers also found that as stated in sustainability marketing literature, marketing is an essential part of sustainable innovation.

3.5 Innovation in the Construction Industry

While the approach open innovation enriches firm's innovativeness, it is limited to the firm's product or features of the industry that the firm operates in. The industry's specific characteristics can both be drivers and hampers of innovation (Bygballe & Ingemansson, 2014). According to Gassmann & Enkel (2004) there are some general features that a company can possess that make them more susceptible for improving innovation and thereby acquire the opportunity to achieve competitive advantage on the market. The characteristics that were found was that high product modularity and high industry speed can increase the innovativeness by opening up the innovation process. Furthermore, companies that requires much explicit and tacit knowledge and with high complex interfaces are also more adaptive for improving open innovativeness. Due to the fact that specific industry features have this influence on innovation, it is necessary to look further into the construction industry characteristics as this study aims to investigate an open innovation platform within the construction sector.

3.5.1 Characteristics of the Construction Industry

The construction industry is often blamed for being non-innovative and conservative (Bygballe & Ingemansson, 2014). In related literature, it is often claimed for having difficulties in creating innovation and the rate of producing innovation in the construction industry is rather low compared to other industries (Matinaro & Liu, 2017). The industry has several specific characteristics which are likely to influence

the innovation process such as contextual inter-organizational features and organizational features. First of all, the complexity of the construction process itself is one factor that bring difficulties for innovation in the industry and it can be risky to make changes that can cause unanticipated effects (Bygballe & Ingemansson, 2014). Secondly, the construction industry involves project-based activities that needs to be performed by multiple parties, where each of the parties is an individual (separate) organization that have own objectives and interests of the project (Dulaimi, Ling & Bajracharya, 2003). Hence, when innovation is created, a serie of various actors with different economic logics needs to be involved (Bygballe & Ingemansson, 2014). A construction project is a temporary inter-organizational venture that ends when the construction is finished. Therefore, the coordination of various stakeholders in a construction project can be challenging and makes the initiation and implementation of innovation difficult. In a study by Bygballe and Ingemansson (2014) it was found that these specific multilevel and inter-organizational features can be of an essential part of the industry's innovativeness. Matinaro and Liu, (2017) find this highly paradoxical, that an industry, which operates cooperative, within the society and have enormous effects to economies, cannot be innovative enough. Further, they state that this refers to the lack of creating the innovative culture needed and moreover to overall difficulties to lead innovativeness. Furthermore, they state that a diverse culture, dynamics and structure of an organization facilitate innovation processes and that the lack of educational and competence variation in construction companies may have a negative effect when considering creating an innovative culture.

3.5.2 Increasing Innovation in the Construction Industry

In this structurally complex industry, companies need to rely on other companies. Contractors and subcontractors with rather less understanding of each other's business and working habits work together in a project-based organization (Matinaro & Liu, 2017). With the previous industrial features in mind, to increase the innovation performance in a construction company, it is essential to consider the interactions with various stakeholders in many levels in the project-organization. Additionally, innovation in the construction industry can only be accomplished through the cooperation between the involved actors, and to achieve innovations it is therefore crucial to collaborate with stakeholders outside of the current operational projects. To get a successful collaboration, managing an open and collaborative organizational culture is important. Furthermore, there must be mutual understanding and agreed methods on how to increase the level of innovation in construction industry (Matinaro & Liu, 2017).

In a study made by Matinaro and Liu (2017), findings show that an organization's innovation culture, structure and strategy is essential for the organization's innovation achievement. They state that a major weaknesses of construction industry is to manage an innovative culture and thereby innovation. Furthermore, organizational culture is an essential feature of a firm's innovativeness and a successful firm has the ability to accommodate innovation into its organizational culture and management processes. Additionally, as the theory on open innovation states, the researchers enlighten the project manager's role in construction projects and states that the manager is essential in sharing information of best practices between projects and forming the culture towards innovativeness. Tabassi, Roufechaei, Ramli, Bakar, Ismail and Pakir (2016) argue that a project manager's leadership capabilities,

transformational leadership and intellectual competence take the most significant part in developing sustainable construction. The characteristics of the manager may have an impact on his/her ability to create an innovative culture which is crucial for the use of sustainable solutions in the construction industry.

3.6 Summary of Theoretical Framework

By now, we have learned that the phrase *open innovation* was coined by Henry Chesbrough and that his definition of the term is the most cited by researchers in the field. The definition tells that open innovation is about how organizations, in their pursuit of competitive advantage, use both internal and external knowledge as well as internal and external methods to market their ideas. In practice, there are two strategies to open innovation, the *outside-in approach* and the *inside-out approach*. The outside-in refers to practices where a company acquire external knowledge into their own innovation process, whilst inside-out refers to practices where a company export internal knowledge to the external environment. Knowledge can be integrated in open innovation projects by Wallin and von Kroghs five-step model; *Define the innovation process steps, Identify innovation-relevant knowledge, Choose an appropriate integration mechanism', Create effective governance mechanisms* and *Balance incentives and controls*. The model aims for managers and can be seen as an iterative process. We have also learned that open innovation preferably should be based on the requirements and co-creation activities of the consumers, as this will increase the consumers acceptance of the product and make it more likely spread on the market.

By now, we also know that there are challenges as well as enablers that can aggravate or facilitate the open innovation process. Example of challenges are; having a strong *leadership* that promotes cooperation and an open climate, to avoid *cognitive distance* and managing differences in goals and working culture, to foster a balanced *team stability* and *group efficacy* as well as a balanced *power distribution* and *hierarchy* within the team. On the other hand, a factor that has proved important for facilitating innovation processes is the use of an *innovation broker*, i.e. a person employed to support and ease the innovation process and knowledge transfer across people, organizations and industries. Finally, there are some factors that can act as both challenges and enablers in the innovation process. Examples of such are *team diversity*, as high team diversity both can generate more ideas and creative solutions as well as inhibit the innovation process. This, as well as the contextual characteristics where both the internal and the external environment can ease or complicate the process.

Last, we know that open innovation activities are used more frequently by companies as they seek to acquire external knowledge and technologies to stay innovative. However, external collaborations are not only favorable in the innovation process, but also important for successfully innovating sustainable-oriented products and services. When developing these kind of complex products, one single firm may not have all resources required in-house, and therefore it may be necessary to go beyond the firm's boundaries and obtain knowledge from outside. Furthermore, we know that the context firms operate in have a crucial impact on the innovation outcome. The construction sector is often blamed for being non-innovative and conservative due to the high complexity of the construction process as well as due to the many stakeholders involved. However, it can be seen as quite paradoxical that an industry, which operates in a cooperative way cannot be innovative enough. This may have to do with the lack of creating the innovative culture needed and therefore a different approach to leadership is suggested when managing open innovation teams.

4. Empirical Findings

The results of the empirical findings are presented in this chapter, in which the data is based on interviews, internal documents, as well as observations of meetings within the PFH platform. The focus is on the PFH platform, its origin, participants, projects, as well as the challenges and enablers the group have encountered, which have complicated and/or facilitated the innovation process.

4.1 Definition of PFH

The authors interpretation of the empirical findings shows that PFH can be defined as a cross-sectional research platform where innovation process aims to, by building partnership and collaboration, develop environmentally, socially and economically sustainable residential areas. The project's outcomes are currently realized in three housing projects, Brf Viva, Bfr Slå Rot and Lindholmshamnen, which constitutes as full-scale laboratories for implementing sustainable housing, see more information about the projects and outcomes in Appendix 1 and 4.

In the beginning, the PFH platform was equal to the building project Brf Viva, and not until later on, the housing project became separated from the PFH platform and identified as a demonstration project. This happened at the same time as the project group tried to identify the PFH platform and its future. The result of the discussion has resulted in a describing picture of the two different processes, the PFH platform, and the demonstration housing projects, see Figure 5.
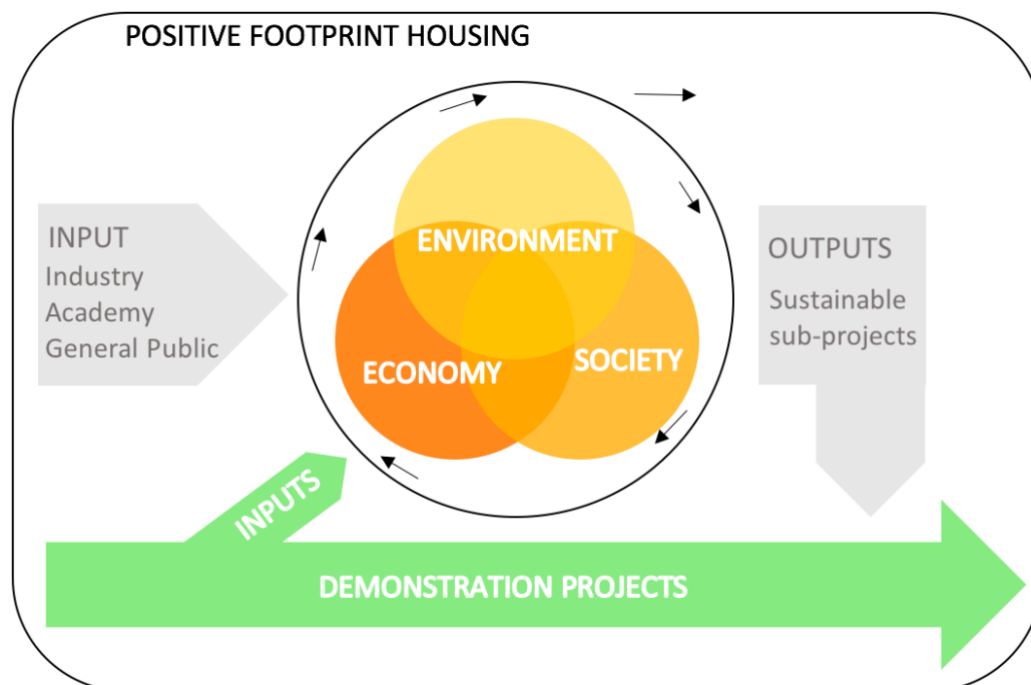

Figure 5   Process of Positive Footprint Housing (Riksbyggen, Internal documents, Edited).

As seen in the figure, PFH is the wheel that spins in parallel to the housing projects which are linear processes. In difference to the linear processes, PFH constantly spins and new ideas comes up along the way. According to Interviewee 1, the construction

and the research projects drives each other, the building projects motivates the researchers which find it favorable to be a part of something concrete by being involved in the platform and at the same time, the researchers within the platform drives the housing projects forward. As PFH spins on and involves the process in which the collaboration take place, ideas will eventually develop and move out of the innovation process in to the construction projects. According to Interviewee 3 it is important that ideas come out in the right time.

4.2 Background of PFH

Ever since the meeting point Johanneberg Science Park (JSP) was founded in 2010, Riksbyggen have been one of the partners and owners of the organization. According to Interviewee 1, JSP have become a link between the academy and industry, and it was through them Riksbyggen got in contact with Chalmers in the first place. The initiator from Riksbyggen did not know what the collaboration with JSP and Chalmers was going to result in, but anyhow, they had early on realized the importance of working with the academy to learn more about housing, civil, and urban construction. Starting a collaboration with JSP was also a way to be at the forefront of sustainable housing construction. They did not want the collaboration to be limited to research and after request from Gothenburg City and Chalmers, actors from Riksbyggen decided upon a demonstration project and started looking for a land to build on. The actors from Riksbyggen had a vision of creating a project that was at the forefront of sustainability and by researching, develop sustainable housing solutions in form of a demonstration project. Besides the research, they wanted to do something concrete and show the industry how one can work with sustainability in housing construction projects (Interviewee 1).

The project started in 2011. In the beginning, there was no distinct picture of what was going to be achieved, only the vision that they were going to do something that is at the forefront of (mainly environmental) sustainability. According to Interviewee 1, PFH was created without precondition and with an open mind. One of the interviewees tells he has been asked many times if he cannot give a presentation about how PFH has been working with the project. He told, he could do that, but the fact is that the PFH group never had a well-developed plan for how to proceed, they have just tested different processes/methods along the way. Maybe it is exactly this approach, with not having too defined boundaries and frameworks that have made PFH successful he states. A too clear goal of what you want to achieve can create a box which does not leave space for all the innovation you want to put in the project.

As the project moved on, the focus switched more towards social sustainability. The cooperation with the department Architecture and Civil Engineering at Chalmers University of Technology and the department of social work at University of Gothenburg, as well as with JSP was deepened, which also laid the foundation of the PFH collaboration. At this time, the group was quite unstructured and according to one interviewee from Riksbyggen, the PFH group had a welcoming climate which in turn led to research, development and innovations. Meetings occurred almost one time per month, where initial ideas were developed in to the PFH project. A great number of people are involved but there is no established researching organization in PFH, more than the consult employment of a PFH coordinator, described more in Chapter 4.4.2. Collaboration partners that are or have been involved in the PFH project are,

besides previously mentioned, researchers, students, customers, suppliers and municipalities, see Chapter 4.4.3.

According to the interviewees, the process of PFH was in parallel with Viva, which means that it was not that one of the processes went ahead and the group known what was going to be applied, but rather a giving and taking back and forth in a quite open, but also complex process that was partly messy. Many people were involved, and they did not really know which direction they wanted to take. Eventually, it began to become more concrete and initial sketches of Brf Viva was made, which was difficult due the group did not think they had fully figured out what they wanted to achieve. The actors in the collaboration were not used to running a from-scratch process in a completely new direction as this was. They did not have such training in this, which meant that they could not make a plan from the beginning, but work with a flexible plan which eventually became clearer. See an overview of the PFH process in Appendix 3 or the simplified version in Figure 6 below.
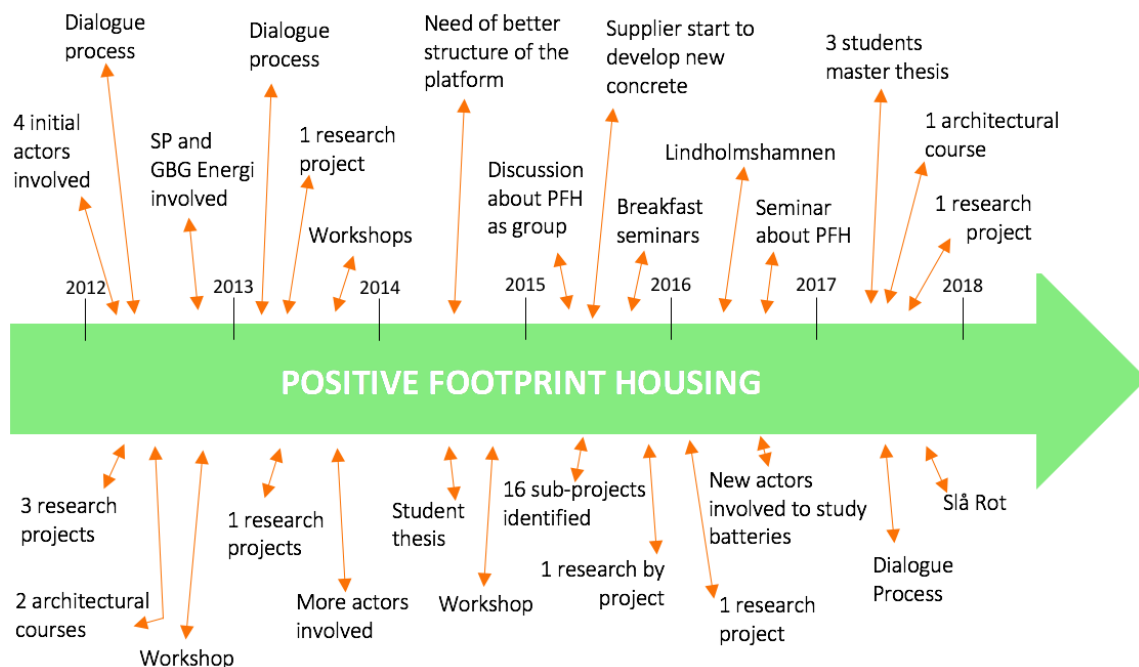
Figure 6   *Timeline of Positive Footprint Housing (Made by the authors).*

4.2.1 Collaborations with actors

The first year of PFH, workshops were used to develop ideas and test the interest from different stakeholders. For instance, in 2012, actors from Riksbyggen, JSP, Chalmers and University of Gothenburg organized a workshop with other companies in the industry, to broaden PFH and get more stakeholders. In this workshop, the first ideas of the platform were developed and categorized after the origin, if they were linked to economic, ecological or social sustainability and if they should be included in Viva or in Riksbyggen´s organization. If the idea could not be applied in either Brf Viva or Riksbyggen's organization, a decision of whether to park the idea for future projects or not had to be made. The outcome of the initial ideas then become part of a matrix in which the motivation of implementing the different ideas, concrete examples of

implementation, as well as risks with the ideas and who they could be perform by, was presented.

During the course of the project, the general public have also been invited to be involved in the project. In 2012, the PFH group wanted to create a dialogue with nearby residents and other public stakeholders that might have opinions about the building projects. Unfortunately, PFH experienced problem with low number of participants at meetings with nearby residents. Moreover, in 2013, actors from Riksbyggen organized external workshops for stakeholders that were interested in the project, such as the general public. The aim was to get people interested in the project, as well as to find out what they thought of Viva and get external ideas. During the workshop, the public got to criticize and come up with ideas for the project. It was also discussed what the main focus in the project should be on (Internal documents). Additionally, in 2013, the actors from JSP, Riksbyggen, Chalmers and University of Gothenburg organized a workshop for all stakeholders (industry, general public, academia etc.) in social sustainability. Not least, in recent years, several events such as conferences, breakfast seminars and workshops have been held to involve external stakeholders, see Appendix 3.

Besides the collaboration partners in PFH, academic stakeholders such as students and researchers have been involved in the platform. Foremost, students and researchers from both Chalmers University of Technology and University of Gothenburg have contributed with ideas through studies, assignments and courses in which they have had the PFH project as a course project, or by using PFH´s case in their theses. For example, in 2012, master students from Chalmers Architecture have through two different courses, been involved in the development of ideas for the Viva project. The student has for instance, created residential designs for the site and in another course, designed housing for young adults. Moreover, students from University of Gothenburg have been working on projects with sharing economy. The projects have been presented to the PFH group in order to create a creative dialogue on specific experimental topics. The researchers have had a key role in bringing in students to the projects, which have led to several student theses have been made, see Appendix 3. To name an example, one thesis was made on behalf of Riksbyggen as they felt the need to find another way to certificate PFH. They did not think that the existing certification-systems was good or comprehended enough for building sustainable. For instance, the current certifications did not consider social sustainability, ecosystem services or mobility. To get a more holistic view and review the certifications that existed on the market, Riksbyggen therefore got assistance from a student that did a thesis work on reviewing different certifications (Interviewee 3 and 2), and the result was used to develop a better certification system.

Additionally, many researchers have been doing studies about PFH, and thereby contributed to the outputs of the platform. The studies have been conducted by researchers at Chalmers and University of Gothenburg as well as by industrial researchers or suppliers.

4.3 Objectives

The PFH platform has several objectives. However, the initial objective with the platform was to achieve the goal that was set out in the beginning - namely to build the most innovative and sustainable housing project in Sweden. That became Viva and now it is growing to other housing projects as well (Interviewee 5). According to Interviewee 1, the objectives with PFH has developed during the course of the project. In the beginning, the objectives were more aimed towards environmental sustainability, and first later the focus shifted more towards social and economic sustainability as well.

At the beginning of the project, the company decided on 10 objectives in order to assess its development. A target picture was made for setting a vision to work towards. The original objectives have later been used to compare with the progress during the course of the project and the result have been positive. The project is today following the intended goal. According to Interviewee 1, these initial and fundamental objectives from 2011 are still relevant and have not been changed during the development of the project, see Table 2 below.

Table 2   Initial objectives of PFH (Internal documents).

Initial objectives 2011
Be an example and a national and international, new-formative time marker for holistic thinking of sustainable housing and urban development.
Demonstrate sustainable building of resource and energy consumption, design, materials selection, technical solutions, building methods and management of the building.
Show that the completed housing project can generate more energy than it consumes and is acceptable from a real estate economic viewpoint.
Set people's needs at the center through solutions that are flexible and facilitate sustainable lifestyles for the residents.
Strengthen social sustainability by specifically looking after children's needs and striving for mixed generations and different economic conditions in the housing.
Achieve social acceptance among residents.
Radically reduce the dependence of private cars.
Be a key project that revitalizes and strengthens the development of campus at Johanneberg and its contact with surrounding residential areas, which adds architectural quality into densification of the city and create the conditions for more life in that part of the city.
Manifest a long-term cooperation, where the project becomes an effective full scale lab for research, education and innovation for at least three decades to come.
Have an active role in learning, public dialogue and knowledge development about housing.

Accept the initial objectives of the platform, concerning what should be achieved and where they should be in five years in aspect of sustainability, there was no clear goal in the beginning. The above-mentioned objectives is something that management of PFH always have been working towards but exactly what they meant was quite

unclear at first, according to the interviewees. It was enough defined goal that gave space for creativity. According to Interviewee 5, one of the things that have made Viva so good as it is, is that they from the beginning said out we are going to build this. This lead to that the researchers in innovation tried to find actual solutions that would work practically and developed into a concrete project.

4.4 Challenges and Enablers of PFH

In this chapter, the challenges, as well as enablers, of the PFH platform will be presented. The material is based on interviews with people involved in PFH, as well as on internal documents and observations.

4.4.1 Overall Challenges of PFH

Three challenges that the group had to face in the initial phase of the project have been identified – how to balance (1) a creative climate with outcomes, (2) innovation with costs and (3) the residents satisfaction with innovation. First of all, it is easy to be creative and find new ideas, but the challenge is to actually concretize them into the projects. According to Interviewee 3, being courageous enough to take decisions that can bring the project forward, is something that the group have learned during the project. With too many ideas in the beginning, when the building project is still quite vague, it can be difficult to know which direction to take. How do you move forward when a lot of individuals come up with ideas? Interviewee 3 states that this can make the group take one step forward and two steps backwards. Furthermore, he states that it could easily be 6-8 project managers in the project that are focusing in all the details of the ideas. Unfortunate this is not realistic, and therefore, it is important as a project manager, to withstand and make decisions of were focus should be, even if it is more fun to be the one that brings the ideas. Being that person to say what cannot be done is not fun, however such a person is needed in order to get forward. Additionally, the question of when to limit the ideas can bring difficulties to the project organization. Should one do it from the first day or not? This question can be quite paradoxical - if the creative phase is limited from day one, there is a risk that creativity gets hindered and some ideas get missed, meanwhile, if there is no limit, there is a risk that too many ideas result in nothing. According to Interviewee 3, when working with sustainable aspects, one realized that it is not only one question or one aspects that needs to be covered, but a holistic picture is needed to be considered, otherwise sustainability cannot be achieved. The trick is to work with something concrete in every focus-area and create a palette of things that can be converted in reality.

Second, although Riksbyggen Region West is the main financier of the project and thereby has the final decision of which ideas that should be implemented or not. According to an interviewee, there is no shortage of ideas, and it can be easy to have opinions about others money. Therefore, management of Riksbyggen have been clear that they have the final decision. Furthermore, interviewees from Riksbyggen state that they are genuinely interested of having as much sustainable ideas as possible. The focus in not on maximizing the profit, if they do so, it is not possible to get the sustainable aspects and ideas. Hence, there is a genuine wish that the project will gain enough from a cost perspective, so as many sustainable sub-projects can be implemented in Brf Viva as possible. Interviewee 3 states however that the project

cannot be outstanding in every aspect, cause if it would be - no one would have afforded to build it.

Furthermore, the need to limit the number of sustainable sub-projects creates difficulties from a management point of view. According to Interviewee 3, in management, it is important to have a clear goal. But, how do one manage if it is not possible to have a clear goal from the beginning, then the most logic is to say no to the sub-project because of the uncertainty factors. This may however result in lower degree of innovation. This problem is something that has been discussed in the PFH group - the difference of working with innovative construction is that the idea phase should not be rushed, and one should not limit the project in the beginning by taking on a "too small suit". It is necessary to narrow down the innovation process to move forward and get somewhere, but if this occurs to early, the innovation will be affected. According to Interviewee 3, several people should be heard in the innovation process, it should take time to develop the result and one have to take early decisions with high level of uncertainty. One example of this is when a decision was made to design space for old bus batteries in the basement in Brf Viva (with the purpose of being used for electricity storage), although the PFH group did not know how the batteries would look. Hence, this is an interesting management question, whether the management should focus on innovation or goal-steering.

In the beginning of PFH there was some discussion about how the project will financially be achieved, but that it was okay with different marginals since the project have to afford to develop the ideas and implement them in the housing (Interviewee 3). According to Interviewee 3, we have been determined to go from word to action, in order to secure that the ideas become realized. They tried to develop and plan Viva with flexibility. Not really knowing which path to take and what aspects to focus on resulted in an approach where the group aimed attention at many different parts related to sustainability. According to Interviewee 6, this can be good but also makes it harder for them to define the design of the building. Early in the project, the group discussed that the building project has to be developed ahead of the research/in PFH in order for both PFH and the building to move forward. Otherwise, there is a risk that the housing project will not get built or that the process gets extremely slow. It is not possible for PFH to sit and wait for the researcher to come up with the answer, then nothing will happen, or little will happen. The building process forces the research to give the solution. Everything cannot be involved in Viva, one has to include some parts and then, the building project can give input to the researchers or students as well (Interviewee 3).

Thirdly, there has to be a balance between the progress of the innovation outcomes and the final building project. Interviewee 3 mention that the final customers/the buyers of the apartments, are not laboratory rabbits. Brf Viva is going to be a functional cooperative housing association in which basic functions have to work, not an experiment laboratory. This have impregnated the innovation process in Viva, the end customers have to have a functional house, e.g. they still have to have electricity even if the bus batteries do not work. Hence, it is essential that the final house should work good enough, but still have high level of innovativeness in it. There are many ideas that Riksbyggen have been reluctant to do, Interviewee 3 estimates that 95 or 100 ideas have been rejected, but still, Viva involved a lot of things.

4.4.2 Leadership

Through observations of the meetings in the PFH platform it can be understood that the management of the platform is a crucial part for the platform to function at all. Mainly, there are two different groups/people that have been observed, that lead and organize the platform. Partly, it is the management of Riksbyggen, with people who has a lot of knowledge within the field of construction and who has a great interest in innovative and sustainable projects like PFH. Partly, it is a person from JSP who has been employed as a consultant for Riksbyggen to lead and organize the meetings, workshops etc. within PFH - to function as a PFH coordinator, see further information in the section below.

Regarding these two groups'/peoples' responsibilities, the management of Riksbyggen is responsible for the projects, which type of projects to be included in PFH, what their focus should be on etc. while the PFH coordinators responsibilities more has to do with organizing and leading the monthly meetings with the actors involved in PFH (Observation). The greatest difference between the two is that the PFH coordinator is leading the meetings, although he cannot take any decisions regarding the projects within PFH as the management does. From observations, it is understood that the PFH platform would not have worked without any of these two groups/people. The group itself, with all the various actors involved, had never been able to organize itself, and therefore a coordinator is needed. The different actors have much knowledge and thoughts, and new ideas are constantly popping up during the meetings, which requires someone to structure the meetings and take the discussions forward. Moreover, the management with people with a high interest in innovation and sustainability are needed to highlight these important issues and to find new innovative projects to take on, allowing the platform to keep on existing.

PFH Coordinator as Innovation Broker

About one and a half year ago, Riksbyggen Region West decided to outsource part of PFH´s activities to an employee at JSP (Interviewee 1). The reason for this was that actors from Riksbyggen in PFH saw a need for a person acting as a link or intermediator between themselves, the academy and the industry (Interviewee 1), as well as a person to coordinate and sort of push all the research and innovation projects within PFH forward (Interviewee 5). They needed a PFH coordinator and Riksbyggen themselves neither had the time nor the competences needed for the job in-house (Interviewee 1). At the beginning of PFH, actors from Riksbyggen received a lot of help from various people at JSP, including a key person who helped them start the project/platform. This key person at JSP had an overall role and took a major responsibility for PFH and its development, although when he quit from JSP it became acute and Riksbyggen had to find a new solution. The key person at JSP then recommended the PFH coordinator who worked as a research strategist at JSP at the time, and it was decided that Riksbyggen Region West would hire him for two years, half time. The PFH coordinator's position was accordingly completely new when he got it. His main tasks of coordinating, leading and organizing PFH had previously been done by his colleagues at JSP, as part of their basic service to their part-owner Riksbyggen.

For the role of acting as a link between Riksbyggen, the academy and the industry, as well as leading and organizing the PFH platform, a whole lot of competences were required (Interviewee 5). First and foremost, the PFH coordinator needed to have a

good foundation/basic knowledge for the job, which he has through his education in sustainability and architecture engineering, as well as from his involvement in a student-led organization aiming at raise awareness about sustainability. In addition, he has been working both as an architect as well as with sustainability issues, which has given him an overall knowledge in both areas. Secondly, more soft competences were required, i.e. being systematic, organized, friendly, social and being able to network and build partnerships and collaborations. One of the most important competencies that the PFH coordinator possesses is probably the network (Interviewee 1). From his time at Chalmers the coordinator knows many people within sustainability in Gothenburg, important contacts that he often uses to test ideas and/or enrich his thinking (Interviewee 5). I.e. he knows people that knows people, which is beneficial in his work constantly finding new contacts and projects for PFH. This leads us to another important competence required, i.e. being able to communicate. A great deal of working with PFH and research processes is about communicating, both communicating with various actors involved in PFH as well as communicating internally to Riksbyggen. Furthermore, it was called for a person who is organized and has the ability to lead the PFH platform, as well as someone who is flexible and able to adapt to changes often arising in innovative groups. Last but not least, a person with graphic/esthetic competences were required, i.e. someone who knows how to put together presentations, handouts etc. in a nice and appealing way.

Except networking with industry and academy, the PFH coordinator's task is also to lead and organize the PFH platform (Interviewee 5). Exactly what it meant was a bit unclear at first since the position was brand new, the PFH coordinator's tasks are therefore something they have worked on together, over time. Today, the coordinators daily activities are mainly communicating PFH outwards, by marketing, networking, organizing study visits, guided tours etc. The coordinator also spends a lot of his time in planning and coordinating the monthly meetings, what to be addressed, which to present and what, doing handouts, presentation slides etc. Part of his work is also about being up to date on what is happening in the industry as well as attending meetings and presentations to see if a project or an arena would be something worthwhile for PFH.

For the way the PFH coordinator works with the PFH platform, he has not developed particularly many methods (Interviewee 5). He has however developed some kind of method of how he run the meetings, which is quite a challenge. He puts a lot of time and energy in planning the meetings as he wants them to be as organized and efficient as possible. He does however point out that they should not be too organized and structured as they must be open enough to bring forth unexpected points of views and ideas. It is in open conversations the most innovative ideas come up and therefore the times and agendas should not be too strict. This is something he has learned over time. Initially the meetings were not as planned as they are now, but the agenda was decided only the week before. In 2017, the monthly meetings were structured up and a specific subject/theme was initiated. Today, the monthly chosen subject is decided before the meeting and is the focal point during the meeting. Furthermore, every meeting has an update of each of the three building projects. In a way, the PFH coordinator thinks the meetings are more stressful now, as he tries to put an agenda on everything. He also feels that he sometimes has made the meetings too strict, and with that underestimated the fact that people in the group just need to talk - which in those cases there has not been enough time for.

Another challenge, is whether how to keep the meetings interesting enough, for people to return (Interviewee 5). In order for the discussions at the meetings to be interesting, it is necessary that the topic in focus is sufficiently general, or unspecified for PFH. It also requires ambitions to be high enough, as well as the openness of PFH to take on new ideas. This is the reason why the coordinator has to work a lot on planning the themes, he must keep the themes broad enough so that they are not only relevant for PFH. At the same time, he believes that everything cannot be interesting for everyone, always, but people may come when they want, if the subject/theme interests them and/or if they feel they can contribute to the conversation.

Another question, is whether how to lead the conversations in a decent way (Interviewee 5). During the meetings, those people who want to talk and have something to add to the group should be able to do so, but at the same time, when the discussion must be taken further, the PFH coordinator has to take the command. Furthermore, the PFH coordinator finds it hard to find time for more strategic issues. He often gets stuck with other things and does not have as much time for research strategy as he would like to, for example, how to make strategic plans for PFH. It is a challenge to get time for planning and developing new things, but it takes a lot of time to maintain the platform. Hence, there are some methods or ways of how the coordinator run the meetings. However, there is no organized method when it comes to promoting and encouraging new research projects within Riksbyggen, but the coordinator is continuously sent various ideas and suggestions, and if he thinks they are relevant or could be used to humanity as a whole he thinks about who he should pitch it to.

The fact that the PFH coordinator spends most of the time at JSP's office when working for Riksbyggen, there are shared opinions about. One interviewee state, that if possible, it is always better to have people employed, in-house (Interviewee 1). However, in this case he believes that it would be dull for the PFH coordinator to spend all his time at their office, not least this would mean that he missed the contact with students and researchers and everything happening at JSP. However, they have recently extended his position from 50 % to 60 % and decided that he should spend two out of three days in week at Riksbyggen´s office. This with the hope that he will get a better understanding of what they do at Riksbyggen, how they work, get better contact with the employees etc. Sharing his time between both places will be a good compromise, he believes. The PFH coordinator himself agrees that it is not entirely good that he works so much of his time at JSP. As in that way he does not learn from their way of working, their experiences and their ways of doing things. He therefore welcomes the new change. Another interviewee believes however that there are positive things regarding the fact that the PFH coordinator is not employed at Riksbyggen full time (Interviewee 2). Meaning he get an outer perspective, a broader view of things and can maintain a larger network of contacts, which is important. If they would hire him, there is a risk that he would lose those competences quite quickly, losing his network. The network needs to be maintained all the time and that is nothing Riksbyggen can afford to pay for, she believes.

4.4.3 Team Diversity

Observations tells that the PFH platform consists of a variety of actors, the fact is that 28 different companies and 111 different people have been attending the meetings from start, see Table 3 below for a compilation of all participants involved, or Appendix 2 for a more detailed version. Consequently, the actors come from different organizations and have different professional backgrounds, experiences and knowledge - which constitutes as a major factor for seeing the PFH platform as an open innovation group with a high degree of diversity. Besides suppliers, consultants, researchers and students in the industry, there are also involvement of consumers, researchers and students outside of the construction industry. Moreover, except the job-, firm- and expertise diversity, there is also demographic diversities as the actors involved are located both in Gothenburg and Stockholm.

Interviewee 4 tells, that when working in these kinds of groups one must be humble towards each other, as everyone possesses different knowledge. For example, the actors from Volvo may not know anything about building houses, while the actors from Riksbyggen do not know how people work at in the car industry. This can be quite a challenge, he believes, to be understanding and humble even when thinking someone is asking a "silly" question. However, on the basis of observations, the climate during the meetings appears to be open, and it feels like people dare to express themselves and ask lots of questions. Overall, it feels like the diversity really benefit the group. Although the diversity in the group sometimes leads to discussions taking longer time, because things need to be explained due to different knowledge, the diversity also allows members to get answers from each other directly, on important issues. This, leads in turn to faster processes and that innovative and sustainable solutions are developed that might not had been otherwise.

Table 3   Simplified compilation of participants in PFH.

No	Organizations involved	Number of participants	Became involved
1.	Riksbyggen	20	2012
2.	RB/JSP	1	2016
3.	University of Gothenburg	4	2012
4.	Chalmers University of Technology	16	2012
5.	CMB - arena for academia and business	2	2016
6.	Johanneberg Science Park	13	2012
7.	Research Institute of Sweden SP/RISE	9	2012
8.	City of Gothenburg	5	2012
9.	Architectural Firm 1	4	2012
10.	Arena for Sustainable Innovation	1	2012
11.	Landscape Architecture Firm	1	2012
12.	Göteborg Energi	10 (2 of which from JSP)	2012
13.	Student led Project-Organization	3	2012
14.	CBI (Concrete Institute)	1	2012
15.	Technical Consultant Company 1	3	2013
16.	Digital Communication Agency	2	2013
17.	University Linköping	1	2013
18.	Fuel Company	2	2015
19.	Architectural Firm 2	2	2016
20.	Student from Vocational Education	1	2017
21.	Technical Consultant Company 2	1	2017
22.	Student-led Organization	2	2017
23.	Consultant Company in Transportation	3	2017
24.	Communal Real Estate Company	1	2017
25.	Technical Consultant Company 3	2	2017
26.	Association Collaborative Economy	1	2017
27.	Association (jagvillhabostad.nu)	1	2017
28.	Region Västra Götaland	1	2017

4.4.4 Cognitive Distance

According to some of the interviewees, the various actors involved have different goals and incentives with the participation in the PFH platform. One of them states however that, although different incentives may create problems there must be incentives for the actors in order for them to join the collaboration, to actively participate and move forward (Interviewee 4). Without incentives, the projects will come to nothing, he means. One from the management in Riksbyggen states that, from their side, the goal has never been to make a lot of money, but to find new ways to build sustainable houses and show this in various demonstration projects (Interviewee 3). He believes if they had been faced with the choice of earning more money or bringing more sustainability into the industry, they answer would always be the latter. Nevertheless, the innovation projects must never go that far that they would in any way endanger Riksbyggen as organization. For example, in the Viva project, the project does not have the same profit claim as usual, but they have been genuinely interested from start in obtaining a sustainable and innovative housing project. Another one from the management in Riksbyggen states that his goal/incentive to be involved was from the beginning due to his interest in building something that was at the forefront of environmental sustainability. First later, he became interested in social sustainability, with focus on housing. Anyhow, he already from the start saw the business value with PFH, together with the City of Gothenburg. The City of Gothenburg sought to be at the forefront of sustainable building, which meant that him and the actors from Riksbyggen also wanted to strive for this. Interviewee 4 state that he goes to the meetings whenever he thinks the theme is interesting, in which cases he takes the time. Normally he has such little time, so just go there listening in not an alternative for him.

Interviewee 5 believes that many of the actors involved are involved because they feel that the management of PFH and actors from Riksbyggen is genuine in what they do, that they do great stuff towards sustainability. But also, because they feel that they can contribute with something, by joining the platform. Furthermore, the research within PFH leads to real results in form of demonstration projects, which he believes triggers many of the actors to be involved. Not least, the meetings are often filled with good and interesting discussions and are certainly a reason for some to participate. Additionally, Interviewee 5 believes that the actors have realized that the goal of PFH is outside of Riksbyggen. Of course, the results from PFH have consequences on internal results at Riksbyggen as well as effects on the organization and its brand, but Riksbyggen are also the ones taking the greatest risks with the project. He therefore believes that most actors probably not participate to get PR, of course it is nice with an acknowledgement, but that is not the reason why they join the platform he believes. However, he believes the consultants and researchers come due to different reasons. According to him, the consultants only participate when they get paid for it, while the researchers come because they really think it is interesting. He is especially thinking about one researcher that has been involved in PFH from the start, he still participates because he thinks it is a nice forum, Interviewee 5 states. Interviewee 2 agrees on this and believes that this researcher participate because he is genuinely interested in these kinds of questions. He researches in social sustainability, but he participates even though subjects like concrete is in focus. Interviewee 2 further state that the researcher learns so much by participating, not just about concrete, but on the platform, how to think and interact. Another actor tells he participate in the PFH

platform and join the meetings due to his interest in this way of working, his interest in co-creation.

According to several of the interviewees, the different working cultures are one of the major challenges when working in PFH. In the PFH platform there are many different actors, and industries involved, that have not worked together before. All these actors think and act in different ways, which sometimes leads to the occurrence of corporate cultural crashes. These corporate crashes and disagreements must be addressed early on in the process, states one of the interviewees. One interviewee from the management of PFH agrees on the fact that it is a big challenge handling all the different corporate cultures involved in the platform. He believes that since every one of them have different ways to work and think, as well as have different goals in mind, there is a great risk that something will go wrong. Further, he states that the management of PFH has a great responsibility regarding this, as they must be able to handle the different actors and the corporate cultures that comes with them.

As mentioned earlier, one of the interviewee believes, that when working in PFH with all kind of actors involved, one must be quite diplomatic and humble (Interviewee 4). This, as the people in the room have completely different competences and skills. One has to be prepared for some irrelevant questions to appear and be able to receive them in a nice way. As written earlier, Riksbyggen work with a company in the automobile industry. In this case, there are two different corporate cultures that meet, which have two different ways of working. In such collaborations, it is very important to have boundaries, he states. I.e. to clearly clarify who does what, and who is responsible for what, during what time. Otherwise, there is a great risk of mistakes to appear, leading to discord among the actors. Anyhow, working with different corporate cultures is challenging but fun, he believes. One gets to know all kinds of different people and learn their way of doing things. However, clear roles and boundaries is the key when working in such new and innovative projects as in PFH. Another challenge, when actors with different corporate cultures are working together, is to make them move in the same direction. During such a long process as the Viva project has been going on, it can be quite hard. Not least, it can be difficult to choose which actors to involve in order to achieve the intended goal.

According to Interviewee 7, a major challenge regarding working culture has been the players' differences in specifying their goals. To mention one example, the Viva project was not specified as much, as they did not really know what the project was going to result in. Of course, they had a lot of different goals with the project, but not all specified from start. This, unlike the engineers, who wants everything specified in the smallest detail in order to know what to construct. Therefore, when they started with the Viva project they first had to clarify the target. Something, that took them half a year and first when it was done, they could start working.

4.4.5   Team Stability and Group Efficacy

From the official start of PFH in 2012, there have been a total number of 50 meetings (approximately 10 per year), with a total of 28 different companies and 111 different people involved. The involved partners have changed throughout the project's development, although most members have been the same since the beginning, others have only been part of a few phases of the project, see Appendix 2. Additionally,

some of the participants come occasionally and other more regulatory. Riksbyggen, JSP, Chalmers University of Technology and University of Gothenburg form the base of PFH platform and are also the ones that comes regulatory to the meetings. Many of the consultants are not involved longer (which may be because they not get paid) but the researchers still come. The PFH coordinator is responsible for the search process and are constantly working to find new actors that may be involved.

As stated in Chapter 4.4.2, one challenge is to make the meetings interesting, so people will return, but at the same time, the theme of the meeting cannot be relevant for everyone. However, it is one factor that determines if people chose to come to the meetings or not. An important part that usually makes the discussions more interesting are the external guests. They usually add much to the conversation and therefore participants should be able to invite external guests if they wish. According to Interviewee 5, it gives legitimacy to the conversation that someone comes from outside, it gives the conversation a shot in the right direction. Generally, there is a fixed invitation list via email and there are often 15-20 persons in the meeting. However, in the last semester fewer actors have participated, which may have to do with the fact that PFH is somewhat between projects at the moment. Brf Viva is almost finished and Brf Slå Rot and Lindholmshamnen are still in their early phases (Interviewee 5).

According to observations, the PFH group is a unified team, which by working together strives to achieve better goals. According to one of the interviewees, PFH is a good team, in which the actors support each other. They really have teamwork, this interviewee states. Further, he believes that all actors in the team a working towards the same goal, which is important. Moreover, by observing the communication during the meetings, the actors appear quite engaged. Of course, some individuals are more engaged in the conversations than others, but all seem interested. For example, actors that are only involved in one of the building projects, seems to be engaged in other building projects during the conversations as well. Hence, the PFH platform feels like *One* project, were individuals collaborate together towards the same goals, not towards individual goals. Furthermore, it is clear that they are committed and have a genuinely interest in contributing to sustainable development in the construction sector.

Even though all actors seem interested at the meetings, there is no requirement that the participating actors must contribute all the time, i.e. contribute to the discussions or come up with new ideas (Interviewee 5). They do not need to participate in all discussions, but it is okay if a person just wants to listen because he/she thinks it is interesting. All actors involved work with different things and have different interests, hence, it goes without saying that everyone is not involved in all discussions all the time. Furthermore, the PFH coordinator states, that he does not want to control the meetings too much by giving direct questions, but those who want to be involved in the discussions may be so. As mentioned earlier, it seems to be important to find a balance of who is communicating during the meetings. Meetings that are too strictly planned do not give room for spontaneous ideas and opinions, but when there is room for a more open communication, the most interesting inputs arise. Although there can sometimes be a fine line between what is interesting for the group as a whole and what is interesting for each individual, and therefore, balancing between freedom of talk and structuring the meeting is important. Further, the PFH coordinator states that,

just as everyone does not participate in all discussions, not everyone is present at all meetings. People come when they feel there is something that interests them on the agenda and when they have the time, but that is fine he states.

4.4.6 Power Distribution and Hierarchy

The primary sponsor of the PFH platform is Riksbyggen's division Residential Region West. However, they, together with the central sustainability division tries to split on the costs, i.e. the development costs and costs for the individual project. Additionally, PFH have applied for several financial foundings during the course of the projects. This have resulted in some part-financing from different authorities. As a primary sponsor, both financial but also other resources, Riksbyggen are responsible for the economy and also for the risks of the projects, which mean that they are taking the final decision making. According to Interviewee 3, there is no shortage in ideas, and it can be easy for the collaborators to have opinions about other's money, and therefore, Riksbyggen have been clear that they have the final decision. Here, it seems to be challenging finding a right balance between the actors in PFH. Due to that the final decisions are always made by actors from Riksbyggen, and that the other involved actors have not financed the project, it may result in imbalance. Riksbyggen will profit most on PFH but they will also lose more if the project fails. It may be conflicts if some expert thinks that they have been invited for expert opinion, but in the end, management of PFH choose not to take the direction they suggested. Not least, it may cause them to lose interest in a future involvement in PFH.

Sometimes, there can also be difficulties when collaborators from Riksbyggen are too engaged, and sometimes take the lead from the PFH coordinator. This is understandable, due to the above-mentioned facts, Riksbyggen takes more risks and also contributes with the most resources, although, actors from Riksbyggen and the PFH coordinator should be synchronized to facilitate the meetings. Findings from empirical data shows however somehow contradictory opinions regarding the distribution of power. According to one collaboration partner, Viva is a very organic project where everyone is engaging in taking the decisions (Interviewee 7). This unlike another interviewee stating that some actors have more to say in the decision-making process than others. For example, one collaborator states that they do not want to say yes to all new ideas, but they state that the aim is to do the right thing. Therefore, if actors from Riksbyggen are taking the wrong decisions, they will hear it. Even if it can be uncomfortable (Interviewee 7).

4.4.7 Driving Forces

Several of the interviewees, both people in the management as well as the PFH coordinator, believes that for the PFH platform and the projects to work, it requires people that are genuinely interested in these kinds of questions (sustainability and innovation) and are willing to work hard to drive them forward. The interviewees describe these people as "Eldsjälar" in Swedish, which are people who have a burning enthusiasm for something and are willing to put a lot of time and energy to work on it.

Several of the interviewees describe that there are, among others, two (one of whom is now retired) such driving spirits in Riksbyggen that from the outset have had a burning interest in the PFH platform and its projects and have driven the projects

forward. Both have been in the management at Riksbyggen and are described as people who have been really ambitious in PFH and have been involved from the beginning and set the ambitions with the platform and its projects. One in the management says that both have had a genius interest in changing things for the better, doing good things, things that are talked about – such things drive these two individuals, he believes (Interviewee 3). Further, he tells about the one driving force that is still working at Riksbyggen, that he has been working there for 20-25 years, and describes him as a person who is confident in himself and in his role, one who dares to make important decisions. He tells, that in the Viva project much was unclear at the beginning and the fact that they were to build on a hard ground with steep slope and in an area where people are against construction did not make it easier. But this person managed it and was not afraid to make the difficult decisions that were needed initially.

Already before one of the driving forces retired, there was a concern regarding the future of the PFH platform. The PFH coordinator expressed concern that both would retire, or especially one of the driving forces since he has pushed and supported the other (Interviewee 5). Furthermore, the PFH coordinator stated that he did not know if there is a big risk that PFH won't keep him funded if both of them would quit. At one of the meetings, a participant also expressed his concern and asked the group how to become independent of the strong driving forces, as they do not have many of them. He meant that the platform may be a total flop without them since their way of leading is about something else than getting the business to roll quickly and efficiently and at a good cost – they have a genuine interest, that is of great importance, he stated. Now, one of the driving forces have retired, but the concern that the platform will be put down when the other one is retiring is still there. He is getting closer to retirement age and there is a risk that he will not stay there for such long.

Interviewee 4, also expresses his concern that the platform will not survive without its driving forces. Of course, he hopes that it will, but then he believes that it is necessary that the management higher up in Riksbyggen actively addresses the question and put some time and effort in it. Otherwise it will be hard he thinks. Further, he states that the driving forces that they have had have been self-named, although it does not mean that new self-named driving forces will appear, but the management really have to address the problem. The one driving force that is still working, also expresses concern that the platform will not be running for so long after he has retired. He says, that for an innovation project such PFH to work, there is a need for a genuine interest in innovation and development, an interest in being at the forefront. Further he states that people must be committed, because such projects take time, and nobody has time today. Therefore, people must prioritize it and understand that it is important. However, in addition to the interest and commitment there must also be a business benefit in the project. From the work with PFH, Riksbyggen have gotten a lot of projects as well as become an attractive partner, this insight one must also have, he believes. If the platform will continue or not, remains to be seen (Interviewee 4). However, one in the management says that he sees a willingness, drive and curiosity within the actors from Riksbyggen to continue with PFH, and to work innovatively and with research.

This is also something that have been witnessed during the observations of the meetings with the PFH group. Based on observations, the two driving forces described above are not the only ones in PFH. Other driving spirits have also been seen, people that may have gained more space since one of the others retired. These driving forces are either in the management of Riksbyggen or work with sustainability issues in the organization, and all have shown great interest and commitment in the meetings and projects within PFH. Furthermore, the authors have also identified other engaged actors which are not part of the management, but which are researchers that have been involved from the start of PFH.

Last but not least, several of the interviewees have mentioned another driving force that has also been of great importance to PFH - namely the City of Gothenburg. According to Interviewee 2, there is a driving force in the municipality of Gothenburg, and they are one of the reasons to all innovation projects in the city. The City of Gothenburg values sustainability issues high, she says. Furthermore, she says that Riksbyggen feels they have to live up to their sustainability parameters. If they do not, they will not get the best ground. This is nothing she has facts on, but she knows however that the City of Gothenburg have tough demands in terms of sustainability, and they pay attention to those who deliver in those parameters. She believes that innovation projects like PFH works well in Gothenburg, since there are both good universities and the city that focuses on sustainability issues. In Malmö, there is no such good universities and in Stockholm, the city is not driving environmental issues as much, at least no one get credit for building sustainable in Stockholm, she states. Interviewee 1 agrees that the City of Gothenburg has a great interest in environmental questions and that they are looking for innovation in every project. He does not believe that PFH could have worked anywhere in the country as the city operates and is at the forefront of sustainability issues. Moreover, Interviewee 5 states that half of the research and development projects in Sweden are located in Gothenburg.

4.4.8 External Context Characteristics

Based on interviews, it is clear that not only the internal environment characteristics (discussed above) are important for the PFH platform, but the external environment characteristics, in terms of booms and recessions at the market, also has significance for the platform and its existence and future.

In interviews, one of the respondents expressed concern about a future recession and its impact on PFH (Interviewee 1). This interviewee believed that PFH's future within 3-4 years looks good, but that it is related to the current boom at the market. Furthermore, he stated, that now there is lots of money in the industry, meaning one can afford to be innovative. In addition, the boom leads to new projects being introduced in PFH, which means that the platform continues. If suddenly there would be a recession, the management may cut projects like this down, it usually happens, he stated. Interviewee 4, on the other hand, argued that it is harder for Riksbyggen to receive tenders from contractors during a boom, since they at that time have so many projects to choose from. Just sending the specifications out and getting contractors to count on those, does not work. Then, they will receive no tenders. Instead, Riksbyggen have to go out and introduce themselves to the contractors, they must promote their proposal. He also stated, they must tell the contractors that they are looking for long time relationships, due to, as he self-described it; "Now, it is a boom

on the market, and the contractors can choose whatever project they want, but sometime a recession will come, and then it is good if we have a good relationship" (Interviewee 4). Unlike, Interviewee 1, Interviewee 5 was not worried that a recession would negatively affect PFH. On the contrary, he believed that is during a recession that companies must be innovative and come up with new solutions in order to stay competitive on the market and compete for the customers.

4.5 Sustainability in PFH

The building projects in PFH are quite spectacular, as they all contain sustainability aspects that usually are not included in "normal" building projects. Empirical findings show however that there are some challenges with the sustainability aspects, which will be presented below.

The goal with the platform is to develop sustainable housing, where the residents can live in a sustainable way. Therefore, the first difficulty that challenge the sustainable objectives is the fact that one cannot force people to live and behave in a specific or sustainable way. It is possible to guide people or nudging them into choosing better alternatives but not more than that. The PFH group want the residents in Brf Viva to live and behave in a sustainable way, but if they do not, there is not much one can do about it. Due to this, Interviewee 5 states that actors in PFH are afraid of the fact that living in a sustainable building is going to be an alibi for other tress-passes, i.e. there may be a risk that people are going to think "I have done my part now, I live in a sustainable building". Riksbyggen has however the intention of following up on how the residents live and to what extent they use the different functions of the building. In the final phase of the project, a dialogue with future residents will namely be conducted, in order to follow their way of living in their new accommodation Brf Viva. More specifically, through this dialogue, Riksbyggen aims to find out to what extent the residents share things, use the mobility service, use the greenhouse for cultivation of vegetables and so forth. If the residents to not use these things and do not live in the "sustainable way" they are supposed to, that is nothing people from Riksbyggen can do anything about. They can only show good examples of how to live sustainable, which they have worked really hard on (Interviewee 5). To name an example, the residents in Brf Viva are not allowed to park any cars in, or near the building but are offered a carpool instead, this to promote a living without car. However, if the residents choose to have a car anyway, and park it somewhere else, this is nothing actors from Riksbyggen can do anything about.

One can discuss what a successful project is. What is success and when is Viva successful? According to Interviewee 4, the project is successful when the user is satisfied, when the project is finished in time and when there is capital left in the end. But, on the other hand, if all these factors are achieved, the project can still be a failure. If the process of achieving a successful project is difficult, if there have been conflicts or people have left the project, then Interviewee 4 thinks that there is no success. Consequently, purely success means a project that runs smoothly, is finished on time, with satisfied stakeholders, both users and the project-organization. In Viva, success means being satisfied in a bigger perspective due to all the extra work (compared to normal housing projects). Even if Viva is not finished on time or runs over budget it would be seen as a successful project due to the fact that one has achieved something new, achieved new sustainable sub projects, achieved something

innovative. For instance, the new concrete has been very successful and got a lot of publicity, which is a triumph itself. If Viva then would be a bit after time schedule due to the ground condition or something else, is would not be a failure, due to all other things that is successful, and makes the project special (Interviewee 4).

So, the process and the result can be differentiated, the process can be successful and even if people are not interested in the sustainability aspects, the apartments are sold anyway. Hence, the process and the result can be very different things. That is why, in the initial phase, the aspect of what success is, is discussed and assessed (Interviewee 4).

4.6 Construction in PFH

The open innovation case, the PFH project have the specific feature of being in the construction industry, whereas the demonstration projects are housing projects. Building projects are very diversified, one is not equal to the other, which is a challenge. Therefore, the management in various building projects have to be used to this and cannot be stressed up when they get new challenging projects with high complexity. According to Interviewee 4, it is hard to be innovative in the building industry, but new technology is developed and in general, one has to work with innovative products more in the industry.

According to Interviewee 2 there are tremendous many challenges in the PFH project. Currently, the PFH group has accomplished the systematics of PFH, which has been a difficulty. The tools that have been developed have a finished infrastructure and can now be refined to accomplish more sustainable developments. A problem with housing production is the long processes and that the building is going to have a life cycle of many years. One can think that something works but then after 10 years, it may not be the case anymore. That is why it is important to understand what one is doing, which Interviewee 2 states is always a challenge, building a huge system where everything is connected to one another and which should exist in hundred years is a hard thing to do. Hence, of course it is hard to make decisions when designing and constructing a building, that are the greatest difficulties Interviewee 2 experiences.

One interviewee state that, they are not creating a sustainable housing project, but a sustainable home/living. When collecting the empirical data, it got clear that in a housing project, the end user requirements have to be considered. This is of course the same case for housing projects in PFH. For instance, there was a discussion about the surfaces in the apartments. The concrete has a higher level of absorbance of carbon dioxide if not covered with, for instance paint. Hence, the concrete will absorb even better if the walls inside of the apartment remains unpainted. This was actually something the PFH group wanted to do, but it did not get realized because they were afraid of what the consumers would think about it. Most consumers do not like the raw surface that unpainted concrete walls bring and therefore this was not an option. However, one decided to not pain all parts of the facade, which has become a specific feature about the project.

The price of the apartment is depending on the market, especially when it is being sold as a condominium. For example, this means that even if Viva's total cost is lower than other similar apartments, this still means that the buyer can, if wanted, sell the

apartment for a lot more the following day, which is unfortunately a common action on the housing market (Interviewee 3 and 6). According to Interviewee 3, Riksbyggen do not want to risk this happening, because to the sustainability perspective. Hence, Riksbyggen cannot stretch too much from market prices. Moreover, people do not want to pay much more for the apartments, despite of the sustainability aspects. Some people will probably pay more but there is a limit of how much more, due to the already high amount that the market prices is today. For instance, it is easy to choose the eco milk for 2 SEK more but not 2 Million SEK more for an apartment (Interviewee 3).

The apartment's price is, among others, calculated from the square meters of it. In the beginning of Viva's business model, it was found that the space that could be sold (the apartment) was too small in relation to the total space, mainly due to the bigger common areas in the building (orangery, living room, greenhouse etc.). According to the calculation, Riksbyggen would not get enough payment from the sale, which resulted in a decrease of the common area and increase of the private apartment areas. According to Interviewee 2, this is not something they could influence internal, but an embedded fault in how firms in the industry design and works. Furthermore, she states that this will not work if we want to head towards smaller apartments in favor of more common space. By doing this, we can reduce the usage of space and maybe get better living standard to a lower price. PFH group also discussed that one wanted that a heterogenous group of people, from different social classes in Viva. The result from the discussion was that it is hard, and the only way was to decrease the size of the apartment (Interviewee 6).

4.7 Summary of Empirical Findings

We now know that PFH can be defined as a cross-sectional research platform where innovation process aims to, by building partnership and collaboration, develop environmentally, socially and economically sustainable residential areas. The projects outcomes are currently being realized in the three housing projects; Brf Viva, Bfr Slå Rot and Lindholmshamnen. In short, PFH is the spinning wheel that spins in parallel to the three housing projects, which are linear processes. We also know that the platform started without any clearly set goals, except with the vision of creating something at the forefront of environmental sustainability and has today involved more than 28 companies and 111 actors at meetings - saying quite a lot about the extent of the platform. It has also been understood, that managing the PFH platform comes with several challenges, as well as enablers, that can facilitate or aggravate the open innovation process. Below the five most important ones are given;

Leadership by "Driving Forces" and "Innovation Broker": First and foremost, the management of the platform is a crucial factor for the platform to function at all, and mainly two different groups of people have been observed that lead and organize the platform. Partly, it is people within the management of Riksbyggen (the driving forces) which have shown a great commitment, have a high interest in sustainable and innovative issues, and drives the platform forward. And partly, it is a person from JSP (the innovation broker), which has been hired as a consultant for Riksbyggen to lead and organize the platform. Both of these groups have had a significant impact on the platform and are crucial to its outcomes.

Team diversity and Team stability: Secondly, team diversity and stability is a big challenge. PFH is a high diverse team which can be hard to manage. The high diversity put demands on the actors to be open and transparent towards each other. However, it seems that the high diversity mainly has benefited the group as it leads to faster processes. Another challenge is to have a balanced team stability, i.e. a balanced in and outflow of actors. Meaning the managers must be able to handle a high diverse team and work on finding new actors to bring life and ideas into the group.

Cognitive distance: Third, cognitive distance, i.e. differences in goals and working culture is a big challenge. The actors in PFH may have similar as well as competitive goals as well as different ways to work, meaning that the managers must create a culture in which there is a balance between competition and cooperation among the actors.

Power distribution and Hierarchy: Fourth, power distribution and hierarchy is a big challenge. The PFH platform have a quite flat structure and the actors do not seem to have a problem sharing knowledge. However, there are some kind of hierarchy as actors from Riksbyggen are the ones taking the final decisions. Therefore, a balance is needed here, so that the other actors will not feel that they have no influence.

User integration: Fifth, user integration is a challenge, but something that is important to have for a successful innovation outcome - and something that actors from Riksbyggen have used quite a lot. On several occasions they have invited future

residents to hear their thoughts and opinions about the project, which is something they most likely will benefit from in the end.

5. Analysis and Discussion

In this chapter the authors make an analysis and discussion of the empirical material and whether it relates to the theoretical framework or not. This is further combined with own reflections of the study.

5.1 Open Innovation Practice

From the empirical findings, the core innovation process of PFH have been identified and aligned with the outside-in-process which Gassman and Enkel (2004) write about. In the outside-in-process, firms invest in collaboration with external actors to integrate the obtained external knowledge in the innovation process, which fits nicely with PFH case. As seen in the empirical part, management of Riksbyggen in Gothenburg contacted JSP among others, to bring external knowledge and ideas to the PFH project. Due to the fact that Riksbyggen Region West is the initial and primary financer of PFH and make all decisions, one can argue that they are the one that bring in external knowledge in their innovation process. Furthermore, as Gassman and Enkel (2004) states, the integration of external actors may enable valuable sources of knowledge and capabilities that are required for product or project development. Indeed, it seems that, by letting external factors such as universities, suppliers and customers contribute with their competence to innovate and develop new ideas, PFH can be enhanced and developed. Moreover, as theory states, companies with products that are highly modular and knowledge intense where the internal knowledge will not fulfill the need of knowledge, should approach the outside-in process (Gassmann and Enkel, 2004). Riksbyggen is a corporate real estate company that builds and maintain condominiums. In their general, daily operation, outside of the PFH project, they are not knowledge intense as they operate as a client. They therefore do not need in-house expert knowledge. However, in the perspective of the PFH platform, they are in need for knowledge intense competences for developing PFH and therefore, acquiring external knowledge is crucial.

5.1.1 How to Manage Open Innovation in Practice

Wallin and von Krogh (2010) have developed a model that managers can use to integrate knowledge in open innovation projects, which involves five steps; 1) defining the innovation process steps, 2) identify relevant knowledge, 3) choosing a suitable integration mechanism, 4) create an effective governance mechanism and 5) balance incentives and controls. Comparing these steps to the case of PFH, it gets clear that the theory is not always aligned with the empirical findings. The PFH cooperation has done many things "by the book" without knowing it, while they also have done many things that do not follow the theoretical framework. In the beginning, the group have identified some objectives, although vague. They knew that they wanted to create a project that was at the forefront of sustainability and by researching, develop sustainable housing solutions, but they did not know which direction to go to achieve the vision. Eventually, along the way of the project, the steps become more concrete. Due to the unstructured steps, sources of knowledge that have been relevant for PFH have been identified along the way, which is in contrast to the literature, where Wallin and von Krogh (2010) state that domains relevant expertise should be identified as a second step of the innovation process.

Comparing the third step to the empirical data, findings show that the PFH group actually use integration mechanisms such as routines and solving group problems that may have enabled an effective open innovation. For instance, theory state that routines caused by tasks or problems drive the organization to access external knowledge, and in this case, routines such as monthly meetings and thereby a regular discussion of how to proceed, seems to have driven the platform forward. Furthermore, theory state that another mechanism is integration trough decision making and solving group problems. For instance, external sources do not only contribute by solving pre-specified tasks, but do also contribute to defining the phases, tasks, issues, and processes of open innovation, which has happened in the PFH platform. Even though all actors have not been involved in the decision making, they have been involved in the discussion and conceptualization of how to solve ideas. This may have been favorable for the integration of external knowledge in the open innovation process. Last, effective governance and balancing between controlling the result and quality of the work of outside actors, and at the same time give enough incentives for actors to be involved, will affect the open innovation process. It is difficult to study all the collaborators motivation or incentives of why they want to be a part of PFH, but it seems that the motivation can be both monetary and non-monetary, depending on the role of the actor. Moreover, the governance and level of control will be more analyzed further below in this chapter.

Wallin and von Krogh (2010) state that involved actors may change gradually and open up new possibilities for innovation. The group will generate new ideas and add more external knowledge and external factors such as new requirements in market and so on, which will cause managers to think through the steps of open innovation. This is something that, through internal documents and studying the process in which the actors have been involved and ideas have been developed, new decisions and new paths have been opened up to the PFH group. Also, by studying the prior decisions or process, one can see that there have been changes along the way (new knowledge, research projects, actors or ideas), which have resulted in the current outcomes. An interesting finding from studying the case and literature on open innovation, is that it seems that the PFH platform have not really stopped for planning, but more, continued forward without a detailed plan.

5.1.2 The Importance of User Integration

In open innovation, many different actors can be involved, and the consumer is one of the stakeholders that can contribute to the process and outcome. Arnold (2017) acknowledge the co-creation activities of current and future consumers in open innovation process, which increases the possibility for a consumer's acceptance but also the awareness of the invention. This means that the user is involved from the starting idea, development process and to the last phase when the invention is implemented and diffused in the market. Empirical findings show that the PFH group have tried to involve the public, as they have invited them several times in the beginning of the Brf Viva project. Unfortunately, it seems that the interest to be involved in the Brf Viva project have been quite low. Therefore, the authors have not made findings of how the public have affected the outputs of PFH. In the later phases of Viva, the general public have not been involved, but rather the consumers, the buyers of the apartments. Findings show that through research projects there have been made some efforts to involve the future residents of Brf Viva. For instance, a

current dialogue with the buyers have been conducted, making it possible for them to affect their own home. As an example, they could be involved in designing the common areas. Here, it seems that the users are more motivated to contribute, but as they engage in their own apartment, this may explain why it is easier to create a dialogue. It would be interesting to follow the proceedings and see whether the efforts of involving users in the later process of the building become a success or not.

Additionally, in the Lindholmshamnen project, Riksbyggen have involved the target group of young adults in the process. In order to take part of their ideas about future living, as well as to let them influence the project they have had a continuous dialogue process. The meetings have, unlike a part of the Viva dialogue, been very successful and many young have participated, which have led to the fact that the PFH group has received many interesting views and opinions that they have taken into consideration when planning the project. As literature suggests and as PFH have done, it seems to be a smart way of using the consumers to try products and ideas. In this case, the different sustainable sub-projects have been the topic of discussion and what the future consumers might think of them. The major goal with PFH is that the residents use and appreciate the sustainable tools and services, and if the PFH platform get feedback in the beginning, there is an increased chance that the residents are more satisfied with the result and will live in a more sustainable way. Not least, organizing workshop etc. for general public is a way of marketing the project.

5.2 Challenges and Enablers of PFH

Below, the challenges and enablers found in the case study are analyzed and discussed, in relation to the challenges and enablers presented in the theoretical part.

5.2.1 Leadership

Theoretical findings of leadership in open innovation state that there is a close relationship between leadership style and innovation outcome (Du Chatenier et al., 2009), and thereby, management's capability to coordinate knowledge flows and relationships is identified as a crucial factor (Ollila & Yström, 2015: Chesbrough, 2017: Chan et al., 2017). Hence, leadership is one of the key challenge in open innovation teams (Du Chatenier et al., 2009). Findings from observations of meetings in the PFH platform show that leadership seems to be a crucial part for the platform's development. There are a few observed people in PFH that lead and organize the platform. Partly it is the managers of Riksbyggen (called the driving forces) and partly it is a person from JSP, which have been employed to lead and organize the meetings and other activities within PFH (called the PFH coordinator). Even though the authors only have been attending to four meetings and due to all different actors involved, management and coordination seems critical for the platforms success. In meetings, the different actors have high degree of knowledge and many thoughts, and new ideas are constantly popping up during the meetings, which requires someone to structure the meetings and take the discussions forward. Therefore, the authors think that, with all the various actors involved, the group had never been able to organize itself, and therefore a coordinator is needed, which aligns with Ollila and Yström (2015) statement that an open innovation process is not self-organizing and therefore there is a need for management for a successful collaboration.

Du Chatenier et al. (2009) acknowledge the need to balance controlling and coordinating involved actors which seems to also be acknowledged by management of PFH. By finding the right balance, a subtle leadership can be achieved, as too little management and control tend to lead to untapped potentials and reduced productivity while too much management tend to reduce creativity. This aligns with the empirical findings, where challenges were identified, and which the authors founded some bit paradoxical. Firstly, PFH management face the question of having an open creative climate versus moving forward in the project. Findings from interviews show that it can be hard to know when to limit the ideas, from the beginning or later on in the project. If the creative phase is limited from day one, there is a risk that creativity gets hindered and some ideas get missed, meanwhile, if there is no limit, there is a risk that too many ideas result in nothing. Therefore, as literature states, management should aim to find the right balance between controlling and coordinating, and preferably use a subtle leadership (Du Chatenier et al., 2009). Empirical findings show that management of PFH, more precisely the PFH coordinator has experienced the difficulty with achieving the right balance. The meetings should be organized to be efficient, however, experiences have shown that the meetings should not be too organized and structured as they must be open enough to bring forth unexpected points of views and ideas. Although there is not always time for long discussions and therefore, is it also necessary to lead the conversations in the right way.

PFH Coordinator as Innovation Broker
Issues like lack of time or fundamental difficulties in establishing partnerships in open innovation may be solved by acquiring an innovation broker or intermediary, which organizes the network and builds trust between the networking members (Huizingh, 2011). The main task of an innovation broker is to ease the innovation process (Petroni, Venturini & Verbano, 2012) and the knowledge and technology transfer "across people, organizations and industries" (Howells, 2006). From the empirical findings, mainly, one person seems to operate as an innovation broker, and is in the empirical part called the PFH coordinator. In theory, Howell (2006) states that innovation brokers often are founded in intermediary organizations, bridging institutions or innovations community, which fits nicely with the empirical findings as the PFH coordinator are employed at JSP (a meeting point for industry, academia and society) and work as a consultant for Riksbyggen to lead and organize the meetings, workshops and other activities in PFH.

According to Petroni, Venturini and Verbano (2012) the innovation broker need to have the ability and knowledge to effectively acquire external knowledge and make it useful in new processes or products. They must have a technical/scientific background as well as a thorough understanding of the organization and its strategies and challenges, enabling them to integrate knowledge in line with the managerial requirements. Riksbyggen wanted someone that could function as a link between the firm, the academy and the industry, as well as leading and organizing the PFH platform. Competences that was required for the role was good basic knowledge for the job, which the PFH coordinator got through his education in sustainability and architecture engineering, prior employment as an architect and involvement in a student-led organization that aims to raise awareness about sustainability. This means that, as literature states, both technical and scientific capabilities are achieved. Furthermore, empirical findings show that the PFH coordinator possess soft skills such as being systematic, organized, communicative, friendly, social and being able to

network and build partnerships and collaborations. In theory, Ollila and Yström (2015) state that there is a need for a manager that can coordinate the complex social processes with many different collaborators. The manager should have interpersonal and relational skills as well as gain trust and respect from involved actors, to manage all challenges existing in an open innovation. Howell (2006) state that the intermediary can help to develop relationships in networks working with open innovation. The competences that the three above mentioned researchers acknowledge, is acquired by the PFH coordinator.

5.2.2 Team Diversity

The literature states that an open innovation group normally involves people from different disciplines that have different professional backgrounds (Chan et al., 2017). This is in line with the case of PFH, in which a total number of 28 companies with 111 different actors was observed at the PFH meetings between the years of 2012-2017, see Appendix 2. In the platform, both suppliers, consultants, researchers and students in the industry, as well as consumers, researchers and students outside of the construction industry are involved. All of these people have different professional backgrounds, experiences and knowledge, telling that the team diversity is high. However, according to Du Chatenier et al. (2009) not all external collaborations, with members from different organizations tend to result in successful projects. The researchers mean, that it might just be the fact that the actors come from different organizations that cause social and communicative conflicts, which tend to lead to a more complicated and expensive project. As seen during observations of the PFH meetings the diversity in the group sometimes lead to more complicated processes. For example, the discussions tend to take longer time as things need to be explained more thoroughly. Furthermore, Interviewee 4 states that when working in these groups with lots of actors involved, one must be understanding and humble towards each other, as everyone possesses different knowledge - which can be quite a challenge he believes. However, on the basis of observations, if feels like the fact that the team diversity is high really benefit the group. It allows the actors to get immediate answers to each other's questions. This leads to faster processes and that innovative and sustainable solutions are developed, that might not have been otherwise, which is in line with the theory saying that high diverse teams tend to come up with more creative and innovative solutions (Du Chatenier et al., 2009). However, such teams do require more work on sharing information, they place more demands on the actors to speak and express their opinions, although on the basis of observations, the climate on the meetings appears to be open, and it feels like people do express themselves and ask a lot of questions.

Overall, the feeling is that the PFH platform benefits from the team diversity. Even though processes and discussions during meetings takes longer time, it also allows participants to quickly answer questions. By working together, they have gained access to a large network that has benefited them in their projects. Furthermore, they can easily come up with more innovative and sustainable solutions by working different actors together. Solutions that they might not otherwise had been able to come up with, not at this time at least. However, for a group like this to succeed, it is important to know how to control it. For example, the leaders need to be aware of the importance of sharing information and to express the importance of the actors to share

their ideas and opinions. Leaders must promote an open climate, which the leaders in PFH really seem to do.

5.2.3 Cognitive Distance

A big challenge in open innovation team is, according to Du Chatenier et al. (2009), to avoid cognitive distance. They describe cognitive distance by, among others, *Differences in goals* and *Differences in working culture*, in which the first refer to the will and commitment of the actors to achieve the same goal, and the second refer to how organizations works and solves everyday problems.

According to some of the interviewees, the various actors involved all have different goals and incentives with the participation in the PFH platform, which is a common problem in open innovation teams (Du Chatenier et al., 2009). Du Chatenier et al. (2009) states that in these kind of teams, actors involved may have similar as well as competitive goals, which can make the process difficult to handle. An actor putting his/her goal in front of the group may even cause the project to fail. This however, seems not to be a problem in PFH. As one interviewee states that, although the various incentives may create problems there must be incentives for the actors, in order for them to join the collaboration and to actively participate. Without incentives, he means, the projects will come to nothing. Of course, all actors have different goals with their participation in PFH, but in general, another interviewee state, most are involved due to their interest in being part of developing something good. Furthermore, he believes, the actors are involved because they feel that people from Riksbyggen are genuine in what they do, that they do good stuff, towards sustainability. Additionally, he believes, the actors feel that they can contribute with something, by joining the platform. According to Ollila and Yström (2015), the conflicting objectives of the actors from different organizations is a challenge that an open innovation manager have to face. However, this is not something the PFH group seems to have problems with. They seem to balance competition and cooperation between the actors rather well, something that Du Chatenier et al. (2009) state can be quite a challenge.

Du Chatenier et al. (2009) mention differences in working culture as another challenge open innovation teams have to face, a problem that has also been identified in the case. According to several of the interviewees, the differences in corporate culture are one of the major challenges when working in PFH. Furthermore, Du Chatenier et al. (2009) state that actors from different organizations are used to work in different ways, something that can cause problems and make it difficult to develop common plans. According to observation, this is just the case in PFH, as many of the actors involved come from different organizations and are used to different ways to work, this sometimes cause corporate cultural crashes. These crashes must be addressed early on in the process, one of the interviewees states. The management of PFH has a great responsibility regarding this, as they must be able to handle the different actors and the corporate cultures that comes with them. However, even though the diversity of actors sometimes causes cultural crashes, working like this is challenging but fun. By working like this one gets to know many different people, however clear roles and boundaries is the key, the interviewee believes. Working like this, can consequently both inhibit and/or stimulate the process, something that is also addressed in the literature by Du Chatenier et al. (2009).

5.2.4 Team Stability and Group efficacy

According to the literature, team stability is another challenge in open innovation teams, and refer to the entry and exit of actors within a team (Du Chatenier et al., 2009). Du Chatenier et al. (2009) suggest a balanced team stability, as in a too stable team implicit rules and groupthink tends to arise, whereas in an unstable team there is a risk of losing the organizational memory. As also mentioned above, from the start of the PFH platform there have been a total number of 28 different companies and 111 different people involved in the meetings, it has consequently been extremely many actors involved in the platform. This has meant that the risk for groupthink is small, and from observations it can be seen that the members have not been afraid to criticize each other if necessary. This is in line with the literature saying that the risk of groupthink is normally very small in open innovation teams consisting of an ongoing mix of actors (Du Chatenier et al., 2009). It does however not seem like the group have lost its organizational memory despite all the various participating actors and their ongoing in and outflow. Du Chatenier et al. (2009) believe that this is a huge challenge, to cope with the uncertainty that may arise when there is an ongoing flow of actors. From observations, it seems however that the PFH group have managed this challenge pretty well. This is probably due to the platform having a "steady base" consisting of a small number of people who have actively participated from start, people who maintain the organizational memory. These people have formed the group and other actors have been able to participate whenever they want, which has given the steady base a new influx of thoughts and ideas. Furthermore, the constant inflow of actors has provided the meetings a new dimension, with more interesting discussions, which in turn has attracted more actors to the meetings. Overall, it seems that the PFH group has a balanced team stability, with a steady base of people who constantly participates and a more moving group that comes when it interests them - which gives a good harmony. The challenge is to constantly bring in these new actors who bring life and movement to the group, who come in with new ideas, as well as to have a group of people that is constantly attending - which can be difficult when people change jobs or retire, and new players come in who may not have the same interest in innovative and sustainable issues.

Group efficacy is another challenge discussed by Du Chatenier et al. (2009), referring to the members faith in their ability to perform but also their belief of a high collective efficacy. According to one of the interviewee involved in PFH, they are a good team in which the actors support each other and work together as a team. This is also something that have been seen during the observations, i.e. that they are a unified team, which by working together strives to achieve better goals. According to the literature, group efficacy is also about fair dealing and a mutual commitment (Du Chatenier et al., 2009), something that also been seen during observations. In the meetings the actors appear quite engaged. Of course, some individuals are more engaged in the conversations than others, but all seem interested. In addition, they are interested in each other's projects, and not just the ones they work with, which gives of feeling of PFH as *One* project, where individuals collaborate together towards the same goals, not towards individual goals. However, even though all actors seem interested at the meetings there is no requirement that they must contribute to the discussions, but it is okay if a person just want to listen because he/she thinks it is interesting. This differs somewhat from the theory saying that one should be attentive to those actors not contributing to the group but enjoy the outcomes of the collaboration, to be attentive to the "free riders" (Du Chatenier et al., 2009). In PFH,

there are of course those who contribute less to the discussions, but anyhow one does not view them as "free riders" but rather they are welcome just to listen.

5.2.5   Power Distribution and Hierarchy

Literature state that hierarchy can be another challenge of open innovation teams and refers to the positions the actors have in a particular team, what control they have, how the power distribution looks as well as how decisions are made (Du Chatenier et al., 2009). Observations of PFH show a flat project-organization, where is seems that many of the involved actors are engaged and have enough power to be critical or state their opinion, which can result in engaged discussions and high level of knowledge transfer. Literature state that knowledge takes place both when there is no difference in power between actors or when there is a difference that is controlled. However, mutual power and influence between actors enhance better learning and knowledge transfer (Du Chatenier et al., 2009). As stated in empirical findings, Riksbyggen Region West is the primary funder of the project, both of financial and human resources, which means that they are also exposed to a greater risk than other collaborators. This also means that they are taking all decisions, and thereby have a higher level of power and hierarchy. Studies have shown that in teams with high hierarchy, actors have difficulty in transferring knowledge and developing new ideas. Furthermore, Du Chatenier et al. (2009) state that in alliances such as open innovation teams, it can be difficult finding a balance between power and dependence, influencing others and being influenced and lastly balance being in control and being out of control. Hence, although these teams must have a plan for how the projects are managed and organized. Due to that the final decisions are always made by managers from Riksbyggen, and that the other involved actors have not financed the project, it is not fully aligned with theory and therefore, may result in imbalance. Riksbyggen will profit most on PFH but they will also lose more if the project fails. It may be conflicts if some expert thinks that they have been invited for expert opinion, but in the end, involved people from Riksbyggen choose not to take the direction they suggested. Here, it seems to be a challenge to find the right balance between the actors in PFH. However, this does not seem to hinder the cooperation due to the success of the collaboration. Moreover, it was found that sometimes, there can also be difficulties when actors with management roles are "too" engaged, and thereby take the lead from the PFH coordinator. Instead, managers from Riksbyggen and the PFH coordinator should be synchronized to facilitate the meetings.

It may be to consider, that other collaborators should have the power to take decisions as well, it might get them even more engaged and responsible for the outcomes of the project, and thereby foster innovation. Although, it is difficult to discuss this further, due to lack of insight in this area. However, from observations, it seems that the current hierarchy of PFH do not limit the discussion and ideas. And, as one interviewee state, the financing actor are putting in a huge amount of money in each project, which justify their decision making. However, it could create the feeling that it is rather a Riksbyggen project than a PFH project.

5.2.6   Driving Forces

In the PFH case it was found that according to several of the interviewees there are so-called "driving forces" in the PFH group, i.e. people in the management who have

a great commitment and interest in environmental/innovation issues and who drive PFH and its projects forward. In the literature study, no specific theory on so called driving forces in open innovation collaborations have been found, however, several researchers mention the importance of management and its impact on innovation outcomes. According to Ollila and Yström (2015) management is central to foster open innovation and Du Chatenier et al. (2009) believe that there is a close relationship between leadership style and innovation outcome. This is in line with what was found in the case, in which several of the interviewees stated that for the PFH platform and the projects to function, it requires people that are genuinely interested in questions regarding sustainability and innovation, people that work hard and drive the platform forward. Furthermore, they argued that there have been especially two such people in the management of Riksbyggen. Both of these have had a burning interest in the PFH platform and its projects from the start and are described as really ambitious. They want to change things for the better, things that are talked about, says one of the interviewees. This is supported by the literature saying that management support is a boundary condition for open innovation (Chesbrough, 2017) and that leadership characteristics are of great importance for open innovation projects (Chan et al., 2017). By this, one understands how great the influence of the leaders and their leadership style is. If they show great commitment, and put time and energy into the project, it is more likely that other actors will too - which most likely will lead to a more successful innovation outcome.

Thus, in the case it was clear that these two driving forces have been a major key factor for the project and its success. But it was also clear that there is a concern among the actors involved about what will happen to PFH when the other driving force in the management retires too. Four of the interviewees even think there is a risk that PFH will not continue without both of its driving forces. One of them states they must become independent of these people, while another argues that the platform may be a total flop without these two people cause their way of leading is about something else than getting the business to roll quickly and efficiently and at a good cost. They have a genuine interest, that is of great importance, he says. In the literature it is argued that the manager's role in construction projects is essential in forming a culture towards innovativeness (Matinaro and Liu, 2017), and therefore, it is suggested that this is something PFH should keep in mind for the future. As stated by one of the interviews, if Riksbyggen want the platform to survive, the management should address the question and put time and effort in it. They should highlight new driving forces/individuals who are really interested in sustainability and innovation development and let them work with PFH - because there is no guarantee that new self-named driving forces, like the two mentioned above, will pop up and take the lead.

What will happen when the other person in the management retires too, we do not know. But when it happens, we do believe it is important for the management to tackle the issue and appoints new leaders for PFH. During observations, we have seen several people in the group who have shown a great interest and commitment in PFH, people which could take the lead. Some of them have a great interest in sustainability issues while other are more the business kind of type. However, both types are needed to take PFH forward. The important thing is that they have the commitment and prioritize and are willing to put some time and effort in the project. Because these kinds of projects require a lot of time.

Last, another important factor, which does not involve internal factors of PFH, but which may have significance for this type of platforms, is the municipalities in the cities. While working with the case, several of the interviewees talked about the City of Gothenburg as a key factor for PFH´s existence. According to the interviewees, there is a driving force in the municipality of Gothenburg, and they are one of the reasons to all innovation projects in the city. They have tough demands in terms of sustainability, and they pay attention to those who deliver in those parameters. The interviewees say that working with sustainability issues and building sustainable projects really pay off in Gothenburg, for example by gaining access to good land to build on. We believe this is something other municipalities in Sweden should take after too - if they want to promote sustainable and innovative building in the future.

5.2.7 External Context Characteristics

According to literature, the context characteristics are of great importance for open innovation processes (Huizingh, 2011), something that has also been seen in the case study. In PFH, both the internal environment characteristics as well as the external environmental characteristics have affected the project and its processes. This is something that is discussed in the literature as well, in which Huizingh (2011) refers the context characteristics to the internal and external environment. According to Huizingh (2011), the external environment characteristics mainly has to do with the industry, as the industry specific characteristics affect the adoption of open innovation, something that fits well with the case showing that the construction sector have affected the adoption of PFH (this will be more discussed under the Construction section further below). However, Huizingh (2011) also refers the external environment characteristics to market turbulence and competitive intensity and South East England Partnership Board (n.d.) states that market turbulence with its recessions and booms have high impact on whether companies chose to focus on innovations or not. Based on the interviews it is clear that the external environment characteristics, in terms of booms and recessions at the market, has significance for the platform and its existence and future. The fact is, that one of the interviewees expressed concern about a future recession and its impact on PFH. He stated, that the nearest future of PFH looks good, but that it is related to the current boom at the market, and that a future recession may lead to the management cutting projects like PFH down. This is completely contrary to what another of the respondents said, which meant that it is in recession that companies must be innovative and seek for new solutions in order to stay competitive on the market, and therefore he was not afraid what will happen to PFH during a recession. This is a phenomenon also discussed in literature in which South East England Partnership Board (n.d.) states that, at the same time as a recession can make it difficult for companies to finance innovations and high-risk projects, a recession can also force innovations as the competition between companies increases.

Overall, one can say that it is important to have both internal as well as external environmental characteristics in mind when implementing and working with open innovation teams. This, since both internal and external factors can have a major impact on the open innovation process. By now, we know that internal factors, such as high diverse teams with actors accustomed to different ways of working, affect the degree of innovation. But we also know that external factors, such as industry and the

market with its ups and downs, have a high impact on the level of innovation. In the PFH group some actors felt anxiety for a future recession and what it might do to the platform. However, a future recession may not be something they are worried about but rather look at as an opportunity, and as a way, by working with PFH, makes them stand out on the market.

5.3 Sustainability Innovation Challenges

Empirical findings show that there are challenges in the context of PFH's specific sustainable goals. Theory state that due to firms' inexperience in new technological frontiers (Goodman, Korsunova & Halme, 2017), external collaboration is important for successfully innovating sustainable-oriented products and services (Melander, 2017). Looking at the PFH platform and the number of people involved, one can argue that the theory and empirical findings correlate to each other, which also fits with theory on open innovation. A real estate company's normal process of designing and building a house have not been compared to PFH, but authors have assumed that there are more actors involved in this case due to the high sustainability goals and thereby, the need for new competences for achieving them. Melander (2017) states that by developing sustainable-oriented products, incentives might be to improve or extend their competitive position on market, being in compliance with regulations, environmental consciousness of the government and public, customer demand, technological opportunities and ecological responsibilities. Case study showed that is seems that, from the beginning, there was a genuine wish for taking responsibility and achieving ecological, economic and social sustainability. The involved actors from Riksbyggen had the vision of that they were going to do something that is at the forefront of sustainability, and according to an interviewee, the focus is rather at finding new ways to build sustainable houses than make a lot of money. He told, if there is a choice of earning more money or bringing more sustainability into the industry, the answer would always be the latter. Nevertheless, the innovations must not go so far that they would in any way endanger the financer's organization. Even if there is a genuine wish that as many sustainable sub-projects as possible will be developed, the project has to gain enough from a cost perspective. Although, there is not the same requirements of making profit in Viva as usual. If it would be, it would not be possible to get the sustainable aspects and ideas.

As one interviewee from Riksbyggen state, of course they want to profit financially on the project, be competitive and advertise themselves. Observations show very engaging participants that do not settle for good, for instance, they want to make the concrete even better which gives us the impression that many of the participant are very genuinely interested in achieving something sustainable favorable. Additionally, it can be difficult to present economic profit and when sustainability results are not directly noticeable for the stakeholders, it may bring difficulties and risks for the firm (Arnold, 2017). This is an interesting point, how can PFH measure the outcomes of sustainable sub-projects? Due to a current housing shortage in Gothenburg, the apartments will probably be sold anyway, even if there are sustainable aspects or not. This could make it harder for construction or real estate companies to be motivated for developing sustainable solutions, if it is difficult to see a direct correlation of profit from it.

Furthermore, theory states that internal practices such as senior management support, clear goals and a strong company mandate, as well as consideration of long-term aspects and planning leads to sustainability and is essential for succeeding in innovation (Melander, 2017). In the PFH case, it is found that the senior management have been a driving force and a critical success factor for the PFH platform. There are a few people from the senior management at Riksbyggen that seems to be extra engaged in the sustainability question. Theory state that some companies have a centralized functional team with capabilities in form of sustainability, which have been identified in the organization of Riksbyggen. Riksbyggen's central sustainability division have been involved in PFH, to develop but also to transfer the outputs from PFH to the rest of the organization, which the authors think has been an important critical success factor. If the PFH platform was not supported by the management of the organization, it would be difficult to proceed with the platform.

Challenges that was not found in theory but that was found in the case is related to the sustainability aspects it how to ensure that the sustainable objectives with the platform are achieved. A company cannot force people to live and behave in a specific or sustainable way. It is however, possible to lead them on or nudge them into choosing better alternatives, which some of the sub-projects try to do (e.g. no car parking, common laundry room, sharing tools etc.). The aim of the building is that the residents should live and behave in a sustainable way, but if they do not, there is not so much to do about it. As founded in the empirical part, the collaborators are afraid of the fact that living in a sustainable building is going to be an alibi for other tress-passes. For instance, that people are going to think that they have done their part now when they live in a sustainable building, and instead will live in a less sustainable way than supposed to. The PFH group are aware of these problems and they have discussed of how to avoid them. Therefore, in the attempt to study this, the PFH platform intend to follow up how the residents live and use the housings different functions. The PFH platform has higher objectives than only selling the apartments. The fact that they want to make follow-ups to see how the residents live, shows that the group are interesting in achieving something more than just selling the apartments. This means that the project can be successful in the way that the apartments is attractive and gets sold out. But, this does not say anything of the sustainability goals, many of the sub-projects cannot be achieved if the users not using them right. Even if people are not interested in the sustainability aspects, the apartments may be sold anyway. If the residents do not live as desired, this will be unfortunate, because the goal is to create a sustainable housing.

5.4 Construction Innovation Challenges

Theory state that the open innovation approach is limited to the firm's product or features of the industry that the firm operate in, as well as that the industry's specific characteristics can both be drivers and hampers of innovation (Bygballe & Ingemansson, 2014). The open innovation case, the PFH platform has the specific feature of being in the construction industry, whereas the demonstration projects are housing projects. One contextual challenge, which is mentioned during the interviews is that each construction project is diversified and that no one is equal to another. This can be related to the complexity of the construction process itself that bring difficulties for innovation in the industry (Bygballe & Ingemansson, 2014). One interviewee state that one challenge related to construction is the long processes with

constructing a building and that the building is going to have a life cycle of many years. Hence, one can think that something works but then after ten years, it may not be that case anymore. Therefore, it is important to consider these challenges when building a huge system where every part is connected to another and should exist in hundred years.

In this structurally complex industry, companies need to rely on other companies and interact with various stakeholders. This mean that contractors and subcontractors with rather less understanding of each other's business and working habits work together in a project-based organization (Matinaro & Liu, 2017). In PFH, many different actors have been involved and they seem interested and want to be involved in each other business. This can be, due to that the collaborators are engaged individuals with an interest in the industry. Matinaro and Liu (2017) says that a major weaknesses of construction industry is to manage an innovative culture and thereby innovation. This is successfully done by the PFH platform, where an innovative culture has been created and operating in several years. Furthermore, successful firms have the ability to accommodate innovation into their organizational culture and management processes (Matinaro & Liu, 2017). As found in the empirical part, as well as stated above, the management of PFH seems to have a huge part of the innovativeness in PFH, and also the driving force for the innovation platform.

The construction industry is often blamed for being non-innovative and conservative (Bygballe & Ingemansson, 2014) and in related literature, it is often claimed for having difficulties in creating innovation and the rate of producing innovation is rather low compared to other industries (Matinaro & Liu, 2017). One interviewee, find the industry in general very conservative. It is hard to be innovative in the building industry, and as a project manager, one can often get stuck with old working methods. However, the development of new working methods is increasing, but rights now, there is a long way to go. In theory, Matinaro and Liu, (2017) find it highly paradoxical, that an industry, which engage a collaboration with a variety of actors, within the society and have enormous effects to economies, cannot be innovative enough. Further, they state that this refers to lacks creating the innovative culture and moreover to overall difficulties to lead innovativeness. This case study show however that the industry can be innovative and that it is possible to create an innovative climate with collaboration of actors, where they are seen as an asset rather than something that makes the process more difficult.

Another challenge that was found from empirical data and that have not been encountered in theory is that an apartment's price is, at a major part, dependent on the market, especially when sold as a condominium. A problem that can be identified by this, is that if an apartment in Viva is cheaper than other similar apartments, the initial buyers may sell the apartment for a lot more the following day, which is unfortunately a common action in the industry. This is not sustainable, the price cannot be stretched too much from market prices, cause then, no one will afford to buy the apartments. Anyhow, people do not want to pay much more for the apartments, despite of the sustainability aspects. An interviewee states that some people will probably want to pay more but there is a limit of how much more, due to the already high amount that the market prices is today.

6. Conclusion and Recommendations

In this chapter, the answers to the research questions will be provided, based on what was found in the literature and in the case of PFH. Besides this, some general reflections of the study, as well as some suggestions for future research will be provided.

6.1 Challenges of the Open Innovation Platform PFH

The main purpose of the study was to identify challenges that the open innovation platform has or will encounter, from a management perspective. By answering the sub-research questions below, we also answer this question.

What is Positive Footprint Housing?
From this study, we now know that PFH is an interdisciplinary research platform where innovation process aims to, by building partnership and collaboration, develop environmentally, socially and economically sustainable residential areas. The project's outcomes are currently being realized in three housing projects, Brf Viva, Bfr Slå Rot and Lindholmshamnen, which function as full-scale laboratories for implementing sustainable housing.

The study has shown that, by using the approach of integrating external knowledge and ideas in a collaborative platform, PFH has been able to successfully develop sustainable-oriented ideas. They have also been able to contribute to the construction industry with knowledge about sustainable sub-projects that can inspire the sector to build in a more sustainable way. Except the projects' specific features (innovative sustainability in construction), which make the projects quite special, the process of PFH have been interesting to study. From the start there was quite ambitious goals about sustainability, but not a clear structure and concrete plan for achieving the goals. Nevertheless, the initial group of few actors have developed into a platform that have resulted in, except three sustainable-oriented housing projects, cross-sectional collaborations with suppliers, clients, consumers and research projects both produced by researchers at Chalmers University of Technology and the University of Gothenburg, as well as industrial researchers. The projects have also function as cases which have been used as foundation for courses at universities and also for student theses. Since the official start in 2012, the platform has involved at least 28 different companies and 111 different individuals, only counting involvement in PFH meetings - which says quite a lot about the extent of the platform.

What are the challenges of sustainable open innovation in the construction sector according to the literature?
Based on the literature study, there are several challenges, as well as enablers, that can aggravate or facilitate the open innovation process in the construction industry. The study has shown that most of the challenges and thereby enablers can be linked to the management of the collaborations, and their leadership style. Open innovation collaborations are not self-organizing and therefore there is a need for management that can manage all the complex social processes that exists when lots of actors are collaborating. Listed below, are those challenges, as well as enablers, that managers should take into account when managing open innovation collaborations:

Leadership & Innovation broker: The managers should take on a subtle leadership, as too little management and control tend to lead to untapped potentials and reduced productivity whereas too much management tend to lead to reduced creativity. The managers can preferable make use of an innovation broker, aiming at facilitating the innovation process and the knowledge transfer across people, organizations and industries.

Team diversity & Cognitive distance: The managers must be able to manage a high diverse team. They must promote an open climate to bring forth all ideas and creative solutions such teams can generate. Not least, they must be able to handle differences in goals in which a balance between competition and cooperation is required, as well as create a good working culture among the actors involved.

Team stability & Group efficacy: The managers should strive for a good team stability, in which there is a balanced in and outflow of actors, to avoid groupthink and losing the organizational memory. They must also promote a climate in which the actors feel mutual commitment and believe in a high collective efficacy, acting with transparency and respect for each other.

Power distribution & Hierarchy: Mutual power and influence between actors often equals better knowledge transfer, therefore, managers should strive to balance power and dependence to reach desired learning outcomes. Flat hieratical structure of a team benefits the transfer of knowledge between members but due to complicated activities in teams without hierarchical structures, the team must be managed and organized. Managers in open innovation teams are therefore facing the challenge of finding a good balance between being in control and being out of control.

Contextual features & User integration: Finally, it can be said that managers must cope with both internal, as well as external context characteristics. They must cope with the actors involved and their various goals and culture, as well as cope with the industry they are working in and the booms and busts at the market. Theoretical findings show that there is no specific managerial challenges for open innovation collaboration in the perspective of sustainability than already have been mentioning in the literature of open innovation. However, for environmentally and sustainable measures to be used, managers should preferably integrate users in the open innovation process. This to increase the possibility for consumers acceptance of the product, making it more likely spread on the market, but also to increase the awareness of the invention. In the context of the construction industry that contains project-based activities which involves complex and uncertain construction processes, managers have to manage the challenge of coordinating various stakeholders. Moreover, manager's characteristics may have an impact on the team's ability to create innovative culture and are crucial for the use of sustainable solutions in the construction industry.

According to the literature, how can Positive Footprint Housing continue to work as an open innovation platform?
So far, PFH´s working methods seem to work rather well. The PFH project started official by cooperation with the initial collaborators in 2012, and have now, the year of 2017, continued for more than six years. It is an impressively long time for keeping an open innovation platform functioning and keeping people motivated. This makes

us wonder, how long will PFH last? and what will the future look like? Several critical success factors have been identified as being crucial for PFH future success and development.

Leadership, Driving Forces & Innovation Broker: Leadership and leadership style is a decisive factor for a successful innovation outcome. The PFH platform have been characterized by some individual's dependency, i.e. in the platform there have been strong leaders and driving forces, with a genuine interest in sustainability issues, who have guided the group towards innovation. We believe this is one of the reasons why the project has been so successful and propose therefore, that this is something the management of Riksbyggen should take into account for the future. If they want the platform to continue to flourish as it does now, they must ensure that, in the future, there are leaders and driving forces, that can take the platform forward. Not least, to facilitate the innovation process and the knowledge transfer across people, we believe there is a need for some kind of innovation broker. We therefore, propose that they continue to hire a person acting as an intermediary between themselves and the industry. However, it is proposed that this person have some kind of outer-perspective not becoming too familiar with Riksbyggen way of working but coming in with new perspective and ideas.

Team Diversity, Team Stability, Cognitive Distance & Group Efficacy: As seen in the PFH platform, it contains a lot of different actors with different knowledge. Although this sometimes has created difficulties, it has mostly benefited the group - probably due to the managers ability to handle all complex social processes that exists. This is something that is crucial also for the future of PFH, that managers can handle a group full of different actors. Future managers must also ensure that the group does not become too homogenic, i.e. ensure there is a constant influx of new actors who bring life and new ideas to the group. Otherwise, there is a risk of actors becoming too familiar, not criticizing each other, which will hinder new developments. Another crucial part for PFH´s future is the influx of new demonstration projects. We believe it is these projects that allow PFH to continue exist, which makes researchers interested in participating and which allows the development of new ideas to continue. Furthermore, innovations tend to become mainstream, which is also a reason for the need of new development projects in order to stay innovative. Therefore, it is suggested that future leaders of PFH ensure that new development projects are continuously brought into the platform. Last, future managers of PFH must have the ability to handle actors' differences in goals and working culture, as well as creating a climate that promotes knowledge exchange.

Power Distribution and Hierarchy: We suggests that the PFH platform should continue to strive for balance of being in control and out of control. Even if actors from Riksbyggen take most risk and thereby most decision, they should aim to have a flat structure of hierarchy in the collaboration where new actors feel they can influence. In teams with high hierarchy, actors have difficulty in transferring knowledge and developing new ideas, and therefore, the PFH collaboration should be aware of the challenge in managing a creative climate and not control too much. Too little management and control tend to lead to untapped potentials and reduced productivity while too much management tend to reduce creativity. In these type of innovative collaboration, it seems challenging to decide when to "loosen" up the management in favor for creative climate with high level of knowledge transfer and

when to control the climate in favor for moving the project forward. Therefore, management of PFH should aim to find the right balance between controlling and coordinating.

One of the initial goals with PFH was to build the most innovative and sustainable housing project in Sweden. In the perspective of being the most sustainable housing project in Sweden, the consumers have a crucial role and therefore, integrate the users in the innovation process becomes a challenge. We suggest that PFH keeps involving stakeholders such as general public in order to spread the projects and its functions as much as possible. In the end, the users and their way of living is one factor that decides whether the building becomes sustainable or not. As PFH want to evaluate how the building is being used, we look forward to seeing the result.

6.2 Reflections and Further Research

This thesis was conducted to investigate the approach of open innovation in a new context - the PFH context. The study has identified and analyzed challenges the PFH platform have encountered from a management point of view. Not only it has provided interesting findings regarding the research questions that were addressed as well as contributed to the literature on open innovation. This is done by filling the gap of case studies on open innovation within the construction industry in the context of sustainability, and thereby provide new insights of how innovative sustainability can be implemented in a construction project.

Today, open innovation is well known in literature as well used among a broad segment of industries. However, there is a lack of quantitative studies within the field of open innovation, and studies with relation to sustainability and construction have not yet been widespread. Therefore, we propose further quantitative studies within the field of construction and open innovation, to understand how organizations can work with challenges in open innovation. By this, a more generalized study can highlight how organizations in the construction industry can work in open innovation, and through that become more innovative.

7. References

Arnold, M. (2017). Fostering sustainability by linking co-creation and relationship management concepts. *Journal of Cleaner Production*, 140, pp. 179-188.

Becker, C.U. (2011). *Sustainability Ethics and Sustainability Research.* Dordrecht: Springer Science & Business Media.

Bogers, M., Chesbrough, H. & Moedas, C. (2018). Open innovation: Research, Practices, and Policies. *California Management Review*, 60(2), pp. 5–16.

Bryman, A. & Bell, E. (2011). *Business research methods,* 3th ed. Oxford: Oxford University Press.

Bygballe, L.E. & Ingemansson, M. (2014). The logic of innovation in construction. *Industrial Marketing Management*, 43(3), pp. 512–524.

Chan, W-C., Chen, P-C., Hung, S-W., Tsai, M-C., & Chen, T-K. (2017). Open innovation and Team Leaders' Innovation Traits. *Engineering Management Journal*, 29(2), pp. 87–98.

Chesbrough, H. (2003). Open innovation: The new imperative for creating and profiting from technology*, Boston: Harvard Business School Press.*

Chesbrough, H. (2017). The Future of open innovation. *Research Technology Management,* 60(6) pp. 29-35.

Chesbrough, H., Vanhaverbeke, W., West, J. (2006). Open innovation: researching a new paradigm, *New edn, Oxford: Oxford University Press.*

Dahlander, L. & Gann, D.M. (2010). How open is innovation? *Research Policy,* 39(6), pp. 699-709.

Du Chatenier, E., Verstegen, J. A. A. M., Biemans, H. J. A., Mulder, M., & Omta, O. (2009). The Challenges of Collaborative Knowledge Creation in open innovation Teams. *Human Resource Development Review*, 8(3), pp. 350–381.

Dulaimi, M.F., Ling, F.Y.Y. & Bajracharya, A. (2003). Organizational motivation and inter-organizational interaction in construction innovation in Singapore. *Construction Management and Economics,* 21(3), pp. 307-318.

Ellram, L.M. (1996). The use of the case study method in logistics research. *Journal of Business Logistics,* 17(2), pp. 93.

Gassmann, O. & Enkel, E. (2004). Towards a Theory of open innovation: Three Core Process Archetypes. Proceedings of the R&D Management Conference, Lisbon, Portugal, July 6-9.

Given, L. M. (2008). *The Sage encyclopedia of qualitative research methods.* Vol. 1 and 2. Sage Publications.

Goodman, J., Korsunova, A. & Halme, M. (2017). Our Collaborative Future: Activities and Roles of Stakeholders in Sustainability-Oriented Innovation. *Business Strategy and the Environment,* 26(6), pp. 731-753.

Hossain, M., Islam, K. M. Z., Sayeed, M. A., & Kauranen, I. (2016). A comprehensive review of open innovation literature. *Journal of Science and Technology Policy Management*, 7(1), pp. 2–25.

Howells, J. (2006). Intermediation and the role of intermediaries in innovation. *Research Policy,* 35(5), pp. 715-728.

Huizingh, E.K.R.E. (2011). Open innovation: State of the art and future perspectives. *Technovation,* 31(1), pp. 2-9.

Mason, J. (2002) *Qualitative researching*. Sage Publications Ltd. 2th ed.

Matinaro, V. & Liu, Y. (2017). Towards increased innovativeness and sustainability through organizational culture: A case study of a Finnish construction business. *Journal of Cleaner Production*, 142, pp. 3184–3193.

Melander, L. (2017). Achieving sustainable development by collaborating in green product innovation. *Business Strategy and the Environment*, 26(8), pp. 1095-1109.

Ollila, S. & Elmquist, M. (2011). Managing open innovation: Exploring challenges at the interfaces of an open innovation arena. *Creativity and Innovation Management,* 20(4), pp. 273-283.

Ollila, S. & Yström, A. (2015). 'Authoring' open innovation: The Managerial Practices of an open innovation Director. *Research in Organizational Change and Development*. 23, pp. 253–291.

Petroni, G., Venturini, K. & Verbano, C. (2012). Open innovation and new issues in R&D organization and personnel management. *The International Journal of Human Resource Management,* 23(1), pp. 147-173.

Saldana, J. (2011). *Fundamentals of qualitative research.* New York: Oxford University Press.

South East England Partnership Board. (n.d.) Economic growth and technological innovation. *(Report South East England Strategy Think Piece 1).* https://www.secouncils.gov.uk/wp-content/uploads/pdfs/_publications/Economic_growth_and_tech_innovation.pdf.

Tabassi, A.A., Roufechaei, K.M., Ramli, M., Bakar, A.H.A., Ismail, R. & Pakir, A.H.K. (2016). Leadership competences of sustainable construction project managers. *Journal of Cleaner Production*, 124, pp. 339–349.

van de Vrande, V., de Jong, J.P.J., Vanhaverbeke, W. & de Rochemont, M. (2009). Open innovation in SMEs: Trends, motives and management challenges. *Technovation,* 29(6), pp. 423-437.

Wallin, M.W. & von Krogh, G. (2010). Organizing for open innovation: Focus on the Integration of Knowledge. *Organizational Dynamics,* 39(2), pp. 145-154.

Watson, R., Wilson, H.N., Smart, P. & Macdonald, E.K. (2018). Harnessing Difference: A Capability-Based Framework for Stakeholder Engagement in Environmental Innovation. *Journal of Product Innovation Management,* 35(2), pp. 254-279.

WCED (1987). Report of the World Commission on Environment and Development: Our Common Future, Chapter 2: Towards Sustainable Development, UN Documents. [Online], Available: http://www.un-documents.net/wced-ocf.htm [2018-05-29].

Wiles, R. (2013). *What are Qualitative Research Ethics*? London: Bloomsbury Academic.

Web Pages:

Riksbyggen 1 (n.d.). Mot en mer hållbar framtid. *Riksbyggen.* https://www.riksbyggen.se/om-riksbyggen/hallbarhetsarbete/positive-footprint-housing [2018-05-17].

Riksbyggen 2 (2016) Länge leve brf Viva. *Riksbyggen.* https://riksbyggen.se/globalassets/1-media-riksbyggen/2-bostad/bostadsratter/vastra-gotaland/dokument/bofakta_brf_viva_web.pdf [2018-05-03].

Riksbyggen 3 (n.d.). Lindholmshamnen - Kooperativa hyresrätter I Göteborg. *Riksbyggen.* https://riksbyggen.se/ny-bostad/aktuella-projekt/vastra-gotaland/lindholmshamnen [2018-05-17].

Riksbyggen 4 (2017). Kooperativa hyresrätter - framtidens upplåtelseform för unga på bostadsmarknaden? *Riksbyggen*. https://riksbyggen.se/pressrum/2017/2753674 [2018-05-17].

Riksbyggen 5 (n.d.). Brf Slå Rot vid Gibraltarvallen i Göteborg. *Riksbyggen.* https://www.riksbyggen.se/ny-bostad/aktuella-projekt/vastra-gotaland/brf-sla-rot [2018-05-17].

Riksbyggen 6 (n.d.). Planeten ska med! *Riksbyggen.* https://www.riksbyggen.se/om-riksbyggen/hallbarhetsarbete [2018-05-21].

Riksbyggen 7 (2017). Klimatsmart och unik betong i Riksbyggen Brf Viva. *Riksbyggen.* https://www.riksbyggen.se/globalassets/1-media-riksbyggen/5-om-riksbyggen/5.-samhallsutvecklare/pfh/pfh/klimatsmart-betong.pdf [2018-05-21].

Riksbyggen 8 (n.d.). Kooperativa hyresrätter i Lindholmshamnen i Göteborg. *Riksbyggen.* https://www.riksbyggen.se/lindholmshamnen [2018-05-21].

Riksbyggen 9 (2017). Riksbyggen förvärvar byggrätt för 250 bostäder i ny ungdomssatsning vid Lindholmshamnen. *Riksbyggen*. https://riksbyggen.se/pressrum/2017/2460231 [2018-05-21].

Rosenholm, M. (2017). Riksbyggen vinner med trähus i Göteborg. *Branschaktuellt.*
https://branschaktuellt.se/byggindustrin/bostad/11362-riksbyggen-vinner-med-trahus-
i-goteborg [2018-05-17].

Älvstaden Lindholmshamnen (n.d.). Älvstaden Lindholmshamnen Projektet.
Lindholmshamnen. http://lindholmshamnen.se/projektet/ [2018-05-17].

Appendix

In this part of the report, things that are considered less important to the results, but which may be interesting to the more curious reader, will be presented. The appendices that will be presented are as follows:

Appendix 1:   Pilot housing projects in PFH
Appendix 2:   Compilation of participants in PFH
Appendix 3:   Timeline PFH
Appendix 4:   Outcomes of PFH

Appendix 1: Pilot housing projects in PFH

In this appendix the three pilot housing projects within PFH; Brf Viva, Lindholmshamnen and Brf Slå Rot will be described briefly.

Brf Viva

Brf Viva is the first pilot project of PFH. As described above, the project was started in 2011, in parallel with the PFH project. Viva is a housing cooperative association which involves 132 apartments and is built on Dr Allards gata in Guldheden, south of Gothenburg city (Riksbyggen 2, 2016). Viva is different to the other projects, where a more holistic perspective of sustainability questions has been approached. In other words, a greater extent of sustainable sub-projects/ideas is tested in the project than in the two others (Interviewee 2). According to one interviewee, this is what makes the project special in comparison to other projects. Some of the individual ideas might have been accomplished in other projects, but in Viva, "everything" is in one place, and that creates something special (Interviewee 7).

What makes Brf Viva stands out, in contrast to other buildings, is that Viva is filled with innovative and sustainable solutions to promote a sustainable life. To name a few solutions, Viva is an accommodation without car, meaning the residents must not own a car but are offered a carpool instead. Further, Viva is a plus energy house, getting its electricity from solar cells at the roof and from reused bus batteries in which electricity is stored. In Viva there are also plenty of social areas, to promote a social sustainable life.

Lindholmshamnen

Lindholmshamnen is the second project within the PFH platform (Interviewee 1), where plans are being made to build cooperative tenancies at Lindholmshamnen, in the area of Norra Älvstranden in Gothenburg (Riksbyggen 3, n.d.). Lindholmshamnen is part of a project called "Vision Älvstaden" (Riksbyggen 3, n.d.), in which several companies have joined forces to build housing, restaurants, cafes etc. (Älvstaden Lindholmshamnen, n.d.) with the aim of strengthening the area of Norra Älvstranden, as well as the picture of Gothenburg as a social, economic and ecological sustainable city (Riksbyggen 3, n.d.). However, unlike the Viva project, the greatest focus at Lindholmshamnen is not on ecological but rather on social and economic sustainability (Interviewee 1). Interviewee 1 tells, that in this project Riksbyggen has set out the strong goal of carrying out the project with cooperative tenancies, a big challenge as they are the first in Sweden to take on. Furthermore, the target group is another big challenge with this project. In Lindholmshamnen, the goal is to create an accommodation for young adults between 18-30 years old. Interviewee 1 argues, that today nobody cares about that target group, and if you are young and not have strong resources from home it is extremely difficult to enter the housing market. This is something Riksbyggen want to change and therefore they have chosen to focus on young adults in this demonstration project.

In order to take part of the young adults' thoughts and ideas about future living, as well as to let them influence the project at Lindholmshamnen, the management of PFH has during the work had a continuous dialogue process with the target group (Riksbyggen 4, 2017). By this, the management have received many interesting views and opinions that they have taken into consideration when planning

Lindholmshamnen (Internal documents). Besides this, the management of PFH have chosen to focus on five things in Lindholmshamnen, see below, that they consider important in a sustainable living, and for the residents to be able to make sustainable choices.

The five things that Riksbyggen will focus on in the Lindholmshamnen project are;

1. *Carpool*
2. *Bicycle parking*
3. *Social areas*
4. *Sustainable solutions*
5. *Open and welcoming ground floor*

First and foremost, there should be a carpool accessible for the residents, to facilitate a life without car (Internal documents). Secondly, there should be a bicycle parking in which it is easy to put in/take out the bike. Thirdly, the accommodation should be equipped with social areas, e.g. a storage room for sharing of items, and possibilities for cultivation at the courtyard. Fourth, sustainable solutions should be built into the house from the start, e.g. solar cells, green ceilings, water treatment, and recycling possibilities. And, fifth, the ground floor should be open and welcoming with several open spaces that are accessible to the public.

Brf Slå Rot
Brf Slå Rot is the third project within the PFH platform (Interviewee 1), in which Riksbyggen plan to build 45 condominiums and terraced houses at Gibraltarvallen in Gothenburg (Riksbyggen 5, n.d.). Brf Slå Rot started as an application for a competition held by the City of Gothenburg, which had set out clear goals that they wanted to go more towards wooden house construction (Interviewee 1). The winning contribution would get a ground to build a multi-family house in wood at Gibraltargatan (Rosenholm, 2017). The management at Riksbyggen said early on that they believed in this and that they had to participate. At that time, Riksbyggen did not know much about wooden house construction, but they wanted to learn, and they decided to give everything and to win the competition. Said and done, Riksbyggen allied themselves with Sweco, which had a lot of experience in wooden house construction, and together they managed to win the competition.

The aim of Brf Slå Rot is accordingly to create an innovative and sustainable residential area by using the latest wooden house technology (Rosenholm, 2017). The greatest focus will consequently be on the building material, wood (Interviewee 2). Moreover, there will be focus on social, economic and ecological sustainability, although not to the same extent as in Brf Viva and Lindholmshamnen (Interviewee 4). To name some examples, it is planned for cultivation on the roof/in a greenhouse at the courtyard, there will be solar cells on the roof, a bicycle and car pool will be available for the residents (Rosenholm, 2017), as well as access to several common areas such as a common venue for parties, entrances, streets, courtyard etc., aiming at functioning as natural hubs for the neighborhood (Riksbyggen 5, n.d.).

Appendix 2: Compilation of participants in PFH

In this appendix, a compilation of all participants involved in PFH from 2012 until now will be presented, see Table A.1 below.

Table A1   Compilation of all participants involved in PFH from 2012.

Company	Participant	Year (number of meetings)					
		2012(10)	2013(9)	2014(8)	2015(8)	2016(5)	2017(10)
Riksbyggen	**Participant 1**	**10**	**9**	**8**	**8**	**5**	**10**
	Participant 2	**9**	**4**	**5**	**2**	**2**	**3**
	Participant 3	**9**	**9**	**8**	**8**	**5**	**8**
	Participant 4	1					
	Participant 5	2	1				
	Participant 6	3	3	1			
	Participant 7		**2**	**5**	**3**	**3**	**7**
	Participant 8		2	2		1	5
	Participant 9			**2**	**5**	**3**	**6**
	Participant 10				2	4	8
	Participant 11				2	1	5
	Participant 12				1	1	3
	Participant 13					1	2
	Participant 14					2	4
	Participant 15					1	
	Participant 16						6
	Participant 17						2
	Participant 18						4
	Participant 19						1
	Participant 20						1
RB/JSP	**Participant 1**					**3**	**10**
University of Gothenburg	**Participant 1**	**9**	**6**	**5**	**5**	**4**	**5**
	Participant 2			1		1	
	Participant 3				1	4	2
	Participant 4					1	

Chalmers University of Technology	**Participant 1**	**8**	**5**	**6**	**4**	**3**	**7**
	Participant 2	**6**	**5**	**5**	**4**	**4**	**7**
	Participant 3	7	4	1	1		
	Participant 4	1	1				
	Participant 5	5	4				
	Participant 6	1					
	Participant 7	1	4				
	Participant 8		1				
	Participant 9					2	5
	Participant 10		1				
	Participant 11						1
	Participant 12						2
	Participant 13						1
	Participant 14						1
	Participant 15						1
	Participant 16						1
CMB - arena for academia and business	Participant 1					1	1
	Participant 2						1
Johanneberg Science Park	**Participant 1**	**10**	**9**	**8**	**7**	**5**	**9**
	Participant 2	**3**	**1**		**4**	**2**	**7**
	Participant 3	3					1
	Participant 4	6	4	1			1
	Participant 5	1					
	Participant 6		2	4	2		2
	Participant 7			**2**	**8**	**5**	
	Participant 8			1			
	Participant 9				1		
	Participant 10						1
	Participant 11						2
	Participant 12						2
	Participant 13						2

Organization	Participant						
Research Institute of Sweden SP/RISE	Participant 1	4					1
	Participant 2	4	8	1			
	Participant 3	1					
	Participant 4			4	5	1	4
	Participant 5			1			
	Participant 6					3	3
	Participant 7						1
	Participant 8						1
	Participant 9						1
City of Gothenburg (SBK, FK, LF)	Participant 1	1					
	Participant 2	1					
	Participant 3	3	1				
	Participant 4						1
	Participant 5						1
Architectural Firm 1	Participant 1	7	6	8	3		
	Participant 2	5	3	2			
	Participant 3	1					
	Participant 4				3		1
Arena for Sustainable Innovation	Participant 1	1					
Landscape Architecture Firm	Participant 1	2					
Göteborg Energi	Participant 1	1		1			
	Participant 2	1	1				
	Participant 3	1					
	Participant 4		1				
	Participant 5		1				
	Participant 6			4	6	4	
	Participant 7						8
	Participant 8						1
	Participant 9						1
	Participant 10						1

Organization	Participant							
Student-led Project Organization	Participant 1	1						
	Participant 2	1						
	Participant 3	1						
CBI (Concrete Institute)	Participant 1	1						
Technical Consultant Company 1	Participant 1		1	5	1			
	Participant 2		1	4				
	Participant 3				1			
Digital Communication Agency	Participant 1		1					
	Participant 2			1				
Linköping University	Participant 1		1	5				
Fuel Company	Participant 1				1			
	Participant 2				1			
Architectural Firm 2	Participant 1						1	1
	Participant 2						1	
Vocational Education	Participant 1							1
Technical Consultant Company 2	Participant 1							5
Student-led Organization	Participant 1							1
	Participant 2							1
Consultant Company within Transportation	Participant 1							1
	Participant 2							1
	Participant 3							1
Communal Real Estate Company	Participant 1							1
Technical Consultant Company 3	Participant 1							3
	Participant 2							1
Association Collaborative Economy	Participant 1							1
Association (jagvillhabostad.nu)	Participant 1							1
Region Västra Götaland	Participant 1							1

Appendix 3: Timeline of PFH

In this appendix, a timeline of PFH with the key meetings and events, from 2012 until now will be presented, see Table A2 below.

Table A2   Key meetings and events in 2012-2017.

2012	Number of meetings: 10, Median number of participations: 12
PFH	- PFH collaboration start-up with JSP, RIksbyggen, University of Gothenburg (GU) and Chalmers Architecture (CA) - Göteborg Energi and Riksbyggen created an energy group.
Academy	<u>Studies start up (Chalmers Architecture)</u> - Knowledge overview of *Research and Reference Project in International Front edge* - Thesis for the degree of licentiate of architecture *Residential Usability and Social Sustainability: Towards a paradigm shift within housing design.* The project involves a student project and PFH is at focus. <u>Study start up (University of Gothenburg, department of social work)</u> - Study of social sustainability in PFH <u>Courses Architecture Programme Chalmers:</u> *Matter, space, structure,* with PFH as foundation. *Visions of residential future/Housing inventions*, with PFH as foundation
Research	<u>SP (Research Institutes of Sweden) involved to make two studies:</u> - Framing system of future Viva, LCA-analysis, wood vs. concrete - Energy program, look at alternatives for energy supplying
Public	- Meeting with coalitions *Bevara Guldheden* and *Rädda Mossen* starts - Start dialogue with the nearby residents
Industry	Workshop with other companies in the industry, to broaden PFH and get more stakeholders

2013	Number of meetings: 9, Median number of participations: 13
PFH	- The name Brf Viva is created. - Riksbyggen starts to advertise the project to the public.
Academy	<u>Courses Architecture Programme Chalmers:</u> *Matter, space, structure*, with PFH as foundation. - Visions of residential future/Housing inventions, with PFH as foundation <u>Studies Chalmers Architecture</u> - Knowledge overview of *Research and Reference Project in International Front edge* is finished <u>Studies University of Gothenburg</u> - School of business, economic and law in Gothenburg have been contacted to make a study of economic sustainability in a housing cooperative and create a tool for measuring economic sustainability. - Researcher at GU have finished the first rapport on social sustainability *Social hållbarhet inom Riksbyggens projekt Positive Footprint Housing – En första rapport,* which summarized so far experiences from involvement in PFH.

Research	• Research project about energy and climate effective construction of SP (Research Institutes of Sweden), CBI (The Swedish Cement and Concrete Research Institute), Riksbyggen and a wood supplier have been granted by Authority of Energy. The project is called +3 and starts 2013 with a length of three years. Among other things, the project is going to make a Life Cycle Analysis of the materials concrete and wood. • SP makes a carbon investigation of wood and concrete.
Public	Dialogue meetings • The dialogue with nearby residents and public stakeholders continues. PFH experience problem with low number of participants at meeting with nearby residents. • Workshops with different stakeholders (industry, municipalities, academia, public) about social sustainability
Industry	• CBI (Concrete institute), Göteborg Energi and a technical consultant gets involved.

2014	Number of meetings: 8, Median number of participations: 13
PFH	• Outcomes from collaboration with academia is summarized in a matrix that shows ideas, their source, their status, if it should be involved or not, or how it is sustainable. Ideas that are not used in Viva will be saved for eventually use in future projects. • Discussion of creating a project platform due to increased number of documents and a need for better structure. • A person from JSP is going to work with research questions as a consult for Riksbyggen.
Academy	Courses Architecture programme Chalmers: • Course Architecture - *Housing Inventions* - Brief of the master students' projects from 2012 and 2013 are shared in PFH. • *Visions of residential future/Housing inventions* Thesis University of Linköping • Thesis for developing a recommendation of sustainable certification of Brf Viva is conducted. Study University of Gothenburg • Startup research of dialogue process at Social Work department. • Study of economic sustainability in a housing cooperative start up
Research	• Riksbyggen and another real estate company have been granted an initiation project *Framtidens hållbara boende inom programmet utmaningsdriven innovation inom samhällsutmaningen hållbara attraktiva städer.* • Project 3+ is started. Outcomes will be used for decision of framework for Viva.
Public	- There are still few people attending the dialogue meetings about the Viva project. Workshops to create interest from stakeholders with themes such as: • Environment • Landscape • Sustainability and architecture • Housing without a car • Internal workshops within Riksbyggen about economic sustainability and also workshops with the residents are conducted
Industry	• A discussion with Volvo about using their batteries from the electric busses, to

store energy in Brf Viva, have been initiated. • SP and CBI, currently RISE, have studied and compared framework construction in both concrete and wood.

2015	Number of meetings: 8, Median number of participations: 11
PFH	• The cooperative tenancy is developed. • Discussion about PFH's future work. • 16 sustainable sub-projects have been chosen to be further investigated. • Riksbyggen have got a land allocation at Lindholmshamnen
Academy	Student course Housing inventions (CA) • Students continue to do architectural assignments and present them for the PFH group. This year, densify area nearby Viva. University of Gothenburg • Collaboration with CFK (Centre for Consumer Research) in a project of sustainable consuming and sharing economy in a housing block. Students of CFK will be involved in the project. • The work with dialogue processes continues.
Industry	Energy group in PFH • Decided to design solar cells with SP and Göteborg Energi. • Further discussions with Volvo about using old bus batteries for electricity storage.
Research	• Göteborg Energi show energy flows in Viva • An agreement with cement supplier is established with the aim to develop a new binder with lower carbon dioxide emissions for the concrete together with SP and Riksbyggen.
Public	• PFH continues with advising the project. This is done by, among others, breakfast seminar with different themes from PFH, to advertise and create interest among another companies/public.

2016	Number of meetings: 5, Median number of participations: 13
PFH	PFH meetings • Riksbyggen are looking for a person who will work with research coordination towards JSP and the academy, the so called PFH coordinator is hired later this year. • Further discussions of how the group should work in future. Discussion about PFH next phase after Viva, should Lindholmshamnen be a part of PFH? Lindholmshamnen should have cooperative tenancies. • Riksbyggen has mapped all research projects, approximately 30 ones. • Riksbyggen West is working to develop a social sustainability plan, originated from PFH. • Further discussion about the facility management in Viva, how residents can manage their energy consumption and how to create a dialogue with the residents.
Research	• Follow up on calculations by cement supplier, aiming to develop a cement with lower carbon emissions.
Academy	• Researcher from University of Gothenburg present project about Social Dialogue Process in Brf Viva. • Two researchers (GU/CA) should write a paper about Brf Viva and social sustainability.

	• Study of the term economic sustainability in a housing cooperative is finished. • A new project (KIVI) *Collaborative Innovation* aims to study how and why collaborations like PFH and ElectriCity, work successfully.
Public Industry	• PFH organize different seminar of PFH where industry and public could visit. • Continuing with breakfast seminar during the year. • New cooperation between Volvo, Göteborg Energi, a technical consultant and Riksbyggen with aim to reuse old bus batteries for energy storage in Brf Viva.

2017	**Number of meetings: 10, Median number of participations: 20**
PFH	• Riksbyggen have created a definition of what social sustainability in a housing cooperative in Riksbyggen is and developed a tool for social sustainability. • Discussion of what will happen to energy group when Viva is finished. • Riksbyggen start discussing if Lindholmshamnen should be a part of PFH, which it becomes, later this year. • Riksbyggen won wood-housing-competition and are going to build Brf Slå Rot. Discussion of how PFH can be used, what should be the focus in the future projects.
Academy	<u>Student work</u> • Three students do their master thesis of Lindholmshamnen. There have also been an architecture course with 65-70 students working with the project as base, with the aim to design housing for young adults. <u>Research Chalmers</u> • Researcher from Construction Management will research of how PFH is managed.
Research	• Lindholmshamnen. Dialog Processes with young adults have been initiated, three focus meetings are performed during the year. A consultant company and City of Gothenburg are involved. <u>The IRIS application (Smart Cities and Sustainable Cities)</u> • A consult company within transportation gets involved, they will form groups with Brf Viva´s buyers to review possible applications regarding the mobility of bicycles and cars. • The research programme Mistra Carbon Exit aims to fulfill the goal of zero net emissions of climate gases by the year 2045. The programme analyses and identifies the technological, economic and political challenges which Sweden faces, and how the industries can achieve this goal. Viva is involved as a demonstration project.
Public Industry	• Short reports describing the research projects conducted in PFH is produced, with the aim is to spread the initiative and activities that have been conducted as well as the results and knowledge that have been achieved. • Breakfast seminar continues, presenting the different developments in PFH.

Appendix 4: Outcomes of PFH

Observations of meetings with the PFH platform tells that the projects, mainly Viva, have resulted in several different outcomes. Outcomes that today are used in Riksbyggens daily work. In this appendix the most important ones will be presented.

Sustainable sub-projects

Observation tells that, during the work with Brf Viva, in meetings and workshops with various participating actors, a variety of innovative ideas emerged that could be implemented in the project. The ideas became more and more, and as all of them could not be implemented in Viva they were gathered in a matrix. The ideas were categorized after source, if they were linked to economic, ecological or social sustainability and whether they should be included in Viva or "parked" for future projects. The ideas that were going to be included in Viva was investigated further, put as sub-projects under Viva, and named *Hållbara Del Projekt* (HDP), which basically means Sustainable Sub-projects in English. In total, seventeen different sustainable sub-projects were identified, see Table A3 below, in which each of them contained concrete examples of implementation, risks and who they could be performed by. As it looks now most of them will be realized in Viva, while others have been removed for various reasons. However, the work with the sustainable sub-projects have been highly appreciated within Riksbyggen and is something that has been incorporated into other projects as well. For example, will the same set-up with sustainable sub-projects be used in Brf Slå Rot, although not to the same extent as in Viva but some well-chosen sub-projects.

Table A3   The seventeen sustainable sub-projects.

1.	Storage of electricity in used buss batteries	*A brand-new idea that will be realized in Viva is the storage of electricity in reused bus batteries. Old bus batteries from electric buses in Gothenburg will namely act as storage for the surplus energy produced by the solar cells on the roof. The aim with this is consequently to create a concept for storing electricity in multi-family houses with used electric bus batteries.*
2.	Shared laundry room	*It was early decided to plan for shared laundry rooms in Brf Viva, partly because it saves water and energy, but also as it frees more space in the individual apartments and promotes social meetings among the residents.*
3.	Greenhouse	*Through Riksbyggen's work on ecosystem services (another outcome from Viva, which will be described further below), the management of Riksbyggen began to think about what they could do to bring nature something good. The answer became, among other things, a greenhouse, an orangery, as well as a beekeeping station. The greenhouse will provide the residents the opportunity to grow vegetables and spend time with the others in the house.*
4.	Community room	*Another goal in Viva was to have a large community room at street level, for both residents and others, where there is room for working and socializing. This to promote social meetings.*
5.	Orangery	*The orangery is part of the ecosystem services just like the greenhouse. However, the purpose of it is also to create meeting places. It should therefore be possible to work and socialize there, as well as it should be possible to book for parties and events.*

6.	Waste disposal	In Viva, there will be no usual waste rooms, but one has planned for a waste room with underground containers instead, this since underground containers saves a lot of space. This sub-project also includes a room for reuse and sharing of items for the residents.
7.	Vehicle pool	Already in the beginning of the Viva project, Riksbyggen had the goal of creating a housing without car. They therefore planned for zero parking places (something that was very difficult and time consuming to get permission for) but chose to offer the residents a vehicle pool instead. At the moment, work is being done to negotiate one.
8.	Charging of electric vehicles	The residents of Viva will be offered the possibility of charging electric vehicles. At first, the vision was that it should be possible to both charge in and out, i.e. that the cars would be used as a form of electricity storage. However, that will not be realized, but one will only be able to load electricity into the cars and not out.
9.	Mail and delivery room	In Viva, there will be a mail and delivery room, which is common to the whole area and contains service boxes that logistics companies can leave mail and packages in. This to make it easier for the residents but also to reduce car usage.
10.	Beekeeping	The beekeeping station is part of ecosystem services just like the greenhouse and orangery. Right now, it is unclear whether this will be realized in Viva or not, it depends if they find a good place for the bees at the yard.
11.	Local disposal of water	In Viva, local disposal of water will be used. Meaning that rain and meltwater will be taken care of locally, at the own yard, instead of being led into a water system or sewage system. To mention, there will be open dikes at the yard where the water flows naturally.
12.	Optimization of self-produced electricity	In Viva, energy optimization will be used. Meaning that Riksbyggen will make sure that all different components in the heating system cooperate with each other for maximum efficiency and minimum possible spill and energy leakage. By doing this, both money and energy will be saved.
13.	Solar cells	Viva will be a plus energy house, meaning that it should produce more energy than it consumes. The energy will be produced through own production of electricity and heat energy via solar cells at the roof.
14.	Sale of cold to Chalmers	The surplus of energy (electricity and heat) from storing in Brf Viva is expected to be useful in premises at Chalmers campus. Riksbyggen will therefore sell energy in form of cold to Chalmers in the summer and collect heat from them in the winter.
15.	DC-network	This sub-project will no longer be realized in Brf Viva.
16.	Home/away function	This sub-project will no longer be realized in Brf Viva.
17.	Visualization after booking	The residents of Viva will be able to, through some form of visualization, follow their own energy consumption, how much cold is sold from their building, how much energy is being supplied, etc. Through visualization, they will also be able to book the common spaces.

Sustainability Management Tool

Riksbyggen felt the need to find another way to rate/certificate PFH. They didn't think that the existing certification-systems was good or comprehended enough for building in a sustainable way. For instance, the current certifications did not consider social sustainability, ecosystem services or mobility. To get a holistic view and review the certifications that existed on the market, Riksbyggen got assistance from a student that did a thesis work on reviewing different certifications. From the thesis, criteria were sorted out and then evaluated. The result from the thesis became *the Sustainability Management Tool* that Riksbyggen currently follows in the projects within PFH, and also, from now on it is implemented in all new construction projects in the whole organization (Interviewee 2 & 3). The new tool facilitates for Riksbyggen management in including sustainability aspects in the whole construction process, manage the project and make follow-ups. In this way, it is easier to see what sustainability profile the project achieves according to their own certification. With the local sustainability specialists, the project manager goes through the projects opportunities and gives an overview of what they need to keep in mind early in the process, due to the project's preconditions (Interviewee 5).

Ecosystem services

Another outcome from Brf Viva, in addition to the sustainable sub-projects and the tool for sustainable steering, is the ecosystem services. The ecosystem services is a tool that Riksbyggen developed during the work with Brf Viva (Interviewee 2), in cooperation with a consultant company to conduct a more sustainable way of building (Riksbyggen 6, n.d.). With ecosystem services means those services that nature provides us with, i.e. all the positive effects that soil, water and nature contribute with to us human beings, and which we are completely dependent on (Riksbyggen 6, n.d.). Riksbyggen emphasizes the fact that we must be careful about those services and therefore, they nowadays make a comprehensive ecosystem service analysis for each and every planned construction project. This means, they analyze what services the land in question contributes with, to ensure that the land contributes the same amount, or preferable more, when the building is ready. In this way, Riksbyggen strives to create environments in which people, animals and nature can grow and live together.

Climate smart concrete

By setting requirements on the suppliers, there is a potential of decreasing the climate influence during the construction phase and also affect the development of sustainable-oriented products. In a collaboration project between Riksbyggen, CBI, RISE/SP and a cement supplier, a climate smart concrete has been developed. The new concrete contains a unique combination of binder, and with the requirements Riksbyggen have on the concrete, together with other material-optimized solutions, there is potential for a reduction of about 30-35% of the climate impact compared with a traditionally proclaimed concrete. The new concrete is used in Brf Viva but is it unknown whether it should be used in another project as well (Riksbyggen 7, 2017). However, Riksbyggen aim to use it as a new requirement of specifications in future procurement and have raised the question in internal management. Other actors have contacted Riksbyggen about the new recipe and it have been spread to other suppliers, as they want everyone to build sustainable construction (Interviewee 1).

Cooperative tenancies

As mentioned in Appendix 1, Riksbyggen is carrying out the Lindholmshamnen project with cooperative tenancies, which is a big challenge as they are the first in Sweden to take on to this dimension (Interviewee 1). Riksbyggen has previously used the concept of cooperative tenancies in Brf Viva, but only in a small scale, but now the concept will be fully used in Lindholmshamnen. According to Interviewee 6 the idea of cooperative tenancies was born in the work of creating a solution for young adults, in helping them entering the housing market. This interviewee tells, is does not matter if they build cheaper apartments today as the buyer always can sell to a higher price the following day. This is a common mechanism he tells, that makes it harder for young people entering the housing market. Riksbyggen wanted to get around this problem and therefore they created a new alternative.

But what is a cooperative tenancy really? Well, cooperative tenancy is best described as a mix between a condominium and a tenancy, but instead of renting the residential unit from a real estate company the residential unit is rented from a cooperative housing association instead (Riksbyggen 8, n.d.). The tenant is a member of the association and pays a membership fee as well as an upfront for the accommodation. The upfront however, is lower than usual, making the residential units available for more people and can consequently serve as a first step into the housing market. What separates the cooperative tenancies from condominiums is that they cannot be bought or sold at market prices, meaning that when moving the tenant will only refund what he/she has paid in upfront (Riksbyggen 9, 2017). The tenant however, will have more influence over his/her accommodation and may be involved in decision making regarding management and maintenance of the building (Riksbyggen 8, n.d.). The cooperative tenancy association is namely governed by its members, which select their own board (Riksbyggen 9, 2017).