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Feasibility of the Implementation of Soft Landings in Sweden

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Abstract

Title: Feasibility of the Implementation of Soft Landings in Sweden

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Close to 40 percent of global energy use is associated with the construction industry and building-related activities. Although several initiatives are underway both on national and international level from both the Swedish government and the European Union regarding energy efficiency, the construction industry is lagging behind, especially with regards to building performance. The difference between projected energy usage and actual energy usage in completed buildings is substantial, with handovers and poor commissioning having been identified as among the main underlying causes.

The purpose of this thesis is to examine how Swedish handovers affect building performance in practice today, to review the Soft Landings framework and its efficacy, as well as analyse its potential as an addition to the Swedish procurement process.

The thesis aims to answer these through a literature review and case studies to understand its uses and potential implementations, with an additional interview study conducted with industry actors to explore whether it can be implemented in Swedish procurement processes and tackle the performance gaps in the construction industry.

The results from the literature review and case studies show that the Soft Landings framework can be effective in tackling the performance gap if it is implemented early in the procurement process along with incentives encouraging use or enforcing it. The interview study revealed that there is a fragmentation of contracts used to handle handovers today in the Swedish construction industry, causing confusion and a general lack of awareness concerning best practises of the handover process, with the participants suggesting that a standardised handover process could benefit the industry. In conclusion, the studies show that the Soft Landings does have the potential to deal with the performance gap in Sweden, but that it needs to either evolve, utilising contractual obligations or liabilities, or be implemented through regulatory means as has been the case in the UK.

Sammanfattning

Titel: Möjligheten av implementering av Soft Landings i Sverige

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Närmare 40 procent av den globala energianvändningen är kopplad till byggbranschen och byggrelaterade verksamheter. Trots att flera initiativ pågår både på nationell och internationell nivå från både den svenska regeringen och EU när det gäller energieffektivitet har det visat sig att byggbranschen släpar efter, särskilt när det gäller byggnadsprestanda. Skillnaden mellan beräknad energianvändning och faktisk energianvändning i färdiga byggnader är betydande, med överlämningar och dålig idrifttagning som två utav de främsta bakomliggande orsakerna.

Syftet med avhandlingen är att undersöka hur svenska överlämningar påverkar byggnadsprestanda i praktiken idag, att se över Soft Landings ramverket och utvärdera dess effektivitet samt analysera om det har potential som ett tillägg till svensk bygg-/upphandlingsprocess.

Avhandlingen syftar till att besvara dessa frågor dels genom en litteraturgenomgång och fallstudier för att förstå dess användningsområden och effektivitet gällande byggnadsprestanda och prestanda-gap, med en kompletterande intervjustudie utförd med branschaktörer med målet att undersöka om den kan implementeras i svenska bygg-/upphandlingsprocesser och tackla problemen kopplade till prestanda-gapen.

Resultaten från litteraturgenomgången och fallstudierna visar att Soft Landings-ramverket kan vara effektivt för att hantera prestanda-gap om det etableras tidigt i upphandlingsprocessen tillsammans med incitament som uppmuntrar till användning eller tillämpning av det. Intervjustudien visade att det finns en fragmentering av kontrakt som används för att hantera överlämningar idag i den svenska byggbranschen, vilket orsakar förvirring och en allmän brist på medvetenhet om bästa praxis i överlämningsprocessen. Deltagarna föreslår att en standardiserad överlämningsprocess skulle kunna gynna industrin. Sammanfattningsvis visar studierna att Soft Landings har potential att hantera prestationsgap i Sverige, men att ramverket behöver utvecklas, där det utnyttjar avtalsförpliktelser eller skyldighet, alternativt implementeras genom reglering, vilket har varit fallet i Storbritannien.

Foreword

This master thesis is written for the Division of Construction Management at the Faculty of Engineering at Lund University. It is the final endeavour of the Civil Engineering program of Construction Management. This work has been supported by the organisation Fastighetsägarna and has been produced during the fall of 2021.

This study would not have been possible without the assistance of the Faculty of Engineering at LTH and Fastighetsägarna. Special thanks goes out to our supervisor at the Division of Construction Management, Stefan Olander, as well as to head of Development & Sustainability Rikard Silverfur of Fastighetsägarna. The authors would also like to thank the BSRIA for providing relevant information and guidance, as well as the people who took part in the interviews, thereby making this study possible.

Thank you,

Lund, January 28th 2022

……………………………..
Sebastian Eddin

……………………………..
Nadja Pilav

Förord

Detta examensarbete är skrivet för Avdelningen för Byggproduktion vid Lunds Tekniska Högskola på Lunds Universitet. Det är det sista momentet av civilingenjörsprogrammet väg och vattenbyggnad, inriktning Byggproduktion & Förvaltning. Detta arbete har stöttats av branschorganisationen Fastighetsägarna och har tagits fram under hösten 2021.

Denna studie hade inte varit möjlig att genomföra utan stöd och vägledning från Lunds Tekniska Högskola och Fastighetsägarna. Ett särskilt tack riktas till vår handledare på Avdelningen för Byggproduktion, Stefan Olander, samt till chef för Utveckling & Hållbarhet, Rikard Silverfur på Fastighetsägarna. Författarna vill också passa på att tacka BSRIA för tillhandahållandet av relevant information och vägledning, samt de personer som deltog i intervjuerna vilket gjorde denna studie möjlig.

Tack så mycket,

Lund, 28 Januari 2022

…………………………….. …………………………….

Sebastian Eddin Nadja Pilav

Terminology

Throughout this thesis, the following terms are used as synonyms: handover, handover process, delivery, delivery process.

Table of Contents

1. Introduction

The introduction includes a background description regarding the chosen thesis, a description of the problem, the purpose of the study, research questions, scope of the project as well as a description of the chosen methods for this master thesis.

1.1 Background

The main problem, and the underlying reason for this study, is the gap between expectations and results in building's energy performance and user satisfaction following handover and commissioning. One of the greater challenges of the construction industry in the 21st century concerns the handover/delivery process between the project organisation and managing organisation/the customer. The delivery process is characterised by Rivera et al (2016) as an area of certain vagueness, a grey-area where undefined areas of responsibility, routines and processes reign.

Regardless of what type of industry is discussed, the challenge of having the different parts of an organisation to coordinate and interact in a synergistic manner will always be immense. This is especially true for the construction industry, where organisations are split into several different branches with varying operations coupled with numerous agents and contractors. The project stages from start to finish is not universally defined, with the Royal Institute of British Architects applying one definition and Designing Buildings applying another (RIBA 2020), though it can be said that the work process generally consists of a feasibility study followed by project planning, construction and handover.

The construction industry has not managed to establish a best practice method for deliveries, this is by no means a problem exclusive to Sweden. Nations around the world have highlighted the difficulties with achieving an efficient delivery process where all interested parties are satisfied (Schultz et al., 2015). This inefficiency is further exacerbated by the industry's views on the delivery process, often approaching it akin to a simple checkbox that needs to be completed before moving on to the next project in line. This simplified view of the delivery process has led to some unfavourable outcomes, one example being the increased building performance gaps between projected and actual in-use performance, where the energy consumption of newly built apartments can be as much as 30 per cent above calculated values during the planning stage (Lavender et al., 2019).

Previous studies conducted in the field concerning project deliveries in Sweden have touched on the problems associated with the views on the delivery process as an activity instead of a process, with the industry's views contributing to the undermining of the delivery process as a simple checkbox activity (Nyberg and Orlinder, 2017). The point of a delivery process is to have it stretch from the planning stage to the management stage, where it can give important information about the building in the early stages to ease the running operations of the building and to reduce performance gaps, as well as be a critical tool for feedback and knowledge transfer (Hammar, 2011). The complexities with regards to the delivery process are not recent.

Swedish construction companies are often aware of their own inadequacies regarding deliveries, yet seldom have well functioning processes in place themselves. Companies are more likely than not to place the responsibility for both the problem and potential solutions on local authorities and government bodies in Sweden (Nyberg and Orlinder, 2017). As for why the handover process is plagued by faults and often rushed through, there are several reasons. The literature alludes to the high turnover rate among project managers, along with the high turnover of running operations teams as potential occurrences that can lead to a loss of experience and feedback, leading project managers to constantly having to reinvent the wheel with regards to the delivery process. This is further complicated by the lack of an industry standard for project deliveries. Other possible reasons include the current organisational culture in the construction industry being reluctant to change (Ankrah et al., 2009).

To realise an efficient delivery process and to reduce the performance gaps that are all too common in newly built projects due to shortcomings related to handovers, change is paramount. A change that takes into consideration the organisational culture of the industry and is also easy to implement and cost effective. If the delivery process is secured in the early stages of the construction process, the opportunity for early identification of risks is optimised and these can be dealt with before they arise (Agha-Hossein, 2018). However, cost benefits associated with an efficient delivery are not tangible early in the process by use of traditional performance indexes, with financial gains often taking years to materialise due to the long project cycles. Unsurprisingly, this can discourage organisations and businesses from wanting to implement costly investments in the procurement process.

Although numerous studies have been conducted and empirical evidence is abundant regarding inefficient deliveries (Schultz et al 2015, Shi et al., 2019, Bordass 2004), this has not resulted in any sector wide solutions in construction, securing a robust delivery process between project organisations and managing organisations, where the operative outcome of a building’s performance achieves the projected performance. To effectively deal with the delivery inefficiencies it may be necessary to legislate and regulate the construction process, as has been done in the UK in 2016 in the Government Construction Strategy (GCS). Through the GCS, the Soft Landings framework was implemented in centrally procured public projects, covering public sector construction projects following the purchasing methods of the Crown Commercial Service, which are subject to the EU principles of free movement of goods and personnel (Crown Commercial, 2015). Contrary to the United Kingdom (UK), Sweden lacks an industry wide standard operating procedure with best practice methods for project handovers along with a clear and distinct structure for responsibilities and separation of roles for this process. As a result, many of today's completed buildings do not achieve their projected performance goals and often fall short of user expectations and energy performance. The lack of an efficient handover leads to economic losses as well as poor constructions that do not gauge well to user needs and purposes.

1.2 Purpose

The purpose with this study is to provide a review of the Soft Landings framework and relevant associated information, its overall effect on building performance, and to investigate if Sweden's construction industry should adopt the Soft Landings framework.

1.3 Research Questions

Has the lack of a standardised handover process affected building energy performance and user satisfaction in Sweden?

Has the Soft Landings framework impacted building energy performance and user satisfaction in practice?

Should Soft Landings or a similar concept be implemented in the Swedish construction industry?

1.4 Limitations

The field is limited with regards to scientific literature concerning Soft Landings, building energy performance, and user satisfaction. Therefore it was decided to conduct a literature review in conjunction with a multi-case study of the Soft Landings framework, as well as an interview study with relevant actors in the Swedish construction industry as it was deemed to be beneficial to the thesis. The multi-case study is limited to reviewing the buildings involved in Soft Landings Case Studies BG77/2019, as well as the Institute of Manufacturing Alan Reese building case study by Ray Pritchard and Scott Kelly.

The thesis regards implementation of Soft Landings on large private and public projects, such as the ones in the multi-case study. It therefore disregards small construction projects by individuals and individual homeowners. This is further reflected in the interview study where only relevant construction actors in large companies were selected to participate in the thesis. The interview study is limited in scope and is meant to give an overall sentiment on handovers in the Swedish construction industry.

2. Method

To reach definitive conclusions to the thesis, three methods were adopted. In this chapter these methods are presented and described, these methods include an extensive literature review, a multi-case study and qualitative interviews. The combination of these methods was deemed to be the most fitting approach for the thesis in order to answer the research questions. The qualitative interview study is seen as complementary to the literature review and the multi-case study, highlighting information and experiences which serve as insight into the needs of the industry.

2.1 Literature review

The consideration of previously conducted research in a field is essential for further research, therefore when performing a study, the author should begin by motivating the aim of the study and the thesis question by justifying the research and hypothesis through the lens of previous research. Generally this is simply referred to as a theoretical framework or literature review. This literature review can also be used as a research method, and can be especially useful when exploring the validity of a certain theory (Snyder, 2019) or when it is desired to integrate and generalise results and conclusions of previous work in a field (Randolph, 2009). When a literature review is undertaken, it is important to specify the coverage of the review. This coverage could be exhaustive and seek to encompass both published and unpublished works, or it could be limited to a representative sample of research studies and draw conclusions based on the sample (Randolph, 2009). As such, this literature review was conducted to establish the context of the chosen topic area and the current problems surrounding it, as well as to gain methodological insights into the area and to evaluate the chosen framework and connected theories.

The literature review was performed through a thorough search of the available scientific literature which was sampled and interpreted. Several databases and search engines were utilised to collect data for the literature review and in order to answer the thesis questions, with Google Scholar being the primary research database used. Since the chosen framework that was to be analysed is new and previous research conducted is fairly slim, government documents, construction journal articles, and news articles were sampled as well. The databases and search engines were used with specific keywords pertaining to the thesis area. The following keywords were used for the search: Soft Landings, Building performance, performance gaps, construction delivery, construction handover. The distribution of reference sources is illustrated below in Figure 1.

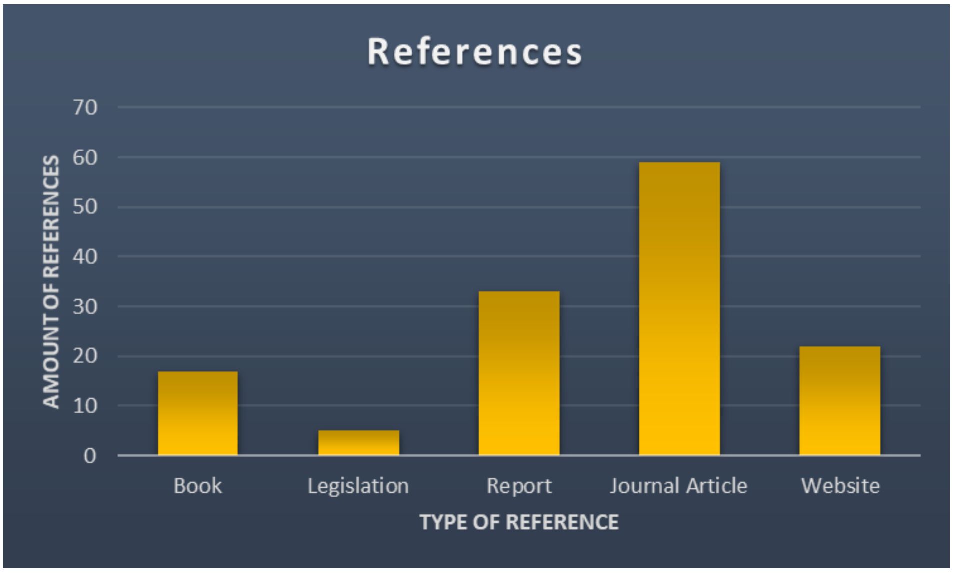

Figure 1. Distribution of reference sources.

2.1.1 Selection

References and sources for the studies and journal articles researched varies regarding year published, with some references being old and possibly outdated. This was considered and as such, a large number of studies were sampled with varying publication years in order for outliers to not heavily influence the sample, but rather to provide interesting insights and views. Additionally, special consideration was given to sample research and publications with a large number of citations in order to provide a just representation of previously conducted studies and the validity of the theories in the field. The yearly spread of the sampled publications is illustrated in Figure 2.

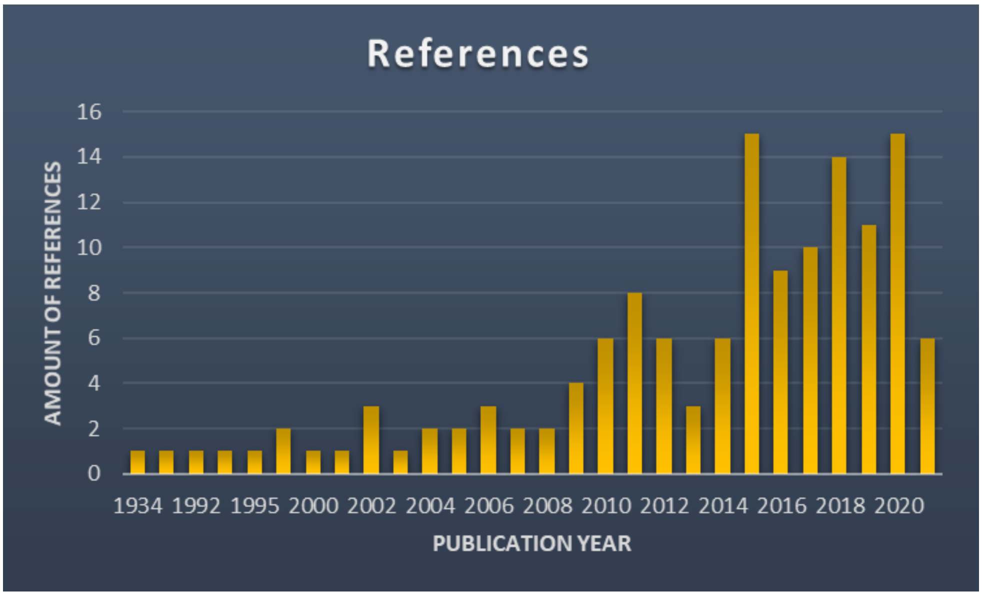

Figure 2. Publication year of reference sources.

2.2 Multi-case study

With limited research studies having been conducted concerning Soft Landings, a case study approach was deemed appropriate, where the approach is characterised by multiple methods of data collection through observations both qualitative and quantitative. A case study is defined as an intensive analysis of a unit, such as a person or programme, which develops in relation to its environment. Essentially, the case study is the choice of what is to be studied rather than the methodological choice of how to study it. The unit under analysis may be studied through qualitative or quantitative means. There are several variants of case study methodologies that can be used when conducting research, as identified by Stake (1995) there is the unique case study in which an individual unit is studied through its development. Alongside this is the collective case study, where a group of cases is studied. The methodology surrounding case studies varies depending on whether a single case or multiple cases are chosen. For multiple case studies, replication logic is used (Tellis, 1997). The methodology for multiple case studies follows an analogous logic, whereby the cases must be carefully selected in order that each individual case will predict similar results or predict contradictory results, but for reasons that can be anticipated.

Case studies are advantageous in that they can provide exploratory depth and understanding of applied theories, especially in new areas where research is limited, but they lack precision and reliability (Merriam 1998). As described by Tellis (1997), the case study methodology covers and satisfies the pillars of qualitative method, namely describing, understanding and explaining. The case study methodology has been used extensively throughout the 1900s, particularly in government and in evaluative research. Government studies evaluating the effectiveness of programs, and whether programs met their goals.

Case studies are valuable tools of observing the real world around us, with Yin (2005) as one of the most cited works concerning the research methodology giving a description of the case study as the following:

> *"…an empirical inquiry that investigates a contemporary phenomenon within its real-life context, especially when the boundaries between phenomenon and context are not clearly evident"*
>
> (Yin, 1994)

Yin (2005) goes on to explain that a case study should be considered when the focus is on covering contextual conditions if the researcher believes these to be relevant. With part of the aim of this study being to understand how the Soft Landings framework affects building performance, a case study methodology.

2.2.1 Selection

With random sampling not being desirable in case studies as there are requirements such as the implementation of the Soft Landings framework during the building process that need to be included for this study, it was decided to make the sampling as representative of the usage of Soft Landings as possible. This was done by the selection of publicly procured projects where the usage had been mandated, such as educational centres, and sports centres.

There are multiple sources of qualitative data that can be sampled when performing case studies, such as analysis of primary and secondary sources, interviews, even quantitative data. For a building project, quantitative data on energy performance and cost can be collected, with complementary qualitative data on perceptions, and experiences. This study focused on larger procurements such as educational buildings, where the Soft Landings framework has been implemented during planning and construction.

The following cases were analysed through document studies and a literature review of relevant information:

- The Enterprise Centre - University of East Anglia
- Keynsham Civic Centre
- Glenside Campus - University of the West of England
- The Engine Shed - Scotland's Building Conservation Centre

- One Heddon Street - The Crown Estate
- Oriam - Scotland's National Performance Centre for Sport
- Urban Sciences Building - Newcastle University
- Institute for Manufacturing (IfM) Alan Reece building - University of Cambridge

Seven of the documents analysed were included in The *Soft Landings Case Studies BG77-2019* document. providing additional information. The Soft Landings Case Study documents and the academic paper *Realising operational energy performance in non-domestic: Lessons learnt from initiatives applied in cambridge* study, along with several journal articles from construction magazines, have been analysed in order to perform the case study. While some of the sources that were used for the case study are academic, many non-academic references have also been used in order to better understand and evaluate the cases as the academic sources are scarce and only provide an overview of the cases.

All of the projects above, except the Institute for Manufacturing (IfM) Alan Reece Building, are BSRIA samples of Soft Landings case study projects. For this reason the *BG 77/2019: Soft Landings Case Studies 2019* document is a large part of the analysis on how projects have benefitted from the Soft Landings framework in the UK. The Building Services Research and Information Association (BSRIA) is a valid non-profit association that promotes knowledge and provides specialist services for stakeholders. This source and related documents are therefore deemed valid in providing relevant information on the implementation of Soft Landings in both theory and practice for the analysis of this thesis. Furthermore, information from the Chartered Institution of Building Services Engineers (CIBSE) and the CIBSE Journal are used in the multi-case study of this thesis. These sources provide general information about the case study projects, related building services and the implementation of Soft Landings. For the understanding of issues and problems related to the projects, information by Max Fordham and architectural practices related to the projects, is incorporated in the multi-case study. Max Fordham, composed of building service engineers with an industry leading approach to Soft Landings, were involved in several of the projects reviewed in the case study, the information from Max Fordham highlights the potentials with Soft Landings in practice.

Additionally, the study of the institute of Manufacturing (IfM) Alan Reece Building - University of Cambridge, where Soft Landings was used and evaluated was also deemed important to include in the thesis as it would ensure that the study encompassed all aspects of Soft Landings, not only the ones brought up by BSRIA.

2.2.2 Criticism

The case study methodology has been frequently criticised for its dependence on single cases, thereby making it unsuitable for drawing generalised conclusions (Tellis, 1997). Furthermore, investigator subjectivity has been cause for criticism, as the cases are selected by the researcher. There are means of mitigating this problem, with Yin (1995) stating that the use of multiple sources of evidence can be used to counteract the issue. Another criticism of the case study is the use of documents. These sources of evidence in case studies are not academic in nature, and whilst these can be used to corroborate evidence from other sources, they can also be misleading (Tellis, 1997).

2.3 Qualitative interviews

With the main topic of the qualitative study concerning experiences and culture, a qualitative study in the form of interviews was adopted in order to emphasise the experiences of industry personnel. With regards to the current pandemic and national recommendations and guidelines, the interviews were conducted through digital means with video and voice communications. The finding of an absolute truth or a generalisation is not the aim of this study, therefore it was decided that exploratory interviews where respondents would feel free to engage in descriptive and subjective conversations regarding the main topic was the right fit for the project. Although the data obtained cannot be generalised, Alsaawi (2014) argues that interviews can still be rich and deep for the interviewers. Utilising this method is seen as highly beneficial if information regarding the topic at hand is limited (Hedin 2011).

2.3.1 Semi-structured interviews

Qualitative studies can be approached through a number of methods and means, among these are focus groups; the variant is characterised by a smaller cohort, often comprising of 10-12 individuals, engaged in a less structured manner although for a longer time, where questions are open ended and allows for the focus group to expand on their answers and are given the opportunity of answering follow up questions (Adams, 2015).

In the middle of the spectrum there is an additional qualitative method, the semi-structured interview. This variant is neither strictly structured nor completely open, it is conducted individually, where the respondent is interviewed in a relaxed dialogue which does not need to follow a strict questionnaire. Semi-structured interviews are best used when it is of interest to extract subjective views and perceptions regarding a topic, but it requires considerable competence of both the interviewer and the respondent, particularly to be able to come up with relevant follow up questions to keep the conversation flowing (Adams, 2015., Hanna Kallio 2016). Although the format of the semi-structured reviews are not as time constraining as the focus groups, they are quite intensive, respondents can easily sway off the desired topic and it is essential to lead the respondent back to the relevant questions with elegance (Adams, 2015).

2.3.2 Selection

The choice of utilising a qualitative approach with semi-structured interview was made due to the study's focus on the experiences of industry actors, and their views on the handover process. The aim of this study is to uncover highly descriptive and subjective views regarding the handover phase and associated processes. To identify the potential problems/efficiencies with the handover process, site managers, and project managers were interviewed as these actors have experience of handovers and surrounding parts of project management relevant to the handover process. Potential respondents were selected and contacted through Linkedin.

Participants were screened via LinkedIn to ascertain their knowledge and competence in the construction industry, with previous experience and current roles being the factors considered.

Throughout the study four actors were interviewed, see chart 1. With such a small sample size, the results obtained are regarded considering the small size of the cohort. The small number of respondents was decided upon since there was no need for a large cohort as the goal of this study is not statistical generalisation throughout the industry. Furthermore, with the focus of this study being the multi-case study, it was deemed sufficient to interview four actors in the industry. The intent of the interviews is not to represent the views of all actors in the construction industry but to investigate whether the relevant industry actors find the handover process to be flawed, and what can be done to effectivise it.

Chart 1. Interview respondents.

LABEL	PROFESSIONAL TITLE	YEARS OF EXPERIENCE
B	Project Manager	> 10
F	Project Manager	< 5
A	Site Manager	> 5
K	Property developer	> 10

2.3.3 Criticism

There are drawbacks to semi-structured interviews. Not least regarding the lack of structure in the information retained from the respondents. Structured interviews and questionnaires provide straightforward answers due to the clear coupling between inquiry and observation; these are easy to equate and draw conclusions from, since the inquiries follow the exact same process and apply to the entire cohort. Conversely, it can be quite difficult to draw any precise conclusions from semi-structured interviews as the questions may differ marginally from each other. An additional drawback with the semi-structured interviews is that they are resource heavy, especially with regards to time, this can lead to cohorts not being large enough for the researchers to be able to draw any conclusions (Adams, 2015).

While Semi-structured interviews are accepted methods of conducting scientific research, there is no random sampling involved. The information seeked is collected from industry insiders with knowledge and experience of the chosen topic, and they must agree to be interviewed. As such Guest et al, (2006) argue that it is important to aim for maximum variation, in order for the sample to be representative of the larger population.

There is always a risk involved with conducting semi-structured interviews in that the interviewer may consciously or unconsciously affect the respondent. If the interviewer gives cues or prompts, the respondents may respond in a particular manner. This may also be the case if the interviewer employs leading questions in a particular direction. This needs to be considered throughout the interviews (Alsaawi, 2014). Additionally, the time and effort required to conduct semi-structured interviews is no easy task. As argued by Adams (2015) the process of planning, setting up and conducting interviews and the following analysis is not something that should be taken lightly, with numerous hours needed to transcribe recordings and go through notes.

2.3.4 Interview structure and approach

The semi-structured interviews are conducted with the help of an interview guide that is created prior to the interviews. The guide, see appendix 1, is used as a framework for the execution of the interviews. By having this framework and not a fully structured plan for the interviews it gives the respondents freedom to answer however they see fit. Depending on how the respondents are answering and how the interviews are progressing, only relevant questions to the thesis topic are asked. When creating the interview guide the questions are grouped into different topics to create some structure, although the questions are not always asked in order. The questions themselves are intentionally very broad. This way the respondents are able to respond however they want to, and the answers are not intentionally influenced by the interviewers. Also, this way the respondents are leading the interviews to a certain degree. If the answers are somewhat short, more lengthy, and detailed answers are encouraged with follow-up questions. Every interview is started by collecting some background information on the respondent. After every interview the recording is transcribed, and the data analysed.

2.3.5 Ethical aspects

Ethical aspects are of great importance in this qualitative interview study due to the few number of respondents and the detailed nature of the interviews. The interviewees are assured of their anonymity, and that their identities are not identifiable through the information procured throughout the interviews. It is difficult to decide what may be experienced as sensitive by each individual respondent, therefore it is decided that their views remain anonymous. As such, only the respondents current role and their experience within the construction industry is noted. The interview study is handled with honesty and openness regarding how the study is conducted, what the purpose of the study is, as well as the application of the responses provided by the respondents.

The message sent to the interview participants contains the following information: Whom the study is conducted by, and relevant contact information. The purpose and aim of the study. Information regarding the confidentiality of the interview, the recording of the interview, and the course of action. In the information provided, it is also made clear that the participant has the right to privacy, which in this case concerns the right to not provide a response to a question, to cancel the interview and/or to withdraw from the study at any time. Also before the interview is conducted the respondents are asked for permission to record the interview and it is made clear that the respondent will be anonymous. The participant is also made aware that they may be contacted again if responses need clarification.

3. Literature Review

In this chapter a literature review is conducted of all relevant information in the field concerning the thesis topics and related research questions.

3.1 The Construction Industry

The purpose of this chapter is to provide an understanding of Sweden's and UK’s construction industries, the performance gap, what the effects of the performance gap is, as well as what solutions have been tried to alleviate the problem. In order to fully understand the performance gap, this study also examines the Swedish and British construction industries and associated processes as these, although separate, have both allowed for the performance gap to remain.

3.1.1 The Swedish Construction Process

The construction process is often divided into three different phases: The Project Planning phase, which includes a needs investigation, planning programme, and project planning. The production phase which involves the actual construction. The management phase is often excluded from the description of the construction process (Hansson et al., 2015).

The planning phase is usually rooted in the idea that a building project can solve a need, these needs and solutions are thoroughly defined through construction documents and work descriptions throughout this phase (Hansson et al., 2015). In practice, this planning involves several activities such as a needs investigation, the development of main- and tender documents, construction documents, and building permits. Each of these activities concludes with a crucial decision which lays the foundation for the next phase in the project (Hansson et al., 2015). Visualised in *Figure 3* is the chain-like structure of activities that encompass the Planning process.

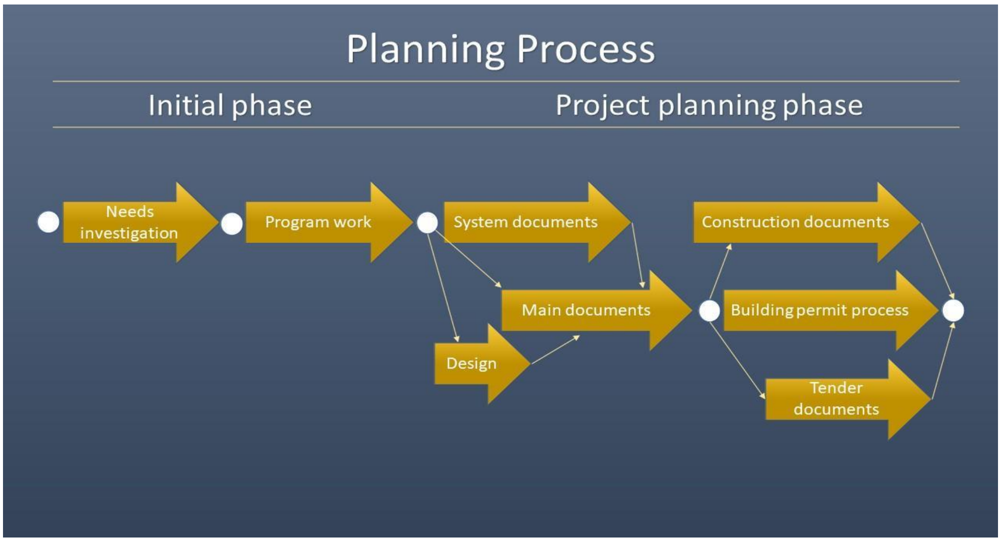

Figure 3. The Planning Process. Source: adapted from (Hansson et al., 2015).

The production phase follows the end of the planning process, though it can be argued that the planning phase continues alongside the production process since changes to the buildings design and construction are almost guaranteed during the construction process (Hansson et al., 2015). Visualised in *Figure 4* is the chain of core activities constituting the Production process. During this process, detail-design and production adjustments of construction documents are realised. The production adjustment must be performed in order for the design to be practically applicable to the project. Tender negotiations constitute part of this phase as well, where the client and entrepreneur come to an agreement on the tender. When tender negotiations have been concluded, time scheduling and budgeting begins, which then manifest into the construction operations where the actual construction of the building takes place. The handover consists of the final inspection and the training of administrative staff, as well as the exchange of building information and documentation (Hansson et al., 2015).

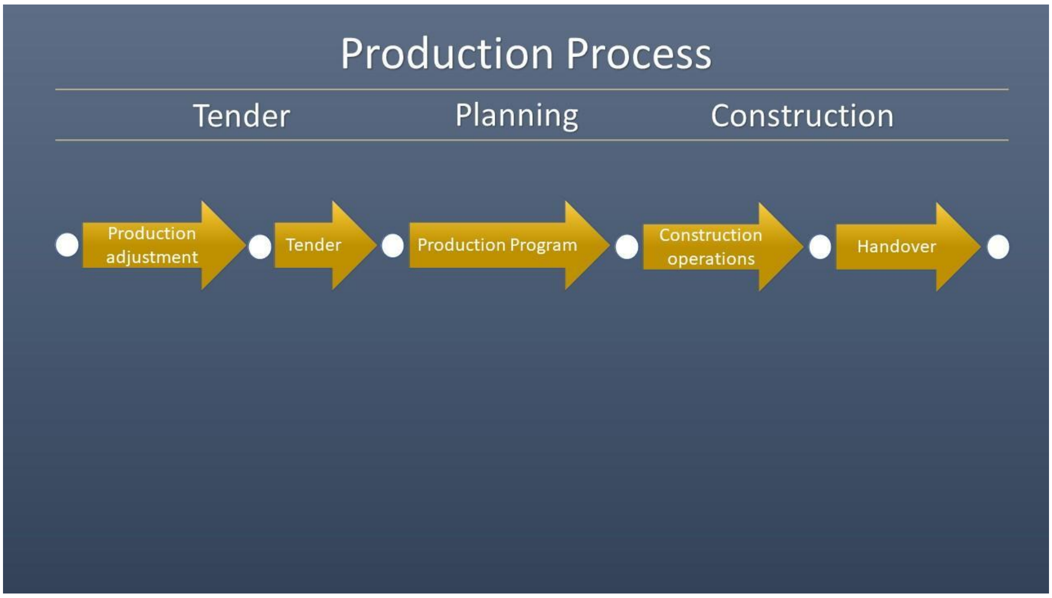

Figure 4. The Production Process. Source: Adapted from (Hansson et al., 2015).

The administration of a building is performed to provide a function, this function being the provision of service to the tenants, and maintenance of the building (Hansson et al., 2017). The administrative activities are often iterative, with continuous planned and urgent maintenance year-round, as is illustrated in Figure 5. The phase starts when the entrepreneur files a notice for final inspection and is finished when the building is fully operational and the administrative organisation has assumed command of building operations and management (Hansson et al., 2015).

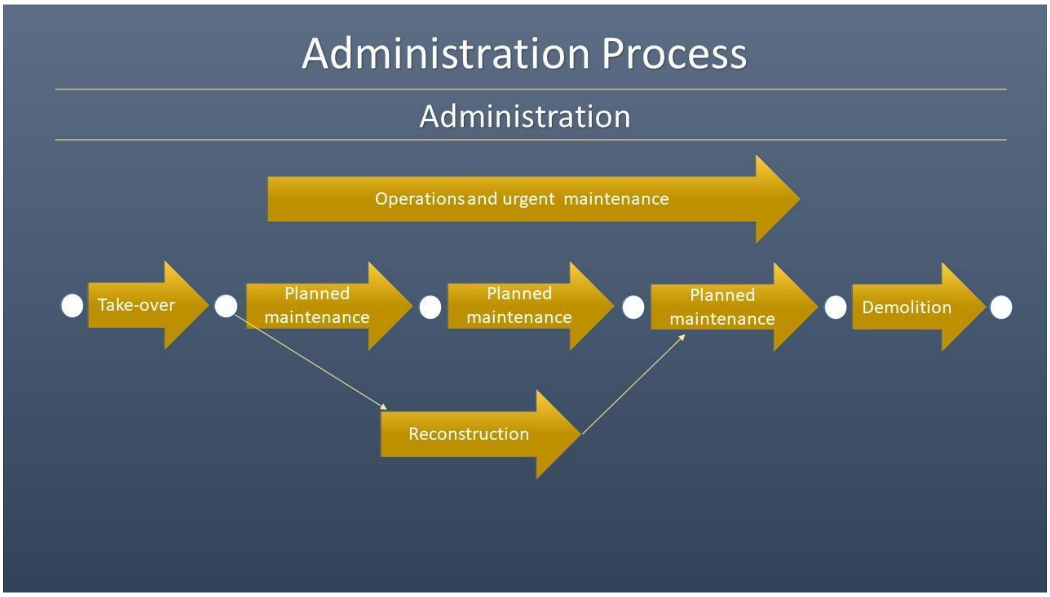

Figure 5. The administration process. Source: Adapted from (Hansson et al., 2015).

Contractors and entrepreneurs rarely highlight the systems and mechanisms in place for feedback and knowledge management. During the production phase, it is easy for other processes to be prioritised, resulting in absent or poor feedback mechanisms (Hansson et al., 2017).

3.1.2 The Swedish Construction Industry

The share of gross value added of the construction industry as a percent of Sweden's GDP reached 6% in 2019, with the broad construction sector employing around 680,000 people, and the narrow construction sub-sector employing 425,000 people. (EC, 2020) The laws and regulations governing the construction process in Sweden consists of a several legal documents, such as the Planning and Building Act (Plan och bygglagen - PBL), the Planning and Building Ordinance (Plan och byggförordningen - PBF), and the Swedish National Board of Housing, Building and Planning Building Regulations (Boverkets Byggregler - BBR). These laws serve as bare minimum requirements for building projects and serve to promote long-term sustainable development for the Swedish people. While mandatory provisions are abundant, they are accompanied by general recommendations to the main statutes which provide guidance on best practices available for use to comply with the mandatory provisions (Ihse and Edberg, 2021).

Construction has historically been subject to prescriptive regulations, specifying design choices through standards. Throughout the end of the 20th century however, there has been a shift towards performance-based regulations, where performance criteria set the minimum standard, allowing for greater freedom in design choices and building methods (Gann et al., 1998). Legislative change came into action in Sweden in 1967 through the Swedish Building Regulation Svensk Byggnorm SBN 67 where performance based regulation was introduced as functional requirements relating to general tests or calculation methods (Statens Planverk, 1968).

On one hand, the focus on functionality allows for market innovation and competition to develop naturally (Lundgren, 2019), on the other hand this can create gridlock, especially in situations where there are several different actors involved in a single project and there are no definitive guidelines that can be leaned back on for guidance and direction. In essence, Sweden has no definitive law regarding contractual terms and conditions, instead acting self regulatory (Ihse and Edberg, 2021).

Through the Construction Contracts Committee (BKK) the construction market has created a series of documents published and maintained by different individual organisations to enable efficiency in the construction industry and the construction process. Examples of these documents are: AMA, the General Conditions of Contract for Building and Civil Engineering Works and Building Services (AB04), these documents cover the division of responsibility for performance on the contractor, the General Conditions of Contract for Design and Construct Contracts for Building, Civil Engineering and Installation Works (ABT06), these document covers the division of responsibility for both performance and design on the contractor, and the General Conditions of Contract for Consulting Agreements for Architectural and Engineering Assignments for the year 2009 (ABK09), this document covers the division of responsibility for consultants with regards to the design of a project. These guidelines are typically used in agreements and implemented in the terms of contracts to secure "best practice" methods and handle technicalities of construction projects. In essence, these documents are the market's solution to the lack of central guidelines provided by the state, and they work akin to laws when put into contracts (Ihse and Edberg, 2021).

The Swedish procurement process is based on EU laws and directives, following the free movement of goods and services. The main part of these processes are regulated in the Public Procurement Act 2016:1145 (Riksdagsförvaltningen, 2016) where it is noted that price is the main factor considered when tenders are evaluated.

> *"A contracting authority shall award the supplier a contract whose tender is the most economically favourable for the authority*
>
> *Which tender is the most economically favourable tender shall be evaluated on the basis of one of the following grounds:*
> 1. *The best ratio between price and quality*
> 2. *Cost, or*
> 3. *Price."*
>
> (Riksdagsförvaltningen, 2016)

Around a third of all public procurements relate to construction work, with the most common evaluation method of tenders being lowest-price tendering (Upphandlingsmyndigheten, 2021).

There is valid criticism of the construction process and the overall organisational culture of the construction industry, especially concerning energy efficiency as the construction industry itself is a major energy consumer. This is evident from outcries from the public regarding the million programme, and several journal articles aimed at poor construction practices (Byggkommissionen, 2002). In the Building Commission's conclusions, the criticism concerns client's and administrative organisation's weakened positions in construction, as well as policy decisions making construction projects more lucrative for client's looking to quickly sell instead of manage finished projects. This has led to weak incentives for constructing high quality buildings (Byggkommissionen, 2002).

In December of 2017 Boverket was tasked by the Swedish government with reinforcing the work concerning indoor climate and comfort. The following year, Boverket released the report *mapping errors, deficiencies and errors in the construction sector* (Boverket, 2018), the culmination of a year's work involving a combination of methods, ranging from surveys with 822 responses and 35 discussions as well as 17 interviews with relevant actors, to the data collection of available statistics. One very interesting find that is uncovered in the report is that most deficiencies and errors materialise first after the expiration of the one-year warranty time. The major deficiencies include water penetration of roof and floor, errors in the production of wet rooms, moisture in constructions and ventilation problems. Furthermore, it is noted in the report that the deficiencies and errors have been recurring problems the last couple of decades. Even more concerning is that the total volume of errors has increased over time. Boverket (2018) concludes that feedback must be central to the construction industry, claiming that the experience and knowledge pertaining to deficiencies and errors is available, but that the feedback process and tools for sharing are not. The organisation further highlights the poor distribution of responsibilities and roles during the delivery process and the initial management of projects.

3.1.3 The British Construction Process

As of 2021 the British construction industry has not yet settled on a singular definition of the plan of work/construction process (RIBA, 2020). However, in essence, the recommended plans of work follow the same order, although with slightly different variations in work definitions which are shown below in *Figure 6.*

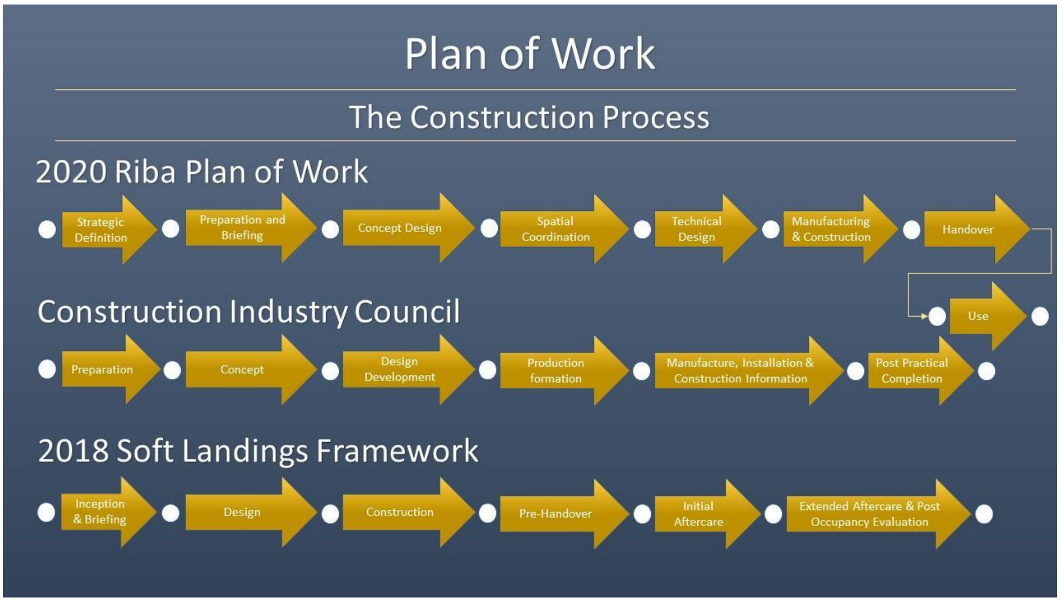

Figure 6. Three market variations of the British construction process.

3.1.4 The British Construction Industry

With an output equivalent to around 6.5% of the UK's GDP, and the employment of roughly 3 million people (Government, 2013), construction is one of the UKs biggest industries with the central government being the largest construction client.

British building regulations are quite similar to Swedish building regulations in that there are a set approved documents covering the various aspects of construction and building design. These documents were introduced as a set of national building standards in 1965, and are now labelled Building Regulations. The documents are not legally binding, word for word, instead rather similarly to Swedish documents the documents describe minimum appropriate standards concerning the following: What qualifies as building work, notification procedures during construction, and requirements for certain acts of building design and construction. A complete overhaul of the Building Regulations was issued in 2010 and has subsequently been amended on numerous occasions following (The National Archives, 2010).

The Royal Institute of British Architects (RIBA) Plan of work is the definitive design and process management tool used in the UK construction industry (RIBA, 2020). Majorly overhauled in 2013 for the first time since its inception, the new changes include additions of sustainable project strategies and an increase in focus on sustainable outcomes. In the 2020 edition of RIBA Plan of work, the RIBA Plan for Use guide was implemented as an interpretation of the Soft Landings Framework developed by the BSRIA aimed at mitigating many of the criticisms associated with the British construction industry (RIBA, 2020).

The British construction industry is plagued by inefficiency. Industry-wide recognition of this inefficiency led the UK government to drive through change in the beginning of 2011 with the Government Construction Strategy and later on Construction 2025 (Cabinet Office, 2011., Government, 2013). Construction 2025 highlights four core targets as the goals to ensure the UK's vision of being a world leader within construction, paving the way forward.

- The first target is to decrease initial construction costs and costs over time of built assets by 33%.

- The second target is to decrease the total project time, from plan to completion, including both newly built projects and renovations by 50%.

- The third target is to lessen the amount of emissions in the built environment by 50%.

- The fourth and final one of the four core targets is to decrease the UK's export deficit with other nations (Government, 2013).

Such a large sector as the construction industry should not be subject to poor optimisation, yet the problem of efficiency seems to be one of the industry's largest problems to date, and the problem with productivity is global (Woetzel, 2017). Constructions are substantially more expensive than initially predicted, often dragging out for years. Only a quarter of construction projects monitored by the global accounting firm KPMG ended up costing within 10 percent of the initial estimation (KPMG, 2015). These are just some of the problems that arise due to the poor efficiency of the construction industry. While some of these problems are a result of poor policy decisions, others are harder to pinpoint. This is specifically the case with energy efficiency, where new buildings are planned to achieve a certain level of performance with new building technologies and designs, yet somehow fall short of their predicted performance when measured in-use.

In the UK the construction industry has been subject to turbulence for a long time. Its shortcomings were first observed in the book *Building to the Skies* written by architect Alfred Bossom and published in 1934 (Bossom, 1934). Bossom heavily criticised the construction industry in the UK for its inefficiencies and the resulting client dissatisfaction. Almost a decade later, in 1944, the inefficiencies were further criticised, this time in the Simon Report, where the British procurement process was heavily criticised for being too strict, not allowing for deviations in the planning process, leading to most construction plans already being finished in design before negotiations and procurement had even taken place. *Building to the skies* marked the start of many critical studies aimed at the performance of the construction industry as well as the performance of newly constructed buildings. Around the year 2000 two large reports were published, both written by British industrialist Sir John Egan. The first one, *Rethinking Construction*, (Egan 1998) identifies five key drivers of change which are necessitated to drive through a new path for the construction industry. These are as follows: A committed Leadership, a focus on the customer, integrated processes and teams, a quality driven agenda, and commitment to people. One of the main tools proposed by Egan to utilise in the change of the construction industry is measurements and extensive use of performance data. Egan goes on to argue the following

> *"To achieve these targets the industry will need to make radical changes to the processes through which it delivers its projects. These processes should be explicit and transparent to the industry and its clients."*
>
> *(Egan, 1998)*

Studies such as *The Latham Report, The Egan Report* have in common that they criticise the inefficiencies of the industry and the poor performance of the buildings constructed (Cabinet Office, 2021). These criticisms have led to some change as the UK's government has attempted to alleviate the inefficiencies with regulations and plans such as *The Government Construction Strategy,* and the recent *Construction 2025* (Government, 2013., Cabinet Office, 2011). In the beginning of 2011, the British government published a strategy of growth alongside the yearly budget, a strategy in which the current inefficiencies and cost of construction was emphasised. The Government Construction Strategy signalled for a deep and thorough change in how the Government conducts business with the construction industry, to ensure that the UK would receive consistent value in its infrastructure. The strategy calls for clients to issue briefs that instead of focusing on the bidding process and the lowest price available, instead puts emphasis on the required performance and outcome of the building/project. It also calls for competition through effective price benchmarking and cost targeting (Government, 2013., Cabinet Office, 2011).

The standard process in the UK with competitive tendering is argued to have several limiting factors on the construction industry such as inhibiting the integration of the construction team as it prevents contractors from engaging in the project early in the design stage (Proverbs et al., 2000). This also tends to lead to an us against them type of relationship between the design and construction team, and poor communication between clients and the project team (Proverbs et al., 2000). Lowest price tendering has received criticism from a number of construction organisations in the UK, among them the think tank Constructing Excellence, which in the publication *The Business Case for lowest price tendering?* argue that the traditional use of lowest price tendering has detrimental effects to the construction industry such as forcing contractors to set unrealistically low price levels for projects, making it impossible to maintain high quality and standards, and leading to cost and time overruns (Constructing Excellence, 2011).

3.2 Building Performance

Of the total energy produced yearly, non-residential and residential buildings worldwide collectively consume around 30 percent (Hamilton and Rapf, 2020), and has been predicted to rise at an average rate of 1 percent yearly until 2035 (International Energy, 2011). While today's energy supply for buildings is mostly electrical, this has not always been the case. During the worldwide oil crisis of 1973, the price of oil soared around the world as the oil producers in the Organisation of Arab Petroleum Exporting Countries (OAPEC) announced an oil embargo. With many of the countries in the 1970s relying on oil for heating being cut off from the supply, drastic measures had to be taken to decrease oil usage to ensure that oil supplies could last. With oil being the primary energy used for the heating of homes and offices, an unofficial drive in energy efficiency began, called conservation. With oil constituting close to 75 percent of Sweden's total energy usage at that time, the nation was affected harshly by the oil embargo, which led to the government introducing oil rations, and individual municipalities regulating energy saving measures for buildings. Examples of such measures were to lower the average room temperature, to adjust ventilation settings, and tighten door- and windows seals (Lunner, 2018). In Sweden, this unofficially led to the first push in energy efficiency such as Svensk Byggnorm 1975 published by BBR implemented several changes to the previous building regulations in SBN, including demands of the following:

- Increased insulation thickness in facade walls
- Strategic placement of windows in order to increase heating efficiency.
- Heat recovery of the exhaust air

These measures were introduced in coordination with taxes being levied on oil and supporting measures used to subsidise energy renovations in buildings (Lunner, 2018).

In 2021, the cost of energy is once again increasing drastically with natural gas prices rising, and electric power having increased by more than twofold in the last year. To effectively reduce carbon emissions as well as combat climate change, building energy efficiency and energy consumption reduction is paramount. According to the Swedish Energy Agency in 2016, the average energy consumption of apartment buildings constructed before 1960 was 147 kWh/ per square metre and year. For apartment buildings constructed between 1961 and 1980, the average energy consumption was reduced to 140 kWh per square metre and year. When comparing these to newly built apartment buildings (2011-2016) where the energy consumption has been measured at 90 kWh per square metre an year on average, it is clear that energy efficient measures are greatly needed for older constructions (Swedish Energy Agency, 2015).

3.2.1 The performance gap

The previously mentioned discrepancy between predicted energy performance of buildings and actual measured performance have been designated as the "Performance Gap" by researchers (Trust, 2011, Menezes et al., 2012). A marginal discrepancy in energy efficiency and energy consumption is unavoidable due complex building designs and limitations of measurement and monitoring equipment. However, numerous case studies have shown that the performance gap is staggeringly wide, with total energy consumption recorded being 2.5 to 4 times as high as calculated (Fokaides et al., 2011) A review study of the magnitude of the performance gap in case studies showed that the performance gap is consistently encountered and ranges from 26% to 400% in additional energy consumption compared to predicted energy consumption (Shi et al., 2019). With rising energy costs (Eurostat, 2021, Statistics, 2013) and criticisms directed at the construction industry for these discrepancies in energy efficiency it is essential to decrease the performance gap and deliver energy efficient buildings that perform as predicted.

The root cause underlying the performance gap is difficult to pinpoint, since it is multifactorial and not necessarily the result of a single error or flaw (van Dronkelaar et al., 2016). Uncertainty of building energy modelling pertaining to a lack of information or inaccurate specifications of the buildings and building systems being modelled is highlighted in several studies as one of the major underlying causes for the performance gap, along with Occupant behavior and poor practice in operation (Zou et al., 2019, van Dronkelaar et al., 2016). These are estimated to have effects of 20-60, 10-80 , and 15, 80% on energy consumption, respectively (van Dronkelaar et al., 2016).

3.2.2 The energy efficiency paradox

With regulations toughening worldwide on energy consumption in buildings, it paradoxically seems that performance gaps widen with regards to projected and actual energy consumption. Although Sweden has initiatives tackling the energy efficiency of new buildings with national directives such as Government proposition 2008/9:163 called *Coherent Climate and Energy* in which it is specified that Sweden's energy consumption shall decrease by 20% by 2020 and 50% by 2050 (Regeringskansliet, 2008), later changed in 2016 to by 2030 (Regeringskansliet, 2017), as well as article 4 in the *Energy Service Directive of more effective end usage of energy and energy services*, a recent study by SBUF shows that only 25 percent of new apartment buildings achieve their projected energy performance. This is indicated to be an industry wide problem; however, it is argued that there are two approaches that are viable in order to tackle the efficiency gap (Kempe, 2020).

1. The first one is to increase the safety margins in the energy calculations in order to take deviations out of the equation. This could lead to the building requiring more solar panels, insulation, and in general more expensive solutions.

2. The second one is to increase expectations and demand when it comes to employee competence and material quality for construction organisations and managers. The increased expectations would also have to cover the entire building process, from design to production and maintenance of the finished project (Kempe, 2020). SBUF Feasibility study Prerequisites for analyses of energy efficient apartment buildings' function and energy use.

Results show that part of the gap could be explained by user habits that generate excess energy consumption such as adjustments to the in-door temperature, variations in household electricity usage, open windows resulting in airflow imbalances and intake of cold air, lowering the in-door temperature. The impact of user habits on energy usage in apartment buildings is usually undermined, this is especially true for tenants living in energy efficient buildings, as the low energy consumption of these buildings is substantially increased through energy consuming user habits. (Kempe, 2020) This is problematic, especially since Boverket (2020) recently implemented new construction requirements on apartment buildings, demanding that these have an energy consumption of no more than 75 kWh per square metre. With regular user habits resulting in an average deviation to the energy consumption of a building by around 19-

20 kWh per square metre and year. It is essential for construction companies to take these into account when designing new buildings in order to comply with the growing number of proposed energy related regulations on both international and national levels, such as the requirement of all new buildings to be Nearly-Zero Energy Buildings (NZEB), and to be able to access grants and subsidies provided for achieving high energy efficiency (Economidou et al., 2020).

3.3 Organisational Culture In Construction

The reason why actors in the construction industry are reluctant to return to previous projects for feedback, is not due to a lack of competence or faulty training, but rather due to the organisational culture that is prevalent in the industry (Bunn et al., 2014).

The thesis that an underlying culture and behaviour of workers and managers in an organisation was introduced in the middle of the 20th century, and further expanded upon by Schein in 1992. The most consistent view on organisational culture is that it can be defined as "values, beliefs and norms which influence the behaviour of people as members of an organisation" (Flamholtz, Eric; Randle, Yvonne 2014). Schein has described organisational culture as a phenomenon that does not simply appear out of thin air in a single day (Schein 2002). An organisation is akin to a process capable of learning from past experiences, thereby creating what would later become a culture from these learned experiences, organisational culture affects everything in an organisation, from strategic goals and underlying values to the daily tools/routines steering daily operations. Research in organisational culture supports the thesis that it can have a substantial impact on projects (Ankrah, 2007), therefore it is important to take organisational culture into consideration when discussing change management and transformative work in construction.

Organisational culture in the construction industry can be defined as the following:

> "*...The overall character of the industry, how the workers view the sector, the competence of both the work force and partnering work forces within the sector, as well as the goals, values and strategies of the organisations involved.*"
> *(Abeysekera, 2002)*

The failure to deliver projects to specified requirements have inspired research into organisational culture in construction and a possible connection to project performance (Ankrah, 2007). In *Rethinking Construction* published in 1998, Sir John Egan elegantly lays out the underlying problem concerning the organisational culture in the construction industry.

> *"The Task Force has looked for this concept in construction and sees the industry typically dealing with the project process as a series of sequential and largely separate operations undertaken by individual designers, constructors and suppliers who have no stake in the long term success of the product and no commitment to it. Changing this culture is fundamental to increasing efficiency and quality in construction."*

(Egan, 1998)

In order to reduce the gaps between predicted and achieved performance, and to meet the increasing expectations of clients, a culture shift needs to be successful in the construction industry, a culture shift which will necessitate a clear focus on the customer and customer needs, the integration of process and production team where defragmentation is avoided, where a no-blame culture is enforced, and where post-sales care alongside reduced cost during maintenance and operations (Egan, 1998). This is further supported by Ankrah, who recommends that the industry needs to devote more attention to cultivating a no-blame culture and (Ankrah, 2007).

3.4 Handovers and the administrative phase

Although identified as being one of the most influential factors underlying performance gaps, limited research has been conducted regarding the handover process and its effects on energy performance (van Dronkelaar et al., 2016).

It is obvious that a fundamental culture change in how buildings are delivered is required especially since there has been a major shift of focus in the construction industry. The commitment to high-performance buildings, both regarding energy efficiency and occupant wellbeing, makes a clearer approach to building delivery processes necessary. Especially since the demand for high-performance buildings is driven by a commitment to net zero carbon emissions in the UK by 2050 (Agha-Hossein, 2019) and in Sweden by 2045 (Ministry of the Environment & Energy, 2017).

The need for better technology is often brought up as a solution to the Building Energy Performance Gap (BEPG), with “hard” technologies such as Building Information Modelling (BIM), Radio Frequency Identification (RFID), machine learning, etc. constituting the majority of research efforts in the area (Zou et al., 2018). But technology is not necessarily the solution needed. Renovations of current buildings can be of great value and in some situations may even be required for the building to be able to continue to operate, but there are easier and less cost demanding measures that can be taken to decrease the energy consumption of buildings such as the methods tried and tested in the PROBE studies (Cohen et al., 2001).

It should be noted that the obstacles regarding the handover/delivery process are not exclusive to a single country, as highlighted by studies and feedback from all over the world, from Australia and the UK, to Scandinavia (Schultz et al., 2015, Shirkavand et al., 2016, Zhu et al., 2019). Concerning actors in the Swedish construction industry, it is highlighted in a recent study that although entrepreneurs work with project handovers, they cannot consistently define when a handover begins or ends. They do however agree with one another in that they define the handover as a process, and not a specific point in time when responsibility for the project shifts from the project developer to the customer/administration (Gustav Nyberg, Frida Orlinder 2017).

It usually takes time for comfort-related building problems to arise, which is not taken into consideration in current construction contracts with inspections rarely taking place following occupancy. Examples of the problems that arise are numerous, and include increased energy consumption, deviating water consumption, noise/vibrations, etc (Boverket, 2018). While these problems are easily managed, if they are not managed quickly, they could lead to deteriorated relationships between manager and occupants, as well as between manager and project organisation. By securing the management process early in the production process and by guaranteeing that problems aren't recurring, a strong relation can be maintained with the client. Maintaining an active relationship between the project organisation and the managing organisation and suppliers can be the difference between securing future contracts and failing to keep clients in the industry.

Common occurrences involved with handovers of IT systems, such as Building Management Systems, to managing organisations are late information deliveries and a lack of competence sharing/ training concerning the management systems (Hammar, 2011). This is relevant to the construction industry as the uptake in utilising Computer Aided Building Management (CAFM) systems and Building Information Modelling (BIM) systems is increasing (İlhan Jones, 2020). Digital management systems require substantial data transfers between the project organisation and the management organisation, which in turn necessitates clear roles and defined structures. With already weak structures in place regarding knowledge of the handover process and responsibilities between project and managing organisations in the construction industry, this digitalisation increasingly complicates the delivery process (Källbrink and Månsson, 2018).

To further complicate the situation, the handover process does not have clearly defined start and finish activities, making it difficult to coordinate data transfers between organisations and responsibilities (Källbrink and Månsson, 2018). The difficulties with project deliveries concern both the role definitions, the obscure distribution of work, as well as responsibilities. With no clear guidelines being provided by the government and market forces having failed in producing any guidelines, the delivery process is often messy, characterised by confusion, misconceptions, and misunderstandings, leading to poor optimisation and poor performance (Hammar, 2011).

3.4.1 Market Solutions in Sweden

Numerous attempts at developing frameworks and methods have been made by the Swedish construction industry and related organisations in order to tackle the challenges with performance gaps and inefficient handovers. Examples of these are as follows:

- Building process with guarantee management. The framework was developed by NCC in a government sponsored organisational cooperative called Bygga-Bo-Dialogen (The Build-Live-Dialogue), with the goal of establishing a model for quality assurance of indoor environment, efficient energy consumption, and long-term low management costs. This was to be achieved through early engagement and coordination between client and project organisation, along with the implementation of the management system Healthy Indoor Environment (Boverket, 2004). The framework introduces a new type of entrepreneurial contract where the entrepreneur is further involved in the administrative phase of the building's life cycle, taking on the responsibility of managing the building during an agreed upon warranty period, for a cost. This would incentivise the entrepreneur to deliver a building that maintains its energy consumption over time, performing inspections and quality controls. Unfortunately this endeavour was short lived as the Swedish government chose to shut down the initiative in 2010 in order to move on to the Delegation for Sustainable Cities (Svensk Byggtjänst, 2010). As such the management system healthy indoor environment failed with market outreach as there is no new information regarding the framework available online since.

- ByggaE is another development that has slowly been gaining traction recently. ByggaE is developed by SBUF (Development Fund of The Swedish Construction Industry). SBUF has previously had success with two commercially available, free of charge frameworks which have become industry standards, these are as follows:

    - ByggaF, a method for a moisture/humidity secure building process. The method consists of routines and directives concerning all involved actors in the process (Mjörnell, 2007).

    - ByggaL, a method for airtight construction. Similarly to ByggaF, the method documents, charts, and communicates building airtightness throughout the entire building process. The method was developed following the success of ByggaF, and the method is composed out of the original ByggaF-framework (Sikander, 2010).

  The newly developed ByggaE framework is a quality assurance method where all questions and documentations concerning energy are collected and gathered from the involved actors in a map-like structure. This is to be facilitated by an energy coordinator that is chosen at the start of the project. Checklists covering the building process from the planning phase to the project handover, similarly to ByggaF and ByggaL for additional guidance is also part of the framework. The overall goal of the method is to ensure that there is no loss of information during the collaboration between the project developer, designers, and client, as is often the case in construction projects and tends to affect building performance (Gustavsson and Lane, 2015). The framework is relatively new, with assessments from industry insiders suggesting that the method is hard to implement, which in turn explains the low implementation of the framework in the construction industry. As of 2016 development haD begun on a simpler, clear and concise version of ByggE called ByggaE Bas (Lane and Gustavsson, 2018).

- SVEBY (Standardise and Verify Energy Performance in Buildings) is a cross-industry program developed and maintained by actors in the construction and real estate industry dedicated to the development and advancement of industry standards in energy verification. By normalising the input parameters of energy values and utilising standard values the aim is to simplify verifications in order to comply with BBRs building regulations, and to ensure that property developers and clients perform comparable calculations. In pursuit of these goals, SVEBY has produced documents outlining guides and routines concerning energy monitoring (Wahlström, 2015), these are complemented with guidelines pertaining to what should be measured and how metering is to take place.

Since responsibilities and roles in construction projects are assigned through contract agreements such as AB04 and ABT06, and since energy monitoring introduces new roles and responsibilities for the property developer and client, SVEBY has produced the document Energy Agreement 12 as a complementary attachment to the above contracts in order to ensure that the energy monitoring methods advocated by SVEBY is followed. Energy Agreement 12 was developed in collaboration with the Construction's Contact Committee (BBK) and is designed to be used together with ABT 06 for turnkey contracts in order to manage performance gaps. In effect energy agreement 12 regulates a specific measurement- and sanction package, with limits recommended pertaining to kWh per square metre for specific years following project completion, and sanctions per kWh that exceeds the limits (Sveby, 2012). A letter of intent to use SVEBY's energy monitoring documents has been signed by several organisations in the construction and real estate industry, and a number of larger entrepreneurs have also incorporated SVEBY's energi verification documents in their quality control processes (Wahlström, 2015).

Some of these frameworks are very similar, which has led to suggestions of incorporating the frameworks SVEBY and ByggaE together into a joint framework utilising the different strengths of each individual method (Wahlström, 2015).

3.4.2 Regulatory solutions

Some countries have tried regulatory frameworks to support the handover process, according to Schneider (2016) Norwegian construction industries utilise NS 8430, the Norwegian standard for handover of buildings and civil engineering works. While the Norwegian construction industry operates under the principle of contractual freedom, the construction industry commonly uses the government produced standard contracts due to their guidance and relative ease of use.

The Norwegian handover standard does not regulate overall building performance, with commissioning only being described as the testing and tuning of technical systems, and with Schneider (2016) stating that the commissioning part of the Norwegian handover standard is poorly described. Handover processes in Norway are characterised by the municipality of Trondheim as being costly and time consuming with an abundance of delays and defects. Schneider (2016) comes to the conclusion that the contracts are too complex, adding to the handover challenges, as developers and contractors have differing expectations and interpretations of the contracts.

The EU has tried alternative solutions to tackle the performance gap. Inspired by the Kyoto protocol of 1997, the EPBD is the main sustainable building related legislation developed by the EU and was developed to realise potential energy efficient savings in building, both new and current ones (Danish Energy Agency, 2021). The main objectives of the EPBD legislation are to improve improvement of energy performance of buildings, require nations to adopt a national or regional calculation method of energy performance of buildings in accordance with the EPBD guidelines, and ensure that Energy Performance Certificates (EPCs) are made available when buildings are constructed, sold or rented out (European Parliament, 2002). The EPBD does not define numeric thresholds or intervals for energy consumption, leaving it to member states themselves to define these, as these may vary due to climate conditions, cultural building traditions, primary energy factors, etc (European Parliament, 2002).

EPCs are, in essence, documents indicating the energy performance of a building, calculated in accordance with guidance provided by the EPBD, and recommendations for cost-effective energy performance improvements. In 2014, energy classifications were introduced alongside the EPCs in Sweden, these energy classifications include a graded scale with seven classes, ranging from A to G, with A symbolising an energy consumption of less than 50 percent of the current threshold requirement for new building stock, and G symbolising an energy consumption of more than 235 percent of the current threshold requirement of new building stock (Boverket, 2021). As EPC's contain information concerning recommendations for cost-effective building improvements, this is argued to be the most valuable information displayed on the EPC's (Kelly et al., 2012). While EPCs show energy consumption, these calculations are based on projected energy performance, and do not provide information regarding the continuous energy performance with real time observations for control systems and operations in the building. Neither does it show occupant behavior, needs or satisfaction, which could all impact energy performance (Norford et al., 1994).

> *"Energy Performance Certificates use an estimation methodology to calculate the energy that is used by a building in providing its most basic functions of Heating, Ventilation and Air Conditioning (HVAC), lighting and hot water provision… The energy consumption estimates used in the creation of an EPC are commonly misinterpreted to represent the entire building's energy use. This can lead to gross underestimation of operational energy use and confusion about the overall impact a building has on the environment"*
>
> *(Pritchard and Kelly, 2017).*

In 2012 the BBP conducted an analysis of actual energy usage of more than 200 properties, which revealed that EPC ratings are poor indicators of actual energy performance, as there is no correlation between the energy efficiency of buildings and their corresponding EPC ratings (Jonas Lang and Bbp, 2012). This suggests that actual energy performance, not theoretical or predicted performance, should be used for energy performance calculations in order to reduce energy consumption (Jonas Lang and Bbp, 2012). The BBP goes on to argue that EPCs are not a sufficient means of lowering energy emissions to stated government goals. EPCs do not take occupancy energy consumption into account, and since these can have large variations as occupants manage their own thermal and visual comfort, they can in turn have drastic impacts on energy consumption (Jonas Lang and Bbp, 2012). Introduced to publicly procured buildings through regulatory means in the UK in 2015 in order to motivate better management. DECs provides an industry example in how actual performance measurements can be implemented, and is highlighted as among the building industry initiatives most likely to achieve projected building performance when in use (Tuohy and Murphy, 2015). Display Energy Certificates (DECs) rate actual/operational energy performance against benchmarks. By illustrating actual energy use after completion, DECs allow for feedback, something that EPCs inherently do not.

> "*People will then learn from their mistakes, not keep repeating them, and report and share findings. This feedback will help to make buildings much more efficient – not by adding more kit, but by doing things better, as NABERS has confirmed in Australia. More thought, less kit is more sustainable too.*"
>
> *(Blackman, 2019).*

3.5 Energy Ratings Systems

3.5.1 LEEDS & BREEAM

In the last couple of decades, countries around the world have increasingly adopted environmental assessment methods. Since buildings make up a vast amount of total energy consumption in the world, energy certificates have become increasingly available and, in some cases, mandated by governments in order to decrease energy consumption, as has been the case with performance energy certificates through the EU legislation EPBD. (EPBD 2002). The British Building Research Establishment Environmental Assessment Method (BREEAM) was the first energy certificate to be developed and is now in use all over the world. The largest and most popular commercial energy certification used is the Leadership in the Energy and Environmental Design (LEED). LEED is American in origin and was developed in 1998 by the US Green Building Council (USGBC). Sweden has its own energy certificate in the shape of Miljöbyggnad, developed by the Swedish Green Building Council (SGBC), that has been used for the certification of over 1500 buildings in Sweden (Sgbc, 2018). However, Sweden has also decided to develop a version of BREEAM, adapted to Swedish regulations, called BREEAM SE (Jonestrand 2020).

Energy certifications such as BREEAM and LEED utilise point-scales where points are awarded if a building achieves certain targets in categories such as indoor environment, energy and atmosphere, water efficiency, materials and resources, etc. The largest amount of points can be awarded in the energy category, points totaling around 30% of all points available (Amiri et al., 2019). This heavy weighting should lead to BREEAM and LEED certified being energy efficient and exhibiting low energy consumption. Despite this, some studies have shown that LEED-certified buildings do not always have decreased energy consumption and better energy efficiency when compared to non-certified buildings (Amiri et al., 2019).

The purpose of the LEED-certificate was to increase energy efficiency in buildings, but the literature is split regarding this (Amiri et al., 2019). There is evidence that LEED-certified buildings consume less energy among new buildings, however there is also evidence that the certification only leads to marginally lower energy consumption, or in some cases not at all, in some extreme cases there has even been increases in energy consumption in the certified buildings (Newsham et al., 2009). The latter seems to have been the case with the lowest possible certification, as these buildings in general do not seem to exhibit any large differences when compared to non-certified buildings (Amiri et al., 2019).

In general, LEED-certified buildings consume around 18-39 percent less energy per square metre than non-certified buildings. However, around 28-35 percent of LEED-certified buildings consumed more energy than comparable non-certified buildings (Newsham et al., 2009). Newsham concludes that there is only a small correlation between certification level/energy points awarded and building performance among LEED-certified buildings.

3.5.2 The National Australian Built Environment Rating System (NABERS)

NABERS differs from other energy certifications in that it was designed with operative building performance in mind, not projected building performance as is the case with other energy rating systems such as LEED and BREEAM. Furthermore, all numbers and values involved in the valuation process are verifiable and available, keeping the certification process and results transparent. NABERS is a building valuation tool that started development at the request of the Australian government at the end of the 1990s to simplify and enable comparisons and evaluations of buildings and their effect on the environment. NABERs has since expanded with several section specific releases such as NABERS Energy for Offices which was developed in 2009 (Bannister, 2012). The NABERS ratings tool measures actual energy performance, and calculates carbon emissions from these in order to provide energy ratings, which are illustrated in the forms of stars, ranging in order from 1 star to 6 stars (previously 5 stars). The rating is only valid for 12 months following certification, and the rating requires 12 months of energy data for assessment for a building to be certified (Bose, 2010). NABERS utilises independent third party valuation specialists to conduct valuations, where the valuation personnel are required to have undergone training and passed a valuation test before they are given the authority to perform valuations on their own (Bose, 2010). According to NABERS themselves, the organisation claims that it has been able to save clients 30-40% on energy costs over the last 10 years (NABERS, 2018).

Contrary to similar rating systems, NABERS discerns where energy is supplied, considering that it rates buildings, as well as separately rating the “base building” managed by the landlord, and tenant occupied space (Mallaburn et al., 2021). There are three different valuation methods used by NABERS NZ, these are as follows: Base building, tenancy, and whole building. As previously explained, base building is used for the core business. Tenancy is used to measure the energy consumption of floors, common areas, computers, kitchen appliances, etc. Whole building valuation interlinks both the base building and the tenancy valuation methods, and weighs these against each other to determine the overall energy consumption of the building and how it relates to similar buildings in NABERS NZ's database (Mallaburn et al., 2021). In 2009, The Department of Climate Change and Water, of New South Wales in Australia estimated that 41% of market office spaces were rated with NABERS (Bose, 2010).

A major driving force behind the implementation of NABERS in Australia, occurred in 2010 when the Australian government pushed through legislation in the form of the Building Energy Efficiency Disclosure Act 2010 (Office of Parliamentary Counsel, 2018), which requires managers of office buildings to present Building Energy Efficiency Certificate (BEEC) for the building for both tenants and potential investors when offering to sell or lease the building (Office of Parliamentary Counsel, 2018). The Australian government launched a joint energy declaration programme formally called the Commercial Building Disclosure (CBD) programme, in which the NABERS Energy rating is the general tool used for valuations by property managers (Commercial Building Program Team, 2020). The introduced legislation helped the NABERS Energy rating spread in office buildings, with the NABERS Energy for Offices having been successful in achieving an implementation rate of over 70% in the Australian office market (Cohen and Bannister, 2017).

In recent years, the NABERS method has inspired other nations to follow suit with the focus on operational performance outcomes. In the UK this led to the inception of the Design for Performance (DfP) initiative, an industry backed project with the aim of dealing with the performance gap (Ratcliffe, 2019). The DfP initiative criticises previous regulatory attempts at tackling the performance gaps with EPCs and the Building Regulations part L, arguing that these have failed in delivering energy efficiency in practice (Ratcliffe, 2019).

Building on the Australian success with NABERS, the DfP initiative employed a Feasibility study in 2016 in order to understand the key elements that led to the success of the NABERS framework. This was followed by a Pilot Programme, which yielded the conclusion that there are no technical reasons that a performance based compliance approach and rating scheme could not be implemented (Ratcliffe, 2019). In April of 2021, the NABERS UK Design for Performance Framework was launched, allowing for any project to be registered by signing a DfP agreement with a target NABERS energy rating of 4 stars of above, requiring teams to both target and verify the energy rating (BREgroup, 2020).

3.6 Building Evaluation, the principles and practises

Questions regarding efficiency and productivity are in close association with post-occupancy evaluation studies of building performance. When you look at how a building actually performs in relation to how it was intended to perform, you look at, at least, three perspectives (Bordass et.al, 2010):

- Occupants, how well are their needs and expectations met?

- Environmental performance, how efficient is the building from an energy standpoint?
- Economic performance, return on investment?

Wherever you look at building-performance you tend to find under-achievement and rarely do modern buildings do very well in all three of the categories above. There are exceptions and many outstanding examples, but these are often unknown and remain unnoticed since buildings are not routinely monitored. But building performance evaluation is not only about efficiency and productivity as there are plenty of other considerations of which many are either hidden, taken for granted or simply deemed as too difficult to handle and are therefore disregarded. Such considerations could be context, individual circumstance, design quality, perceived value and public interest verses commercial self-interest amongst others (Bordass et.al, 2010).

Building evaluation is largely about empirical field work, so-called real-world *research* a term by Colin Robson. Two of its main features, see *Figure 7*, is *Solving problems* and *Predicting effects*. Building evaluation, by monitoring performance to discover and solve problems, is not simply about gaining knowledge for its own sake. It is with the aim to make more informed decisions to help improve the building, which is being studied, and to spread this knowledge further in order to improve future buildings. When given sufficient knowledge of preconditions and contexts many effects are predictable and by predicting these effects it helps to understand consequences which is very important especially in buildings with complex systemic processes (Bordass et.al, 2010).

In building-evaluation studies the methods used must provide repeatable and convincing results even though the inputs for the study are not directly controllable as in laboratory science. The inputs are the circumstances, operation, and context of the building in question. Regarding the methods, it has been found that the POE approach, with an energy-assessment, occupant survey complemented with an air-tightness test and a water consumption analysis, is a valuable foundation for studies overall (Bordass et.al, 2010).

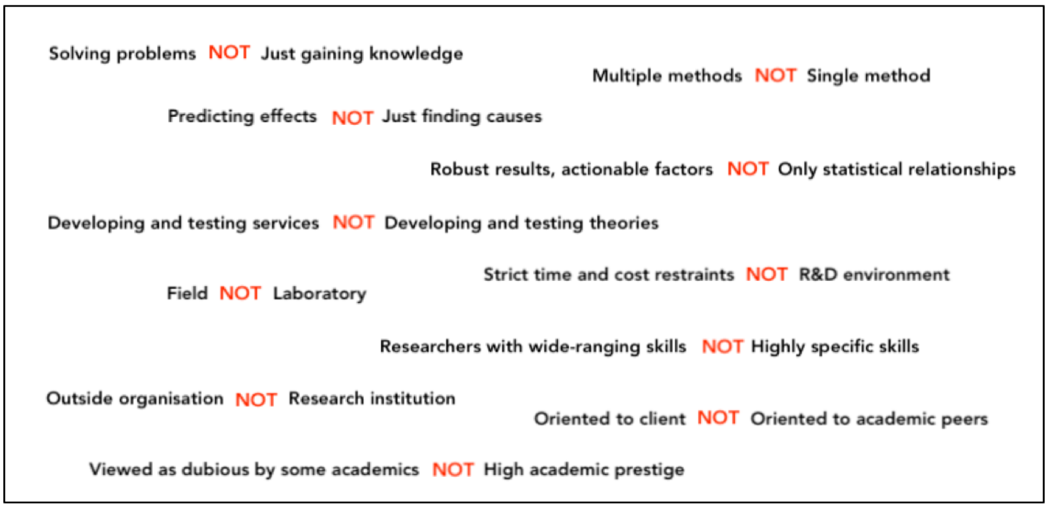

Figure 7. Building-performance studies as an example of real-world research. Source: Adapted from (Bordass et.al, 2010).

3.7 Post Occupancy Evaluation (POE)

Buildings are complex systems. The complexity of a building is determined by the amount of physical subsystems it has and the fact that all the systems have to work together for the building to work as planned. What adds to this complexity is the usage patterns of the occupants. For this reason management of the building is oftentimes even more important than the construction of it. Therefore buildings should be managed in a preventive manner meaning issues should be prevented and maintenance planned instead of issues being solved once they appear. This long-term approach to management must be planned for early on in a project (Leaman et.al, 2003).

During the delivery process heavy focus lies on inspections to ensure that buildings operate effectively. Inspections typically concern building technicalities and are usually followed through during production as well as during the delivery of the building itself. Final inspection is usually carried out around one month after user occupation of the building. This disconnect between inspections and user needs is disconcerting, and there are routines and procedures that can be taken in order to avoid user dissatisfaction and potential building problems that can arise after tenant occupation. POE is an evaluation tool that was developed by social scientists, building planners and designers in the 1960s. Originating in the UK in the post WWII period, it spread across the world to the US, Australia and NZ (Kooymans and Haylock, 2006), however, it hasn't been able to gain significant traction in the construction and facilities management industry, this being the case although it has been shown to lead to increased building performance and user satisfaction in several studies such as the PROBE studies and the case studies made by Kooymans and Haylock in 2006 (Kooymans and Haylock, 2006, Hadjri and Crozier, 2009).

Previous research in the area of POE has analysed whether the method can be implemented in Sweden, what barriers need to be overcome, such as cultural and organisational barriers, as well as how Swedish property developers orient themselves towards the building management tool (Palm, 2008). Palm argues that there is an inherent lack of demand from higher up in the hierarchy chain, from executives and organisational leaders for evaluations. This in turn leads to a lack of incentive from the administrative organisation/facilities management to push for evaluations. Palm also argues that organisational culture could be a possible reason for the lack of demand for evaluations, as this is a culture reluctant to change, born out of the construction sector. As such, Palm argues that it is not sufficient to implement POE in Swedish construction companies as a simple policy to achieve a change in building performances, it must be complemented with knowledge management systems in order to create long lasting change. In order for this to be achieved it will also require engagement from the organisation's board and approach the evaluation tool from a top down perspective (Palm, 2008).

A more informative expression for POEs are Building Performance Appraisals (BPA), a term that was introduced in the UK in the beginning of the 1970s by the Building Performance Research Unit (BPRU). The expression BPA puts emphasis on the building's performance and not on its physical properties, which is also the essence of POE, putting emphasis on the results and consequences of designer and planning choices. This change in focus allows for a feedback experience with the purpose of enhancing the next generation of buildings. In the end, POE is a clear and concise form of quality control where the end-product and more importantly its performance during tenant occupancy is evaluated (Leaman, 2003).

3.7.1 PROBE-Post Occupancy studies

Post Occupancy Review of Building Engineering (PROBE) is a series of case studies which ran from 1995 through 2002 and describes the practical evaluation on several buildings with various areas of use. The series of case studies was run under the Partners in Innovation scheme funded by the UK Government and The Builder Group, publishers of the Building Services Journal – now the CIBSE Journal. The project was executed by the Energy for Sustainable Development, William Bordass Associates, Building Use Studies and Target Energy Services (CIBSE, 2012)

The PROBE-project is almost universally seen as a success. This is attributed to the fact that the project does not include too much and utilises three already existing and proven methods for building performance and tenant satisfaction that are restricted to energy, occupants and air tightness (Leaman, 2003):

- The Energy Assessment and Reporting Methodology (EARM) which covers the building performance from two different perspectives: supply and demand. This provides an understanding of the building's technical performance which facilitates diagnostics. The method doesn't simply demonstrate the building's performance in direct relation to benchmarks, but also provides a direct measure of in which categories the building performs better or worse. The benchmarks are derived from "typical buildings" and "buildings according to best practice". EARM is applicable for multiple types of buildings, from offices to housing.

- Building Use Studies (BUS), a questionnaire/form for tenants which includes questions concerning health, comfort, as well as productivity in relation to the building and the management of the building. There are 65 different types of benchmarks for the UK in BUS, and there are several similar frameworks used throughout the world as well. As with EARM, this method is also applicable for multiple types of buildings and tenants.

- An air pressure test in accordance with CIBSE TM2314 specifications which test the air tightness of the construction shell. The test is analysed with relevant benchmarks found in CIBSE's database.

Apart from these three methods, PROBE also has the following (Leaman, 2003):

- A Pre-Visit Questionnaire (PVQ) that aims to collect essential data, ahead of the survey, about technical systems, hours of use and other background info. This data is useful in assessing the seriousness of the client and whether a POE should be performed.

- A water-consumption method.
- An additional questionnaire to the occupant survey regarding transportation.

4. Soft Landings

The purpose of this chapter is to explain the concept of the Soft Landings and associated terms and processes.

4.1 The Soft Landings framework

> *"At its heart, Soft Landings is a mindset - delivering better buildings by setting requirements at the start of the project, and then maintaining the focus on those throughout the project from inception to completion and beyond... Soft Landings requires everyone involved in the project to share risk and responsibility for the success of the project. This is indeed more of a change of culture than a change of process."*
>
> (Agha-Hossein, 2018)

The framework known as Soft Landings was developed in the UK by architect Mark Way along with several architects and engineers as well as the Building Services Research and Information Association (BSRIA) in 2004 (Way et al., 2009). The framework began development after M. Way had described his own experiences of non-satisfactory deliveries regarding construction projects where he himself was working as the lead architect. Way (2005) noted that poor user knowledge of building systems, as well as a lack of organised follow-up was the case in said particular project (Way et al., 2009). The concept of Soft Landings was formed with help of the Building Services Research and Information Association (BSRIA) and several architects and engineers in order to increase the reliability of deliveries intended to perform according to client and user needs and expectations. Of these, most notable is Bill Bordass of the Usable Buildings Trust, who has been deeply involved in furthering research within building performance and Soft Landings (Way and Bordass, 2005, Bordass, 2004).

Means of improving building performance through new technological advancements are often expensive, which raises the question of why not simply use the tools already at our disposal? By examining in-use building performance, it is possible to fine tune facility management systems such as ventilation and heating in order to achieve the expected building performance without the need of expensive energy efficiency renovations or investments (Way, 2005). As building- and facility management technology develops, management and control systems become more complex, Way and Bordass recognized how this can complicate end-user operations, as architects and designers seldom consider these during the design process (Way and Bordass, 2005).

> *"It is common practice today for project organisations to depart from current projects in favour of new ones as soon as possible, thereby accelerating the delivery process in a substandard manner. The delivery process and the following post-handover period is often dismissed, with little interest from neither designers nor contractors"*
>
> (Way, 2005)

The disregard for handovers as critical parts of the construction process affects not only the project, clients, and tenants, but feedback and learned experience as well as the expertise moves on with the personnel to other projects. An active compliance of already existing models and methodologies is one of the most effective instruments available to be used against recurring problems encountered during deliveries of construction projects, and the following management process. This is where proponents of the framework such as R. Bunn of the BSRIA argues that Soft Landings succeeds, the Soft Landings programme does not include digital solutions that need to be implemented throughout the construction process, requiring training of personnel, it does not include new concepts from the 21st century based on cutting edge technologies and research, it simply includes what we already know we should be doing yet abstain from following through (Bunn et al., 2014). As explained by BSRIA, at its heart, Soft Landings is a mindset which is characterised by setting higher standards and expectations at the start of a project, and by maintaining these standards from start to finish thereby delivering better buildings (Bunn et al., 2014).

In its most basic function, the Soft Landings framework requires the continued involvement of the design and construction teams beyond practical completion. These fundamentals benefit both clients and designers/contractors as it both facilitates the client's need for assistance during the post-completion period, and provides valuable feedback for the designers/contractors which would otherwise go to waste (Hossein 2018). The framework provides projects with a golden thread which is integrated into the building process and all of its stages, from procurement to initial occupation and following aftercare.

When Mark Way and Bill Bordass of The Usable Buildings Trust initially developed Soft Landings, the community inquired whether the framework would develop into an entirely new procurement process. With the procurement process in the UK already having several standard documents and contracts attached to it with regulations and provisions, Way argued that coupling the framework to a new procurement process would only lead to Soft Landings becoming one procurement route of many, hampering the framework (Way et al., 2009). It was during these discussions that the idéa of the Golden Thread was conceived. Soft Landings interlinks the entire already existing procurement process in the UK, linking together the numerous phases of planning, production, delivery and management through this golden thread (Way et al., 2009).

In 2018 the Soft Landings Framework was reworked and updated with the release of SL 54/2018 *Soft Landings Framework 2018 Six Phases for Better Buildings.* The new version of Soft Landings made several changes to the framework in reflection of feedback gathered from the industry and operational practices. The changes included the rework of the Soft Landings Stages, renaming these as Phases to emphasise that the framework is not tied to any particular plan of work (Agha-Hossein, 2018). Another change is the establishment of six phases in contrast to the previous five stages, reworked to distinguish the Design and Construction activities. It would serve as a guide for project managers, facility managers, and designers through whatever procurement process chosen to fit the current project. By being disengaged from a specific procurement process, the framework is stated to be adaptable to fit any procurement process (Bateson, 2015, Agha-Hossein, 2018).

> "*...it provides a robust chassis to carry other performance-enhancing mechanisms, such as the NABERS and NABERSNZ energy rating schemes.*"
> (Bunn et al., 2014)

This is supported by the push for adoption of Soft Landings in Australia and New Zealand (Bunn et al., 2014), and the experimental theoretical implementation of a Soft Landings approach in Sri Lanka (Samarakkody and Perera, 2021, Samarakkody et al., 2020).

4.2 Activities in the framework

The fundamentals of the Soft Landings framework consists of six phases which encompass the project and are divided into activities specifying the project requirements, activities that construction workers are already familiar with, yet needs to be laid out in a concrete manner.

4.2.1 Phase 1 - Inception and briefing

Described by Hossein (2018) as the most crucial stage of procurement, where the emphasis is often placed at the completion of the project and not on the procedures facilitating the completion. First and foremost, it is important for the project team to understand the client's needs and expectations, establishing well-structured success criteria. It is during the briefing stage when the responsibilities and roles are to be defined in the project inception, and the client's facilities management team needs to be involved in the process early. If a client's facilities management team is not yet appointed, independent counsel should be seeked. Experience and benchmarks from earlier projects should be used to set realistic targets. Incentives pertaining to performance outcomes should be set. Soft Landings champions should be identified during this process to ensure that the framework is tailored to the current project. Champions should be selected both in the client team and project team and should preferably be people who are likely to be on the team throughout the entire project, such as architect, client representative or project manager (Agha-Hossein, 2018).

4.2.2 Phase 2 - Design

The Design phase emphasises meetings are critical as they can pinpoint difficulties and issues concerning the building and building usage. The building must be designed with consideration taken into account regarding accessibility of controls and technical requirements for users. By including a cross section of expertise into the design review, insightful aspects of building operation can be lifted and potential issues that arise can be solved. Everyone needs to be made aware of the commitment that Soft Landings requires, and the tailored framework needs to be implemented into the scope of the contract (Agha-Hossein, 2018). It is during the design phase that the Soft Landings requirements need to be integrated into the tender contracts, the BSRIA guide BG45 can provide guidance and facilitate this work. At this time, an evaluation of the contractors and their understanding and willingness to use Soft Landings should also be undertaken.

4.2.3 Phase 3 - Construction

It is during this phase that Hossein (2018) argues that the team shall begin planning for handover, with special consideration regarding commissioning and aftercare. With sub-contractors entering at this phase, it is important to inform new project participants about the Soft Landings frameworks, the success criteria established in Phase 1, and the responsibilities stemming from it. The construction team must be fully aware of the project's success criteria, and construction activities must not affect the defined operational outcomes. Changes to the building are common during the construction phase and can sometimes not be avoided, therefore it is important to communicate and record changes with the project team, and to check the changes against the success criterias' previously established. An accessibility review should be carried out after changes have been made, an accessibility review of plans and equipment aimed at the facilities management team. This will aid in the production of maintenance plans, and the coming commissioning (Agha-Hossein, 2018). With the relationship between the project team and the future tenants being a priority, a positive connection can be facilitated by arranging project tours when appropriate.

4.2.4 Phase 4 - Pre-handover

As stated by Way (2009) the aim of the pre-handover phase is not just to provide a physically completed building, but to provide one which is accessible and prepared for operation. An essential part of this process is ensuring that the client's management organisation/team assumes operations management as soon as possible to acquaint themselves with the building management systems. Commissioning of building services, and training of operations teams should be a priority during this phase, as a lack of training and a lack of familiarity with building management systems often leads to poor building performance in the initial lifetime of the building's life cycle. Way (2005) explains that issues concerning operation arising post handover are often due to poor training of technical staff with regards to building services and user interfaces.

A building readiness program needs to be established early before tenant occupation, with activities, documentation, and guides having been prepared. This is important since the commissioning phase is often hurried through, this can be due to external factors, or due to earlier delays in the project. Handover dates, for example, are often negotiated months in advance and violations can be quite costly for the project organisation. A soft Landings approach can minimise the consequences of this and minimise the risk (Agha-Hossein, 2018).

4.2.5 Phase 5 - Initial aftercare

The initial aftercare only covers the initial four to six weeks following tenant occupancy, with the service provided by the project team intended to assist tenants and facilities managers to operate and understand the delivered building. During this time it is important for the facilities management team to be engaged, utilising the assistance from the aftercare team and developing their own skills. Accessibility is key during this phase, which means that the aftercare team must be visible and accessible for everyone. Information regarding the purpose of the aftercare team should be easily available, and aftercare should not be used as a marketing ploy, but should be utilised as a service for the tenants. This will generate goodwill and invite relevant stakeholders to discuss the project. Accessibility through a website or bulletin with biweekly updates on operational issues keeps users informed and engaged with the project.

Guidance for the building tenants should be given through either meetings with the users post occupancy, or through walkabouts where the aftercare team roam the building and engage in discussions with tenants regarding the building and building systems (Agha-Hossein, 2018).

4.2.6 Phase 6 - Years 1-3 extended aftercare and POE

Begins once the initial aftercare phase is completed. The first year is subject to the traditional contractual obligations concerning the defects liability period. Fine tuning of the building systems to optimise energy-efficiency is at the centre of attention during the initial aftercare period (Way 2009).

Following the first year a POE survey should be undertaken as tenants have settled in and the building has experienced the seasonal conditions. The POE survey should ideally be conducted between 12- and 18-months following tenant occupancy. During year 2-3, the aftercare team will still visit the project periodically, but to offer guidance, not to run operations management, as it is important to delimit this exclusively to the client's managing organisation (Agha-Hossein, 2018). When the aftercare team is on site, the primary focus should be on performing post-occupancy surveys, and collecting/reviewing building performance, with the feedback benefitting both the client and the project team. (Way, 2009).

4.3 Government Soft Landings (GSL)

The need to improve the value offered by public sector constructions was established in the Government Construction Strategy of 2011, with Soft Landings being selected as a viable solution. GSL was developed during 2011 by the UK Government Property Unit in coordination with a task group of industry specialists. The framework is complemented with GSL's implementation guide which provides comprehensive guidance and structure regarding the application of the framework within state procured public projects. The UK government's vision for GSL is that state procured public buildings will achieve better performance than comparable buildings, with reduced costs during both the handover and management phases. Furthermore the goal of GSL is for it to contribute to more precise cost estimates through mandated feedback and benchmarking (B. I. M. Task Group, 2013). While Soft Landings is defined by BSRIA as a cradle-to-operation process consisting of 6 distinct phases established to ensure operational performance success, GSL focuses on project delivery and facilities management, with heavy emphasis on a GSL client champion and a project GSL Champion. A core difference between the two frameworks is that GSL mandates that targets be set for energy/ carbon dioxide emissions, usage of water, operation costs, capital costs, as well as functionality; this is not mandated in the Soft Landings Framework (Bateson, 2015).

A major part of the BSRIA Soft Landings and especially the GSL method that distinguishes them from traditional project management methods is the use of a Soft Landings champion tasked with ensuring that the Soft Landings activities are carried out successfully. A Soft Landings Champion establishes a high level of commitment and should be chosen by the client organisation early in the process in order to establish an organisation culture fitted to drive through change. This is not an easy task, as organisational culture is difficult to change, especially when required to do so in a short period of time. As such, it is of great importance that a Soft Landings Champion possesses the following competencies to be able to manage this change and project successfully.

- Engage with end-users to assist with the identification of key performance indexes that can be used to evaluate the operational performance of the building, operations training of personnel, the handover, as well as the performance of the facility manager. This may require a deep understanding and comprehension of the relevant BMS and CAFM systems with regards to building performance to be able to identify how actual building performance differentiates from projected building performance. This also includes being able to analyse and understand changes in building performance that arise during the building life cycle. Furthermore, competence in identifying and managing operational outcomes and providing feedback to the project organisation for future projects are desired traits.

- Have a deep understanding of demands and the implementation of Post Occupancy Evaluations that are to be conducted a number of times throughout the first three years following the handover of the building.

- Work together with designers and project organisations to establish end-user functions that are both practical and viable. Competency in Commissioning, Training and Handover (CTH), these are key aspects of GSL and vital to the process.

- Being able to assist project organisations and consultants, working together to establish a CTH-programme/plan where end-user training, user guides and asset databases/registers are available. The CTH-programme/plan identifies POE as well as the operation and maintenance plan (Philp et al., 2019) .

The first Soft Landings framework was published in 2009, with the last updated version released in the UK in 2018 (Way et al., 2009, Agha-Hossein, 2018). The original Soft Landings framework is an open-source methodology that can be adopted by any organisation or business, and tailored to their specific needs (Way et al., 2009). The original Soft Landings document describes the process for implementation as well as the division of responsibilities for the relevant actors. The form addresses UK documents, but can, according to the BSRIA, be used for guidance and implementation of Soft Landings in other nations, such as Australia and New Zealand, nations where the program already has been introduced and adopted (Bunn, 2014).

4.4 The Soft Landings Framework - Australia & New Zealand

In 2014, Soft Landings was introduced in Australia and New Zealand, where a revised version of the framework was developed from the methodology originally devised by architect M. Way to fit the ANZ Construction Industry's policies and needs (Bunn et al., 2014). With the introduction of NABERS and NABERSNZ, Australia and New Zealand have seen increased energy efficiency, especially in office buildings. However, the consistent delivery and maintenance of reliable buildings have not yet been cemented in the construction industry. In The Soft Landings Framework Australia and New Zealand document, it is noted that performance gaps, specifically with regards to energy performance, was a regular occurrence in the ANZ region. This was highlighted through the use of surveys of recently completed buildings in the area (Bunn et al., 2014).

4.5 The Business Case

Current practice is for clients and head contractors to withhold retention money as a security and an incentive for contractors and sub-contractors to complete their work and ensure that any upcoming defects are fixed accordingly (Donohoe, 2015). The Soft Landings framework introduces an alternative to retention money. By situating a resident after care team in accordance with phase 5 in the Soft Landings activities, and engaging in post-care through POE and occasional visits by the aftercare team in accordance with phase 6 in the Soft Landings activities, there is no need for retention money to be withheld by the client, since the contractor has already committed to delivering a finished product with post-care considerations.

The price tag for the aftercare team activities and the following post care phase is not high, with Bordass (2005) arguing that it would constitute no more than 0.25% of the entire construction cost on a full-scope appointment. This cost is also not considered against the potential gains reaped, as there are bound to be net gains in the form of fewer defects, less visits by the contractor to the project post completion, and potentially fewer legal costs as the responsibilities are clear and no disputes regarding retention money are bound to occur (Donohoe, 2005).

4.6 Criticism

Soft Landings can be viewed as an alternative to the practice of retention money. The practice was originally developed as protection against supply chain insolvency and as an incentive for contractors to fix defective work, but the practice can also be misused as withheld payments that are passed downstream to smaller contractors can result in insolvency of the latter. Some actors in the industry argue that the use of Soft Landings would be a viable alternative to using retention money, but warn that unless it is a legal requirement, main contractors simply won't utilise it since it is in their interest to withhold retention money from sub-contractors (Donohoe and Coggins, 2015).

5. Multi-case study

Soft Landings is by now a well-known term in the British construction Industry. But the question of how well the framework applies in practice and whether it delivers improvements to performance and results remains. In the following segments a summary and analysis of cases of completed buildings is carried out with the intention to show how projects in the real world can benefit from Soft Landings.

5.1 The Enterprise Centre - University of East Anglia

The Enterprise Centre at The University of East Anglia is located in Norwich and was completed in 2015. The building, with an internal area of 3,400 sqm, had a cost of about £11,600,000 (Passivhaus Trust, 2020). Approximately half of the office-building is used by the University of East Anglia for academic purposes and the other half accommodates a range of specialised workspaces for small and medium-sized organisations, both local and start-ups. The university building aims to encourage new sustainable businesses developed by emerging graduates and others within the Norwich Research Park (Agha-Hossein, 2019). With the purpose of the building being to promote enterprise, a key focus of the brief was to connect the building itself with the community and commerce outside of the campus setting. As a result, residents and businesses in the area were involved from the start in workshop consultations as were apprentices who were honoured all throughout the process (Passivhaus Trust, 2020).

The Enterprise Centre, an exemplary innovative low-carbon architecture utilises innovative local bio-based materials in a contemporary way and investigates the effects of the interior materials on health and wellbeing. Being able to physically observe change in materials and data over time makes this building the first international one to offer Passivhaus performance along with renewable materials (Architype, 2014). A simulation of the effect of climate change on the building over the next 87 years was conducted as well as a model of embodied-carbon over 100 years which enabled optimization of systems over the entire lifespan of the building. Significant levels of daylight and deep penetration of it into the building is allowed by the orientation and form of the building, high floor to ceiling heights, the internal glazed partitions as well as central light shafts. The heat source for the building is the University combined heat and power (CHP) via the local network, which is fueled from non-toxic waste burning. High levels of fresh air and ventilation are provided to the space through a mixed mode ventilation approach to conditioning with a Variable Air Volume (VAV) system. Compliance with CIBSE, saying that summertime overheating of spaces may not exceed 28 C for more than 1% of occupied hours, is ensured with night cooling strategies in combination with the thermal mass of concrete ground and the fermacell wall partitions. Further, indicator panels in the building advise users on opening windows and vent strategies (Passivhaus Trust, 2020).

The Enterprise Centre was delivered using a 'Single Point Delivery (SDP) form of contract with the main contractor and Single Point Deliverer being Morgan Sindall. The SDP was used to promote collaborative working practice for all the work stages, based on the New Engineering Contract 3 (NEC3). The building was designed and delivered to achieve

BREEAM Outstanding rating, the Passivhaus standard as well as a 100-year lifecycle. Apart from this the building, through use of roof mounted PVs, exceeds the local planning requirement for 10% of the energy to be from renewables. Also, the building is well above best practice regarding embodied carbon in new university buildings (Architype, 2014).

Alongside the thorough commitment to collaborative working a significant amount of consultation and engagement has been undertaken at many different levels such as one-on-one sessions with the user client to stakeholder workshops and engagements with committees and the city council. The local community was included in an exhibition of the proposed designs for the project where they could give feedback and comments. Regarding consultation and engagement with The University of East Anglia (UEA), a series of very intense workshops which was concluded which looked at all aspects of the plan, design and specific elements such as learning spaces, enterprise spaces and exhibition areas. These workshops involved the project team on the client side, the design team, student representation and user group representatives including staff from Teaching and Learning, Space Management, Cleaning Services, IT Infrastructure etc. To ensure fulfilment of the users' needs and engagement at every design stage of the project a Design Quality Indicator (DQI) was utilised. The DQI process in the early stages of the project established the client's priorities and aspirations and as a part of this an appraisal of an already existing similar university facility was done with the intent to better understand design performance from users' perspective. There was also a mid-design review where an assessment in relation to the original aspirations was made (Architype, 2014).

A full Soft Landings approach with three years of post-occupancy evaluations (POE) was implemented to ensure optimal building performance and that throughout the process, decision-making was based on client needs and expectations. For the delivered building, high sustainability was ensured with operational performance being reviewed from the start. Both hard metrics, such as carbon emissions, and soft metrics, such as quality of light, were established. The soft metrics for the project were ensured to be met by having occupant and user engagement from early stages of the project. Key aspects affecting the user experience, like the ventilation strategy, were worked on by the Soft Landings Champion, Morgan Sindall, in collaboration with the University's estates team. Series of workshops, with user group representatives and the University 's project team engaged, were held looking at several aspects of the design. To help inform the aftercare team of emerging issues and decisions, an operational risk register and sensitivity analysis for occupancy levels was developed. Throughout the entirety of the project input was coordinated into lessons learned and improvement studies (Agha-Hossein, 2019).

The result of the POE studies showed the building's positive impact on productivity and perceived health of the occupants' (Agha-Hossein, 2019). Feedback regarding the performance, from both energy and comfort perspectives, has been positive and the Primary Energy Performance the first year in use was better than was anticipated. Regarding user satisfaction, The Enterprise Centre was ranked in the top 5% of all independently surveyed buildings by the BSRIA (Passivhaus Trust, 2020). The Enterprise Centre satisfied both

BREEAM Outstanding and Passivhaus certification while staying on budget (Agha-Hossein, 2019). Minor issues throughout the project were successfully managed through regular Soft Landings meetings and with a small contingency these issues were mended with a “no blame” culture and in good time (Passivhaus Trust, 2020).

5.2 Keynsham Civic Centre

The Keynsham Civic Centre is a redevelopment that replaces 1960s outdated buildings with a new council office, information centre, library, retail space, streets, market square, car parking and highway improvements. The site was split with two new pedestrian streets which made 50% of the site 24-hour accessible public space. The Civic Centre reinvigorates the Keynsham town centre giving the town new public space and amenities with retail on the ground floor of the centre surrounding a new pedestrian public ground space. The new design maximised the building frontages and attracted major retail providers. The project, finished in 2014, had a total internal area of 9,600 sqm and a value of approximately £28,000,000. The project exceeded all expectations of a new corporate office and retail development and serves as an example of sustainability in UK public buildings (Ahr, 2015b). The aim was to deliver a low-energy and low-carbon building within a local authority budget (Pearson, 2017).

A challenging brief was set by the district BANES council where the project was to achieve an energy-in-use ‘A’ Display Energy Certificate (DEC) A rating by the end of the second operational year (Quilter, 2016). Another client target set was achieving an Energy Performance Certificate (EPC) A rating (Agha-Hossein, 2019). The strategy for the achievements was laid out by the Soft Landings champion Max Fordham, the Monitoring and Evaluation Sustainability Consultants (Quilter, 2016). An Energy Risk Register was developed together with a contractually binding energy budget and a plan for engagement of the contractor for a two-year aftercare period in order to optimise energy performance (Ahr, 2015b). The Energy Risk Register was developed based on Max Fordham’s experience from post occupancy evaluation as well as research by University College London. The aim was to, in the process of achieving a DEC A rating, identify energy risks and strategies on how to reduce them at every stage of the project from briefing all the way to building operation (Quilter, 2016). Thereafter these strategies informed the user guidance and contract documents for the building. A great advantage of this approach is the emphasis it puts on personal responsibilities of the project team members in achieving the project goal. The contractually binding energy budget resulted in less modification to the original design than what is generally common in build contracts. The contractor had to review the energy consumption monthly and make comparisons to the energy budget. This resulted in reports which were disclosed to the team with the intent to inform seasonal commissioning and fine tuning for the building. The approach is considered innovative and recognizes shared responsibility. It creates a collaborative environment were working towards the best outcome, while still maintaining accountability through performance evaluation, is the goal (Agha-Hossein, 2019). More than two years after the Centre was put in operation it is performing nearly as well as designed. The design achieved an ‘A’ EPC rating but only a ‘B’ DEC rating. This is set to improve with energy reductions under the Soft Landings framework (Pearson, 2017).

A ‘passive first’ approach to architectural- and services design was adopted to deliver a low-energy office in use. The building orientation was intended to maximise the daylight and to minimise solar heat gain. Therefore, principal facades face north and south with large windows on the north-facing facades and smaller windows with light shelves, facing the south, providing shading and enabling light to bounce deeper into the buildings. The floor layout and height was designed to let fresh air move freely for natural ventilation (Pearson, 2017). For the natural ventilation, rather than opening windows the space is ventilated via acoustic window louvres integrated into the window frames and separated by two insulated panels from the offices. A smaller top panel is controlled by the building management system (BMS) and provides daytime ventilation and allows night-purge ventilation. The larger lower panel is manually opened by occupants, when needed, for additional ventilation (Ahr, 2015a). The structure was designed with a steel frame and cross-laminated timber infill to further complement the ventilation strategy and minimise embodied carbon. For added thermal mass, 50 percent of the floor area is precast concrete floor planks which absorb heat during day and purges during nighttime. Future-proofing against effects of climate change and increases in occupant load has been done with cooling pipework cast into the floor concrete planks which will be connected to future cold-water circuits. Winter heating, approximately 20 percent, is provided from the IT-servers water-cooling system via a heat pump and top-up heat is provided by gas-fired boilers (Pearson, 2017).

The Keynsham Civic Centre is the first building in the UK to apply the full Soft Landings framework in all stages of the project and have the energy performance aims written into the contract and not only estimated in the design. For this project, Max Fordham wrote some of the first Soft Landings Employer’s Requirements in the industry, establishing roles and processes contributing towards the goal of achieving a DEC A rating (Agha-Hossein, 2019). The principles of Soft Landings were followed to ensure that operational energy use was as close as possible to the intended in the design (Ahr, 2015b). The Employers Requirements have since then been incorporated into the *How to Procure Soft Landings*, a BSRIA publication (Quilter, 2016). A key aspect of the Soft Landings framework, and the project’s Energy Risk Register, is the significance of effective building commissioning and therefore also management and planning. The main contractor for the project had to, according to the contract, assign a Soft Landings Co-ordinator (SLC) and a specialist Commissioning Manager (CM). The SLC was involved throughout the construction phase and for two years post-occupation and was responsible for the delivery of the contractors’ responsibilities as well as coordination of all Soft Landings activities. Additionally, the specialist commissioning manager was appointed to manage all commissioning aspects of the building to 12 months post occupation. This manager reported directly to the main contractor and not the monitoring and evaluation (M&E) subcontractor. Close contact and regular communication between the SLC and CM was required for all the stages from design to post occupancy. The Soft Landings champion, contractor and design team for the project committed to two year of Post Occupancy Evaluation (Agha-Hossein, 2019). During this time, the designers and constructor remained involved to fine-tune systems, de-bug them and help occupiers manage. The contractor reviewed, on a month-to-month basis, the actual energy performance with the aim to identify where it differed from the budgeted energy. Thereafter the project team worked to further optimise the performance and this approach was shown to work well and after some time in use and a period of learning, ways to further refine the systems were identified (Pearson, 2017). After the initial two years, the contractor together with Max Fordham, the Soft Landings Champion, continued their cooperation with the building management with the aim to further optimise performance (Agha-Hossein, 2019).

This project has taken advantage of every possibility to spark regeneration, improve connectivity and instil civic pride and ownership into it. Three public consultation events were held at hey stages during the planning process of the development. Firstly, a general meeting presided by BANES councillors followed by two week-long exhibitions- and feedback events in the town centre. For these meetings, a consultation facilitator was employed to lead and gather feedback. As part of these consultation events local schools and the Keynsham youth club were consulted. Even before the start of this project the council established a Civic Focus Group. This way the views of the locals were built into the brief of the project. As the project progressed monthly or bi-monthly meetings were held to keep the group up to speed with the development and to get their input along the way. There were also crucial moments of community involvement such as when 4 workshops with the Civic Focus Group were undertaken to seek their view on rood and cladding material choices. This demonstrates how locals and their opinions have made a significant difference to the design. As the grounds of the centre are public space local police was consulted at an early stage in the design process to increase the security and safety of the people through the landscaping design (Ahr, 2015a). Additionally, apart from regular stakeholder workshops there were Soft Landings workshops held where the appointed contractor was briefed and roles and responsibilities were agreed upon. There was also an occupant survey conducted by the University College London (UCL) after two years of occupation and it was shown that there was an overall positive response from the users (Agha-Hossein, 2019).

The Keynsham Civic Centre is a great example of how the Soft Landings framework can deliver a high-performance building. The building has been covered in numerous industry publications and has won many awards including the following (Agha-Hossein, 2019).

- British Council for Offices Best of the Best Award 2015
- RIBA South West Sustainability Award 2015
- CIBSE Building Performance Awards Project of the Year (Leisure) 2017

5.3 Glenside Campus - University of the West of England

The Glenside Campus is a Grade II listed building dating back to the 1850s. The building, which was previously an NHS Laundry, was refurbished for the University of West England’s Faculty of Health and Applied Sciences. The refurbishment started in December 2017 and was completed in October 2018. The vibrant new campus incorporates contemporary teaching and learning spaces with many of the original heritage characteristics retained. The University was in need of a building that met the Optometry Council's requirements on the use of digital technologies for evidence-based learning where students are recorded. Another requirement for the building was for it to be delivered on budget therefore ensuring a funding stream for other University projects. The project was assessed by the SKA Rating method, with the target set to Silver. The retained original features were one of the success keys to the refurbishment. Another one was the adoption of BIM level two, which assisted and bettered the building design, construction as well as facilities management. BIM was an important tool in achieving the project goals. Visualisation tools were utilised for detection of potential arguments and conflicts. These tools were also used in the design review meetings, with conservation officers and planners, to explain the design intent and they also helped to keep the project on track and successfully retain the heritage features. During the construction phase BIM played an important role providing visualisations with the aim to make sure all client expectations were met. It also made it possible to have a paperless construction site (Agha-Hossein, 2019).

The Soft Landings approach to this project enabled increased stakeholder engagement early on in the project which was considered a part of the reason why the project ended up being considered successful. Workshops for all parties throughout the project were held regularly. Engaging the client resulted in a reduction of typical late changes for University projects and therefore costs. Having increased planner engagement ensured the building was delivered according to the desired timeframe. M&E designers were able to gain a good understanding of the site due to facilities managers being involved with the decision-making and offering their expertise on design, resourcing and environmental control. The Soft Landings champion established and led the initial aftercare period for the project. Crucial to this period, and the extended post-occupancy evaluation (POE), was the Archibus computer-aided facilities management (CAFM) system which was used to file and resolve all operational issues. The data collected through the system was used to improve the operational performance to match the targeted performance goals. It was further improved through the POE processes in the second and third operational year (Agha-Hossein, 2019).

As a result of the project's Soft Landings approach, the project was delivered on schedule. The usage of BIM reduced time taken to sign off on proposed plans since the intent of the plans was easier to understand. Maintenance after delivery was effective and performance data was constantly fed into the CAFM system for the first operational year's seasonal commissionings. The facilities management successfully utilised augmented reality (AR) for catching issues on-site. It was also used for increasing the engagement of the Bristol Council, which resulted in the Grade II listing. The project climate was overall open and unified due to the sharing of learned processes from both the client and contractors (Agha-Hossein, 2019).

5.4 The Engine Shed - Scotland's Building Conservation Centre

The Engine Shed, Scotland's Building Conservation Centre, was originally built in the 19th century to accommodate steam engines. Later it was used as a workshop for truck-repair by The Ministry of Defence until it was abandoned in 1976 and stayed empty before being chosen to be the new space for Historic Environment Scotland's (HES) conservation, outreach and science teams (Pearson, 2020). The Conservation Centre is used as a space to promote the public's engagement with traditional buildings as well as space for learning about skills and materials which are needed for construction, conservation and maintenance of these buildings. The aim is to shift the view of conservation and heritage as something of the past to something contemporary (Fordham, 2020).

The old Engine Shed is the centrepiece of the new facility. Completed in 2017 with the price of £5,300,000, it has two new sheds added to the existing floor plan, one on the east side and one on the west side, as two new wings (Fordham, 2020).The objective of the design was to keep the original shed as a single volume and focal point, and have the two new wings accommodate all the necessary spaces and rooms. The west shed accommodates the reception, seminar spaces, offices and toilets. In the east shed a studio, equipment room, offices, kitchen, laboratory and a plant room is housed. In the original shed a freestanding lecture theatre is added (Pearson, 2020). The new dynamic centre brings together HES' outreach as well as expertise in science and education and combines it with built heritage, visitor attraction and space for learning and engagement. The spirit of railway and industrial buildings is the essence of the new facility design (Fordham, 2020). For the design and execution of this project sustainability was embedded at every step of the way, from briefing workshop to the aftercare of the building, which landed it the title of Building Performance Champion (CIBSE Journal, 2020). HES's aim from the outset was for this project to be seen as an exemplar of sustainability in every way possible (Fordham, 2020).

The new Engine Shed was designed for deconstruction, future flexibility and following a materials hierarchy – reclaimed, recycled and new local materials, to minimise waste (CIBSE). Aligned with the project's sustainability ambitions, a fabric-first approach was used to minimise operational energy use. The approach aims to maximise the performance of the building fabric itself, the components and materials, before using electrical or mechanical systems (Pearson, 2020). The building services design's prime target was to create a low carbon and energy efficient facility through the improved fabric performance, efficient environmental solutions as well as passive design strategies. Traditional skills and natural low-carbon materials have been used along with passive design measures to provide a comfortable and healthy environment (CIBSE, 2020).

As part of the fabric-first approach the new wings of the shed were designed with high levels of insulation while the original shed's existing roof had additional insulation added to improve the thermal performance. However, despite the approach, the building warrant did not include testing of airtightness and therefore nor did the employers' requirements. Because of this, the airtightness of the two new wings as well as the entirety of the building has not been quantified (Pearson, 2020).

The environmental design of the Engine Shed includes a ground source heating pump (GSHP) along with underfloor heating which allows sensitive insertion into the original shed (Max Fordham). Option appraisals on the energy source for the building were done before the underfloor heating was chosen. The chosen system also strengthened the argument for the use of heat pumps and it satisfied a requirement of architectural cleanliness. The GSHP solution has since shown to be a great success. In wintertime, it takes heat from groundwater and uses it to heat the building through buried pipes in the screed of the concrete floor. An option to address overheating in the future is given by the ability to run ground-cooled water through the same pipework. The only space in the building that has warm-air heating is the lecture theatre (Pearson, 2020).

The new building is partially naturally ventilated. In the already existing shed fresh air enters through windows in the gable and exits primarily through openings in the glazing alongside the roof ridges. In offices and seminar rooms in the new east and west wings fresh air enters via ventilation panels and can be exhausted through roof lights. The laboratory and digital studio has mechanical ventilation and coil units for cooling (CIBSE, 2020).

As part of the briefing process for the Engine Shed, HES appointed Max Fordham to be their sustainability consultant and support them in defining all the sustainable design criteria. Therefore a brief-setting workshop was held with key stakeholders to identify and also benchmark key sustainability challenges and ambitions. The results of the workshop were documented in a Sustainability Matrix. The matrix was fundamental to establishing sustainability targets in contrast to the capabilities of the industry and also in making sure that the right measures were implemented in the whole process from concept to handover and aftercare. It was used in the tendering process and to alleviate the design development as well as the decision-making for the project (Fordham, 2020). Once the matrix was set another workshop was held, a more detailed one, for HES's design team to review the matrix and understand how different measures would be implemented. The matrix underpinned all the decision-making and included all relevant topics such as energy management, thermal comfort and waste. The energy management measures included detailed and seasonal commissioning, training, fine-tuning and also operational energy monitoring. The role the matrix came to play, in making sure that the designer's intentions and ideas did not end up being only aspirations but actual targets that were fulfilled, was extensive. In addition, HES retained very close control of the sustainability aspects (CIBSE, 2020).

Max Fordham was also appointed for continuing sustainability monitoring and a two-year aftercare period, using the Soft Landings approach, and Post Occupancy Evaluation (POE). Max Fordham, the Soft Landings champion for the project, facilitated the whole process and provided monthly performance monitoring including energy monitoring, monthly site visits, monitoring occupant satisfaction through building occupant meetings and a POE with occupant interview sessions. Based on this quarterly aftercare reports on achievements and recommended actions were prepared. After practical completion (PC), the Soft Landings team was engaged in the following ways (Agha-Hossein, 2019).

- Carrying out detailed commissioning and fine tuning.

- Producing a simple building user guide.

- Providing extensive training.
- Facilitation of a two-year aftercare period and in-use energy monitoring during this period.
- Monthly meetings with main contractor, subcontractors and control specialist.
- Carrying out POE.

The Soft Landings approach protected and advocated the performance targets for the project and progress was reviewed through regular meetings at each stage by Max Fordham. Members of the client team, the design team, contractor and subcontractor attended these meetings. During the design stage these progress meetings and Soft Landings clauses were put into the specification documents. The intent of this was to ensure that the contractor would provide sufficient training for the handover, full aftercare and complete seasonal commissioning service. An “as-built” Sustainability Matrix was created at the end of the project, following a ‘lessons learned’ workshop, to show what had actually been achieved in the project and how targets changed along the way and were addressed in the end (Agha-Hossein, 2019). After the practical completion, monthly aftercare meetings and walk-arounds were arranged for the main- and subcontractors as well as control specialists. For the aftercare, quarterly reports were written on systems and energy performance and they also included recommendations actions. Measures that were taken in response to these reports have shown to be effective for reduction in energy use (Pearson, 2020).

A Post Occupancy Evaluation (POE) was conducted in 2018, a year after the building had opened. The POE gave relevant feedback on how the building was operating and whether it met the user needs. There was plenty of positive feedback regarding good acoustics and natural ventilation in most of the spaces. However, there was also negative feedback primarily concerning overheating and humidity in certain parts of the building as well as lightning glitches. Due to the findings from the POE all the issues were solved and the Engine Shed was still able to receive an A under the England and Wales EPC system, with as well as a C from the Scottish Building Standards for an EPC (Pearson, 2020).

Even though it is hard to quantify, the sustainable design resulted in a reduction of energy costs that more than outweighs the cost of the Soft Landings activities. The project successfully exceeded the original targets in the Sustainability Matrix and one of the main reasons for this was the client’s commitment to sustainability. A vision of the clear framework was also presented in the invitation to tender so all parties understood the target and success criteria from the beginning (Agha-Hossein, 2019). The Engine Shed was awarded BSRIA’s ‘Soft Landings Project of the Year’ in 2019, and CIBSE’s ‘Building Performance Champion’ and ‘Public Use Project of the Year’ in 2020 (Fordham, 2020). The building highlighted the thorough attention to detail as well as commitment during the aftercare period. The project has shown a very rounded approach to sustainability with many aspects being taken into consideration as well as the long-term view for the development. The POE showed that high comfort levels were achieved and that this project is a great example of a delivery that continues after the handover (CIBSE, 2020).

5.5 One Heddon Street - The Crown Estate

The Crown Estate's, One Heddon Street is a Grade II Listed building which was completed in 2018. A part of the building has been a flagship store since 2012 and the other part has since 2018 been a flexible collaborative workspace accommodating 335 co-working spaces. The capital expenses for the building was £ 6,000,000 and the operating expenses approximately £ 2,000,000 based on a ten year return on investment. For this project a traditional method of procurement was utilised. As part of the Regent Street portfolio, One Heddon Street was one of the first Soft Landings projects. The cost for the Soft Landings approach was approximately £ 60,000 and included consultant support. The Soft Landings success criteria for the project were set from the start and the aim was for the Regent Street portfolio to offer something new to its customers. The health-focused building's performance criteria were set in line with the WELL Standard. For the building services focus was put on water, air and light in line with the WELL quality targets. Furthermore, the focus on wellbeing was shown with sourcing of sustainable products (Agha-Hossein, 2019).

As part of the Soft Landings framework for this Crown Estate project, a Soft Landings manager was hired. The managers responsibility, apart from managing the Soft Landings activities, was to deliver the whole-life value methodology with the aim to understand economic value and performance over time in order to establish business resilience. For the Soft Landings activities, design teams were provided with clear objectives identifying performance and success criteria linked to the vision and marketing strategy of the Crown Estate. Success criteria and building performance objectives were both covered by the design intent, which was developed before the design process, and it formed a part of the project's RIBA Stage 0 case. It layed out objectives to support the project's business case. The intent outlined aspirations and benefited the realisation as well as the relationships among the stakeholders. This resulted in the development of a Soft Landings transition programme which related all parties and outputs to the design intent and provided the project a mechanism for assessment of design team proposals in relation to the design intent. The project's Soft Landings manager attended all design team meetings and worked across all the different teams (Agha-Hossein, 2019).

The requirements by the WELL standard specified in the beginning of the project were evaluated at practical completion (PC) of the project. The requirements were after practical completion also put into the operating model to ensure they were upheld post-occupancy. For the design intent, a series of meetings were held to review it regularly and capture lessons for future projects. The Soft Landings framework has proven its support for the Crown Estate's values continuously through the project (Agha-Hossein, 2019).

5.6 Oriam - Scotland's National Performance Centre for Sport

Scotland's national home for football, The Oriam Sports Performance Centre, is a training base for the national rugby team and is also the training home for governing bodies of handball, squash, basketball and volleyball. The centre, at a value of £30,000,000, was opened in 2016 as part of the Heriot-Watt University's Riccarton campus in Edinburgh (Fordham, 2018). As a large sport complex, it offers state of the art modern gym, changing rooms, hydrotherapy pool and a synthetic pitch which is the largest in Europe and is accredited by FIFA. Oriam was designed with the aim to be an inspirational environment for sporting activities on all levels including university students, the local community and top foreign athletes. The building was designed and constructed to be a part of a large sports complex when linked and integrated with the campus's existing facilities. It was important that the building cater not only to top athletes but also to recreational sports, campus students and the local community (Pearson, 2018). At the 2018 CIBSE Building Performance Awards, Oriam was awarded the Project of The Year in the category leisure (Fordham, 2018).

The design vision for the project was to create an inspirational national facility for sports and at the same time minimise the environmental impact as well as the energy consumption and operational costs of the facility. The form and materials of the building were developed to provide both natural ventilation and daylighting in order to reduce the need for artificial lighting, fan energy and mechanical cooling. To ensure acoustic comfort throughout the building, internal environments were designed and tested accordingly (Fordham, 2018). As a general, sports buildings have very irregular occupancies as well as use- and activity patterns. For that reason, systems for ventilation, cooling, heating and lighting had to be set up to respond according to the situation and free heat, fresh air and natural light is taken advantage of whenever possible while still meeting the strict requirements for overheating and lighting.. The way the services of the facility have been designed, they minimise energy use while at the same time maintain the optimum conditions for sports (Pearson, 2018).

To ensure successful operation without excessive mechanical cooling or heating, a thermal comfort analysis was performed to establish the optimal balance between ventilation openings and roof transparency. Peak summertime temperatures were also established by the analysis and it was concluded that mechanical cooling would only be necessary in extreme summer conditions. For this a design strategy was developed that would aid installation of temporary, rented cooling plants for larger gatherings (Pearson, 2018).

Spaces with high occupancies, such as the hall and fitness suite, require very high cooling loads and ventilation rates. Enabling natural ventilation and adequate ventilation for large numbers of people in the hall, are the facility's rooflights. They open and close under an automatic actuator control which is linked to CO2 levels and temperature in the space. The fitness suite's mechanical ventilation system has a high ventilation rate. Just as in the hall the fresh air flow is controlled by CO2-levels to match variable occupancy and minimise energy consumption (Max Fordham). The mechanical cooling system consists of a variable refrigerant flow (VRF) linked to an air-source heat pump which cools via fan coil units. The mechanical heating was initially designed with a ground-source heat pump but budget constraints led to a design change to NOx gas-fired boilers. Gas consumption after one year of operation ended up being substantially less than predicted mainly due to showers not being used as much as expected (Pearson, 2018).

In this development, a key challenge in the daylight design was to meet the required light-levels without any glare that would disturb the athletes. Additionally, the design was developed with the intent to maximise the use of daylight, therefore reducing lighting energy, while preventing overheating in the summertime. With extensive modelling, making sure the design worked as intended, the intention was met and for the most part of the year no artificial lighting is needed during daytime (Pearson, 2018). Being a daylit hall, rather than a traditional black-box one, it both saves energy and makes for a more pleasing sports environment. Compared to a black-box hall, the lighting loads at Oriam have been reduced by 75 %. This reduction was accomplished with lights being switched off whenever daylight was accessible and also by having the lights automatically set to suit occupancy levels and the sports being played in each zone of the hall in accordance with CIBSE guidelines. This is hard to achieve in practice but since lighting is generally where biggest wins can be had it was worth the commitment as well as collaboration between contractor, client and design-team. The collaboration was crucial when identifying, investigating and fine-tuning settings and control interfaces (Pearson, 2018).

Oriam exploits daylight through rooflights in four lines running the entire length of the arched roof. Glare is controlled with diffused glass which the rooflights are fitted with. The hall is also fitted with a translucent roof membrane. Its transparency was tuned to both control solar gain and deliver a daylight factor of 6 % (Max Fordham). The hall's artificial lighting is controlled to illuminate each of the occupied zones separately and to suit the sporting activity level. During the development's Soft Landings process, an intuitive controls interface was developed to manage light-levels according to CIBSE guidelines and requirements from the Sport Scotland brief (Fordham, 2018).

Even though in Scotland, Display Energy Certificates (DECs), for public buildings are not mandatory, drafts were still produced to benchmark the hall's performance. The building delivered a DEC A quite comfortably at first. But since synthetic pitch areas tend to distort the rating, a second DEC rating was calculated, with the pitch area excluded, resulting in increased energy use per square metre giving the building a DEC C. For the first year of occupancy, the building is believed to have performed somewhere in between these two ratings which is considered very good. The Oriam also had a higher electricity use than predicted the first year which is considered to be a result of unregulated loads. However, this was expected to drop after fine-tuning of controls and plant operation due to the Soft Landings process. Therefore, tweaks and minor issues aside, the Oriam is considered today a high-performance sports building and successful in delivering minimal environmental impact (Pearson, 2018).

The full Soft Landings framework was applied to the project and followed through all the stages, from early briefings to handover and aftercare. It has played a major role in the delivery of sustainable design and construction. The framework helped ensure that the design of the building was appropriate, that the occupiers understand the building, that the facility management knows how to operate the systems in order to achieve the best performance, energy efficiency and occupant satisfaction (Agha-Hossein, 2019). Soft Landings was instrumental in achieving a complex sports centre with adaptability and flexibility of the environments as key to its low-energy building services design. It was also important in the fine-tuning process of heating, lighting and ventilation control with the aim of reducing energy consumption and maximising comfort (Pearson, 2018). The Soft Landings Champion, Max Fordham's role included the following (Agha-Hossein, 2019).

- Integrating Soft Landings requirements into the contract.
- Developing an operational risk register with the intent to identify building performance issues.
- In collaboration, developing a staff training plan.
- Facilitating controls usability workshops.
- Facilitating pre-handover workshops with intent to fully involve building managers.
- Preparing the building user guide.
- Monitoring monthly performance, providing support to managers and holding monthly meetings as part of the 12 month aftercare period.

For the design phase of the project, the Soft Landings activities included (Agha-Hossein, 2019):

- Appointment of an independent commissioning manager.
- Holding early operability workshops with the client's facility management (FM) and operations team.
- Holding various workshops to ensure that the best solutions are chosen. These workshops include the contractor, subcontractors, specialists, FM team etc.

After the facility's completion in 2016 Max Fordham, the M&E engineer, continued their support for the occupants. They also continued their monitoring of the environmental performance and along with the contractors, facilities team and controls specialists they identified issues that needed resolving. This resulted in the achievement of the best building performance, energy efficiency and occupant satisfaction in the shortest possible time. With Soft Landings being implemented early on in the project, needs for all the activities and likely occupancy variations were able to be established and therefore design goals were reached (Welch, 2018). In 2017, post-occupancy evaluation in the form of a BUS survey was performed and it demonstrated high satisfaction among the occupants. Max Fordham aimed for a M&E design that would require minimum intervention and is easily controllable. Therefore, in association with the Soft Landings process, there were no additional M&E installation costs. Due to the Soft Landings process, the building is controlled efficiently and maintenance costs are low which means that the Soft Landings fees resulted in a net reduction in costs (Agha-Hossein, 2019).

5.7 Urban Sciences Building - Newcastle University

The Urban Sciences Building (USB), a £60,000,000 world-leading teaching and research centre in Newcastle opened in September of 2017. The facility is a ’living laboratory’ and hub for sustainability research and computing science. The USB, a 12,500-square metre triangular-shaped, six-story building with a huge atrium linking two sides with laboratory, research and teaching space (CIBSE, 2018). The building is home to the National Centre for Energy Systems Integration, the National Green Infrastructure Facility, Newcastle University’s School of Computing as well as many laboratories with the key research theme of potential future green urban infrastructure. For this development, the goal was not only for it to be an investment in new space for research but for the building itself to over time provide palpable research results. Therefore the facility was designed to be both adaptable and flexible in order to collect performance data and also foster change for an experimental purpose (Hawkins/Brown, 2018).

The USB was designed with the intent to improve the understanding of relationships between buildings and their surrounding environments. For this purpose, it was wired with over 4000 micro-sensors that collect performance data and monitor inner and outer environmental conditions. This system ensures that the control systems are constantly fed with the right information ensuring optimum building operation. It is also very helpful in understanding how buildings dynamically respond to the surrounding environment. To be able to resolve certain challenges and meet the strict data-collection specification, a research partnership with Siemens was adopted. The system was developed in BIM and the BIM-model is used during the operational stage and is continuously fed with conditions recorded by the sensors (CIBSE, 2018).

The atrium of the building faces south which means that extensive analysis had to be concluded to optimise glass performance and shading. As a result, the glass exterior was clad with digital artwork to ensure that the glazing meets the required g-value. This way temperature comfort conditions in the space can be maintained without having to use mechanical cooling. To heat the space in winter, an underfloor heating system was installed. For this system, sensors were embedded into the concrete floor to collect temperature data which will be used for further academic studies on thermal mass and related purging during night-time. For ventilation of the atrium, openable vents, controlled by CO_2 concentrations and temperature, were put in to the facade at both low and high levels. Most of the research and teaching spaces are equipped with active chilled beams. These are connected to a water-to-water heat pump and supply the spaces with both cooling and fresh air. The heating for these spaces is from a perimeter system. The comfort in the event spaces is upheld by an all-air system which is controlled by temperature, occupancy and CO_2 levels (CIBSE, 2018).

The Urban Sciences Building POE studies have shown it is about 90 percent electric. Initially an all-electric solution was explored, but in order to future proof the building, gas condensing boilers were added with the goal to supply top-up heat for the heating system and water system. The building is also fed renewable electricity and thermal energy through the solar photovoltaic (PV) array and photovoltaic-thermal (PVT) hybrid solar collectors on the roof. At the design stage, a prediction of the total energy usage was made using the CIBSE TM54. The results were equivalent to a DEC D rating. Two additional TM54 operational scenarios were tested giving a DEC D (98) and an E (125) rating depending on how the systems were set up. There was also a scenario for achieving C (75) prepared to give Newcastle University an idea on what would be necessary to achieve this rating. With the help of POE data, concrete advice for how this building can achieve a DEC C and a DEC B for coming years can be given by the design team (CIBSE, 2018).

Newcastle University has with this project been provided an opportunity to make a major change in how academic buildings are both designed and operated. For this project a sustainability framework was developed that pushes this development far beyond BREEAM. The framework provided a verifiable approach for developing sustainability targets for this project. It incorporates sustainability targets in six core themes including achieving BREEAM Excellent (Constructing Excellence). The goal was to push far beyond BREEAM since solely a BREEAM certification would not entirely meet the university’s sustainability brief and performance goals. A BREEAM ‘Excellent’ certification was not necessarily going to result in a low energy building and it would not support the digitally enabled sustainability research. This was shown in another one of the university-buildings which had achieved BREEAM Excellent but only a DEC rating of F (CIBSE, 2018). Therefore a sustainability framework that reflects the brief was developed. The framework was tailored to this specific project with the aspirations of the client in mind to ensure the building would have minimal impact on the environment. It covered both design, construction as well as in-use aspects (Hawkins/Brown, 2018). The framework was also supported by a meticulous audit trail and the cost for it was comparable to BREEAM. (CIBSE, 2018).

It was in Newcastle University’s interest to develop a sustainable building. Due to this the stakeholder engagement approach to the project was extensive and the engagement was integrated into all stages, from design to operation, of the development giving palpable value to Newcastle University. The Head of Sustainability and the in-house team were involved in the early stages of the project with the intent to set as realistic as possible energy targets based on either similar projects or typical energy use. Furthermore, a building manager was appointed early in the design stage to engage the facilities management in the whole design process (Hawkins/Brown). A Building Use Studie (BUS) was done a year after occupation and its results were compared against the BUS data and also the university buildings in which the occupants were previously based. The Urban Sciences Building scored better than the BUS benchmark mean (CIBSE, 2018).

With the aim of sustainability and optimal building performance, the Soft Landings framework was enforced in the project. As a result of this, the handover process of the Urban Sciences Building began in early stages of the project long before the construction phase (Dawson, 2019). The Soft Landings Champion, seeing to that the framework was actually applied, was the University. Additionally, the contractor had their own sustainability and Soft Landings champion that supported the process and attended all meetings (Agha-Hossein, 2019).The Soft Landings approach to this project included regular workshops with stakeholders as well as involvement of facility management personnel and stakeholders in commissioning and handover, site visits throughout the whole construction phase and brief input with key subcontractors. Additionally, there were formal reviews done at the RIBA Stages Signoff and a log of comments was kept.

The Soft Landings initiative was continued post-handover with regular meetings with the building manager and key stakeholders, seasonal commissioning surveys and also Post Occupancy Evaluations (POE) at six months, regarding the delivery, and at twelve months for first year use and performance (Dawson, 2019). The key lessons learned during the Soft Landings meetings included (Agha-Hossein, 2019):

- Workshops must be focused and have the correct participants attend at the appropriate stage of the process.
- For the Soft Landings process to be successful, there has to be a clear understanding of it and the construction team's responsibilities and roles have to be set.
- Stakeholders are essential in providing the brief, but also supporting the detailed design and reviewing the commissioning.
- Making a clear decision at the beginning of the project to follow the Soft Landings concept and implementing it during all stages ensures there are no surprises for any of the involved parties along the way.

To ensure the building performs as intended, Post-Occupancy Evaluations were done for a total of three years. These POEs' resulted in useful feedback from users and all issues being recorded and closed out effectively. Many lessons were learnt from the Soft Landings approach in this project one being the importance of feedback and shared experiences. Also the usefulness of having workshops and a session, at the beginning of every new project, where lessons learnt are shared. Another good lesson learnt from the project is that it is of great value to have a detailed project brief rather than project preliminaries (Dawson, 2019).

5.8 Institute for Manufacturing (IfM) Alan Reece building - University of Cambridge

Beginning construction in 2008 and finishing in 2009, the 15 million GBP IfM building is a multipurpose laboratory office building with 4380 square metres of office space, requisitioned for the engineering faculty of the University of Cambridge. In 2006, the University of Cambridge commissioned an early version of Soft Landings Framework in the Cambridge Work Plan, as such, the newly requisioned IfM building in 2008 required the implementation of a Soft Landings approach during the procurement process and the following construction. The Cambridge Work Plan is comprised of 17 pages of guidelines, with 7 of these being checklists. The IfM building subsequently used a BREEM approach and calculated that the IfM building would consume 18% less energy than the Target Emission Rate through simulations made during the design phase (Pritchard and Kelly, 2017). Designed as a low energy building having a biomass boiler and committing to a BREEAM excellent rating, internally, the building would be designed to be lit through natural dayligt and utilise natural ventilation, and to make use of low-e glass end external shading to limit excessive heat build up (Jones, 2008).

The heating system for the IfM building was designed as a retrofitted integrated 220kW biomass system with wood pellets used as fuel. The project required the heating system to be installed on the roof of the building, leading to difficulties with delivery and handover of the heating system. The boiler itself was not modular and would therefore have to be craned onto the roof to be put into commission (Rural Energy).

The building's energy performance was compared against four different benchmarks:

- ECON19, which contains high data availability for naturally ventilated offices, and air-conditioned offices, that can be weighted and compared against the IfM since two thirds of the IfM building is naturally ventilated.

- ND-NEED benchmark which covers more than 20% of all non-domestic buildings in the UK. The benchmark reveals energy use intensity for electricity and gas.

- Carbonbuzz, which utilises an open-source building data approach to benchmark actual energy performance provided by end users (Kimpian and CHISHolm, 2011).

- CIBSE TM46, which uses building energy benchmarks for university buildings. (Pritchard and Kelly, 2017).

Results from the study showed that the IfM consumes 10-29% more energy than average office buildings constructed in 2003, and 93-127% more energy than comparable good practice buildings. The excess energy consumption is showed to be due to an increased use of regulated electricity which includes chiller, HVAC (Heating, Ventilation, and Air Conditioning) and lighting loads. Designer energy estimates for the building were around 80 kWh/m2/yr, 180 kWh/m2/yr, and 300 kWh/m2/yr for the respective years 2009, 2010, and 2011. Actual energy consumption hovered around 300 kWh/m2/yr from 2010-2012. This underestimation of energy consumption is further supported by the benchmarking performed, showing that the IfM exceeded average energy consumption in several different benchmarks (Pritchard and Kelly, 2017).

Observations made evident from meeting minutes that were recorded during the project show several discrepancies concerning the requirements and design intents of the Soft Landings approach detailed in the Cambridge Work Plan. It is noted that the highly variable attendance at the designated meetings during planning and construction suggests that the Soft Landings approach detailed in the Cambridge Work Plan was not prioritised among the involved parties. This is further evidenced by the lack of a performed Building User Survey during the extended aftercare, even though this specific activity is an explicit requirement in the Cambridge Work Plan as part of the aftercare phase (Pritchard and Kelly, 2017).

Although the expectations are made clear from the beginning of the project and kept clear throughout the project as made evident by the results of the study, repeated breaches of the Cambridge Work Plan are observed (Pritchard and Kelly, 2017).

6. Interviews: results and conclusion

6.1 Experience and description of handovers

The amount of experience of handovers varies amongst the interviewees. Three of the four have had a lot of experience. B has worked as a project manager for over a decade and has been over the years quite invested in handovers. A, being a site manager, even considers it a specialty of theirs. K, a property developer, has had a lot of experience of handovers in one way or the other over a period of ten years. At K's current workplace, K has had part in the delivery of a preschool, several renovations of outside environments, expansion of a high school building, more than ten nursing homes with Attendo and has been a tenant representative. F has on the contrary not had that much experience and has only been involved in the delivery of one project. However, F was not directly involved with the management, as F's colleagues were, but was a part of the discussions as a project leader.

Regarding handovers, at B's workplace there is a typical process called the final stage where inspections of the buildings take place and tests of various functions are carried out. Furthermore they have something called coordinated function testing where certain functions are tested individually, and then tested collectively. This can regard different doors that are designed to shut in case of fire, during which ventilation should stop as well as to not allow the fire to spread. This is one example, where several functions should be coordinated. The inspection is of course an additional important function. Furthermore, the handover of all of the warranty notes is another one, as well as the training of operation and maintenance of the product that is delivered to the operations team of the customer. B also mentions the final revisions of the economics of the projects as part of the handover. This is usually highly intense, as the time frames are tight, and everything needs to click, and this responsibility falls upon B and his team. There are also a lot of certificates that need to be forwarded to the managing organisation. The company that B works for follows the project alongside the handover in order to ensure that the facility operates as expected.

F explains that the delivery process differentiates from what is taught at universities. When you study the process at university, you get the understanding that the entire process surrounds the final inspection date, where everything happens on that date, but this is not really how it works in practice. F goes on to expand that in regards to the one project having worked with the delivery, and many projects that F's been involved with it is extremely important to maintain a close relationship to the company's inspection personnel, something that is not emphasised enough according to F. It is argued that a lot of time is required for planning deliveries of parts of the area one by one and inspection of these areas (F). All of the documentation that is to be provided also requires time and planning, and there is a greater need for clear and concise planning concerning what documentation that should be provided, fire documentation, quality controls etc (F, K). Several of the participants state that a certain position is designated to work full-time with these issues and tasks, making sure that everything is performed correctly (F, K). However, the participants all agree that there seem to be no special guidelines covering the entire handover process. K has personally been devoted to trying to get the end user to engage more with project teams. At K's workplace they have building managers but management has been poor as the managers haven't had the proper tools or circumstances to take over management and operations with poor divisions of responsibilities and communication even when handovers are internal. There has been an effort to try to receive more information from project organisations, but it has been hard since project teams are used to handing over specific types of information regarding building systems and specifications, with information useful for tenants not being included.

As previously stated, the handovers are not ruled by a specific framework at any of the respondents' workplaces, but the larger companies do however have their internal standardised methods, which have arised from previous experience and culture according to (K, F). Therefore the steps for the handovers are partially the same for every project in a specific organisation, although it can vary depending on the conditions of the project. One of the participants claims that there is no system in place at all, instead referring to the final inspection dates as guidelines, although this does seem to be quite rare. (A).

F describes the handover process at the workplace as beginning roughly 6 months prior to the final inspection, with the collection of documentation. Although the process is started in advance, it always seems that it is not enough, with the organisation scrambling to be able to finish in time in the last couple of days leading up to the final inspection (F). This is further enforced by A, who claims that the stress seems to arise from poor planning, and organisations operating under high pressure, competing with short execution times since it is a factor that can be used in tenders and contracts even if it is realistically unattainable.

6.2 Roles and responsibilities

While all of the participants agree that the responsibility for a proper and well functioning handover lies with the project manager, they argue that the roles and responsibilities concerning the documentation is split, with F stating that the project team is responsible for providing documentation relevant to the building management, and the management team being responsible for ensuring that they are able to receive the documentation. K and B argue that the responsibility is split between the project team and the building management with regards to documentation, stating that the management team needs to clearly communicate what documentation is required and when. Project teams would like for the managing organisation to involve early in the process, with technical teams learning the building systems and getting ready for commissioning as soon as possible, but (B, A, K) state that managers currently do not reflect enough on this, perhaps not knowing that it is their responsibility to make sure that experience is transferred from the design/construction teams of the project organisation to the technical teams of the managing organisation.

With the construction time of projects often being around two to three years, B brings up the problems concerning turnover in the management organisations as well, stating that it is problematic enough when you have a designated manager that is to receive documentation and be a point of contact for the project team. When someone new comes in, with a possibly different position as well, does that change the roles and responsibilities? It's hard to say. There is little to no guidance concerning this (B).

Responsibilities and roles are not always clear depending on the workplace. At B's workplace the responsibility always lies with the project manager. Then there are several different parts of the project that are distributed to numerous instances of the organisation so the processes are quite clear regarding handovers. At F's workplace they are usually the management, meaning they don't have the responsibility for ensuring a smooth handover, as the project manager on the construction team does. The project manager on the construction side is responsible for the handling of documentation so that the inspection personnel can receive these in time, that the areas are ready for inspection, that installations are ready for operations usage etc. F and the company F works for are as clients responsible for ensuring that there is a management organisation on site being able to receive all of the information. The project manager on the construction has a finished building and hands over all of the information to F and F's colleagues. As a practical example, for facility managers working in a building, F and the team need to make sure that they are available and on site to learn how the systems work and how to finetune them. It is very important for the project manager to have made sure that their employees have performed their duties so that sufficient information can be handed over. F means that it is the responsibility of two parties. For A's workplace responsibility lies with the site manager, in coordination with the site management. For K's workplace it is not as clear and the organisation is lacking. The division of responsibilities between project organisation and client/managing organisations is poor.

6.3 Energy performance and energy contracts

Energy consumption monitoring is performed by the organisations of all participants, with F and B's organisations requiring monitoring for the first couple of years. This does not seem to be the case with K, who states that it is not required as the building is sold post-completion and therefore the responsibility is transferred from the organisation to the managing organisation.

Common among all of the participants is that they do not have any proactive measures in place to detect errors or defects before they cause any effects on building performance (A, B, F, K). Both B and F monitor buildings post-completion with specific organisational frameworks in place to ensure building performance doesn't deviate from predictions, with all of the monitoring being digital, such as electricity usage and energy consumption. F argues that it is more important to look at the quantitative data instead of qualitative as the experiences of tenants can differ while the numbers do not lie, but also states that it is important to engage with end-users to understand concerns. With this being said, no POE surveys are currently conducted at the organisation. B claims that there is no proactive monitoring such as POE as BBR simply does not have an available framework in place for it. B lifts the possibility of negotiating Energy Contract 12 into the procurement process to ensure energy performance, but also claims that it hasn't been used at the organisation as the organisation has realised energy performance goals. Most of the participants have not heard of Energy Contract 12 or

ByggaE, as handover contracts ensuring building performance (A, F, K). Energy certificates are brought up as a possibility to secure energy performance, but the opinions are split, with A encouraging use, and K criticising some certificates such as Miljöbyggnad for being bare minimum and not especially beneficial for energy performance.

6.4 Feedback processes

There seems to be a split concerning feedback processes and mechanisms utilised during the handover process in construction, with B claiming that there are separate instances of this in the organisation with examples such as organisation-wide internal projects called "Projects in world class" where the project teams asses their own projects and try to attain world class status. B also describes the process of having a group of personnel that move around from project to project to provide guidance and assistance throughout the handover process in order to ensure project quality. Interestingly, F who works at the same company although in a different branch of the organisation claims that there are no feedback processes in place during the handover process.

The industry wide problem of lacking feedback processes are supported by A and K, who both claim that they have had sporadic attempts to establish these but that it is hard to get employees on board if it is not mandated. A states that there simply aren't any resources available and that the focus on new projects is too great, with experience and talent moving on to new projects as soon as construction on buildings is completed. Since any material gains related to feedback takes time to be realised, businesses aren't going to waste precious hours on it unless forced to (A).

6.5 Standardisation

With tightening construction times, the spread of digitalisation and the increasingly complex intricacies of buildings, the risk for issues arising during handovers is high (B). While many of the larger organisations have systems in place to secure handovers, these are not standardised, which causes confusion and time delays when dealing with new clients that are used to other processes. There is potential for development, as many of the organisations colleagues do not have the systems needed in place for efficient handovers.

F further expands on the needs of the industry with regards to the handover process, stating that with all of the information transfers concerning building performance and documentation switching hands it can be difficult to keep track of everything, especially as project teams and clients often have different practises in place for these processes. The clearer routines are, the easier it gets, as long as the routines are not too numerous and saturates the view of what the process should look like (F). Today the amount of guidance is poor when compared to the motor industry for example which has clear processes and routines for every single activity (A). An industry-wide standard for how handovers should be conducted could be a potential solution to the issues related to handovers as guidance is significantly lacking, with organisations currently making it up as they go (F, K). A does not think that yet another standard would solve anything unless mandated, but even then it could hinder the freedom of the industry since standards inherently restrains innovation, but goes discusses the possibility of adding amendments concerning handovers to ABT or AB04, since the documentations are already used in almost every single construction project.

7. Discussion

With Sweden having entered into the EU's EPBD programme and introduced legislation tied to EPBD in both 2016 and 2017 emphasising energy efficiency in newly built buildings and buildings that have undergone alterations or renovations, property managers need to employ effective management methods through the continuous monitoring of building management systems in order to keep up with regulations. Several management methods, frameworks and energy certificates have been theorised to be able to deal with the handover and building performance, with some having achieved better success than others. DECs, NABERS, and Soft Landings are three methods that have all been implemented through legislative measures; they all also have in common that they emphasise measuring actual building performance, in contrast to predicted building performance. With the Swedish construction industry in need of a resolution concerning performance gaps, it can be argued that we should look to other countries' strategies for inspiration.

7.1 Barriers to implementation

In essence the Soft Landings Framework appears to make the case that since buildings need monitoring after completion in order to function properly, a project team needs to remain on location during the aftercare period, financed by the client, in the pursuit of realising the projected building performance. However, with the practice of lowest-cost tendering still being the industry standard procurement process, it creates a barrier for the implementation of Soft Landings as businesses would be more inclined to prioritise low costs. As such, quality and value-for-money must be the criteria used for procurement processes if Soft Landings is to be voluntarily adopted by the construction industry. As long as the industry favours cheap construction costs over long term gains, it will be difficult to introduce frameworks requiring the client to take on additional costs for quality assurance, especially since it can be argued that the responsibility should already lie with the contractors in the first place to ensure that actual building performance reflects predicted building performance.

7.2 Fragmentation of standards

The amount of different methods provided by the respondents in the interview study as being used in their building projects/construction companies, further suggests that there is a fragmentation of used handover frameworks, with no standard currently being employed in the construction industry. Widespread throughout the respondents is the need for more time to be prioritised for the handover process, potentially through an additional clause in the ABT06 contract or through a complementary contract alongside the standard procurement contracts.

Feedback mechanisms were found to be lacking throughout the construction process by some of the respondents interviewed; this has previously been highlighted through other interview studies conducted in the field, *Nyberg, G. and Orlinder, F., 2017. Hinder vid överlämning i projekt: Projektledares upplevelser av överlämning till interna mottagare.* Where the administrative manager's needs were not clear throughout the process, and the handover process was not prioritised throughout projects, often due to time related constraints.

Interestingly two of the respondents working with the same company gave very different views concerning the contracts used when procuring building projects. Whereas one was quite familiar with Energy Agreement 12, the other was not familiar with the contract at all, which further suggests the fragmentation of contracts/methods used even within companies, not just within the construction industry as a whole.

While standards can be seen as effective tools to tackle building performance gaps and have been advocated by some of the interviewees as a potential solution to the current handover issues, standardisation is not a guaranteed quick fix, as demonstrated by Norway's handover related issues. If a handover standard is to be implemented through regulatory means in Sweden, it must be easy to understand and follow, with the construction industry wanting to adopt it.

7.3 Implementation of Soft Landings

This brings us to implementation of Soft Landings through regulation as an industry standard. While early case studies have shown that Soft Landings does facilitate the realisation of predicted building performance in many of the buildings that have been constructed with the framework as made evident by the examined cases, there are examples highlighting the shortcomings of the framework. The Institute for Manufacturing (IfM) Alan Reece building case showed that although expectations were kept clear from the beginning of the project, repeated breaches of the explicit requirements of the framework guidelines were observed. This could be due to the lack of any contractual obligations, which is further supported by the conclusion provided by Pritchard and Kelly (2017), stating that there is little incentive to alleviate the performance gaps if there aren't any verifications integrated into building assessment methods, or binding contractual obligations regarding verification.

With the review of the case studies it can be concluded that the engagement of the Soft Landings framework, and all its procedures, as early on in a project as possible provides a graduated handover process and a basis for efficient professional aftercare. It passes a project smoothly on from the design stage all the way to the occupation stage and ensures that occupational performance needs are considered throughout all the stages. A key aspect of the Soft Landings success in the case studies is the change in focus and commitment to delivering better buildings it brings to organisations. This is shown through the success criteria set in the beginning of the projects which are then protected throughout and evaluated during the operational stage. The framework also promotes building better by capturing lessons learned giving the organisations and their project teams valuable feedback for their next projects.

The Soft Landings approach to the cases and its aftercare period during the operational stage was essential to achieving performance goals and especially reduction in energy consumption. Therefore improvements in energy performance after occupation were not simply achieved by smart technology solutions only. This was especially clear in the Keynsham case, where a key to its performance success was the close collaboration of parties with the aim to achieve the very ambitious energy performance goal. Due to these performance goals, in several of the cases Energy Risk Registers were developed which highlights the importance of building commissioning and more importantly effective commissioning and management.

For all but one of the cases reviewed the Soft Landings and associated Post-Occupancy Evaluation process has been successful and have demonstrated the value of feedback and monitoring in such projects. The impact on occupants' satisfaction, shown by the POEs is an important outcome.

8. Conclusion

The interview study highlights the fragmentation of standards currently used in the construction industry regarding handovers, this lack of a single guiding process leads to poor communication between project organisations and managing organisations which in turn can have detrimental effects on building energy performance and user satisfaction. As needs and expectations aren’t communicated clearly between developers and clients, time delays leading to rushed handovers are common in the industry.

Sweden could benefit from further evaluation regarding whether or not Soft Landings should be adopted and implemented into the building process as today's solutions to handover related building issues can be argued as to not have been successfully implemented and embraced by the construction industry. Since the framework has shown promising results in the UK, as is highlighted by the multi-case study where both energy performance and user satisfaction benefited from it, and the framework does not interfere with current Swedish building regulations or the EBPD, it is concluded that the framework could also perform well in Sweden and the construction industry could benefit from it. Although it could be argued that the implementation of the Soft Landings framework might result in additional costs in a project, the multi-case study has shown that the framework gives overall reduced costs in the handover and management phases and a net reduction in costs overall. The extensive focus on building evaluation resulting in feedback for future similar projects also has a positive economic impact and for these reasons the implementation of the framework should be considered. Soft Landings has shown that it enables better collaboration and communication which allows for better integration of design- and construction solutions resulting in simply better performing buildings. Overall it can be concluded that the framework in large extent reduces risks and gives more certainty in projects and should therefore be implemented, especially considering the growing importance of sustainability in the industry.

If implemented however, the framework would need to be complemented with contractual obligations and concerning compliance, as it has been shown through previous studies that compliance with the framework can be an issue. Furthermore, it could be beneficial to consider the potential implementation of a Soft Landings approach coupled with an energy rating system emphasising in-use energy performance, such as NABERS, as these systems also have the potential to tackle performance gaps, and this would utilise two different approaches to energy performance and user satisfaction.

As both NABERS and Soft Landings have been adopted by other countries, it would be interesting for further research to analyse if these have been embraced by the international markets, and if they have had success in ensuring building performance internationally. Furthermore, it would be of interest to analyse the usage and adoption of Soft Landings by the private sector in the UK, as it is only mandatory for the Government to use the framework when procuring large projects with public funds at the moment.

Considering further research on the implementation of Soft Landings in Sweden, a larger study should be carried out. Preferably where the framework is adopted to a smaller number of large projects and thereafter a case study is performed. This would allow for a more concrete analysis on exactly how to adapt the framework to the Swedish construction industry.

9. References

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Appendix 1: Interview guide

Topics	Main questions	Sub-questions
Experience	How much experience of handovers do you have?	
Handover	What does the typical handover look like at your current workplace?	Is the handover identical in every project?
		Is the handover process standardised?
		Is the handover managed as a process or simply as an activity/phase?
		Is there a specific framework for the process?
		At what point in a project does the handover start and end?
		Who participates in the handover?
Responsibility	Is the division of responsibilities and roles clear in handovers?	Is the allocation of responsibility always straightforward?
	With whom does the responsibility of ensuring an efficient delivery lie?	
Feedback	Do you have a system in place for feedback and transfer of knowledge/experience?	What does the process look like?
		Is feedback and transfer of knowledge/experience considered valuable?
Energy	Do you work reactively or proactively at your workplace with regard to energy performance?	Are certain energy contracts utilised?
		Do you follow up on the performance post occupation?
Management	Is building management involved in the handover?	At what point in the handover is management involved and how?
		Are the management's needs always clear and concise?
		Does the complexity of the project have an impact on when

		and to what degree management is involved?
Workplace culture	What does the workplace culture look like in regards to handovers?	Does the attitude of the employees have an impact on the handovers?
Personal opinions	What do you think about the handovers at your workplace?	Is it flawed?
		Would you add something to it?
	What do you think about the concept of a national standardised framework for handovers in the construction industry?	