Decision-Making in Sustainable and Fire-Safe Building Design

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Lund university

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Abstract

The construction industry faces many challenges, among which sustainability has become a prominent global goal to assess. In a European context, environmental certifications such as the Nordic Swan Ecolabel are a key incentive for addressing sustainability challenges and aim to reach the 2030 goals (UNFCCC, 2015). However, these incentives and considerations must be integrated with the requirements that must be met, including fire-safety as one of several critical design constraints.

This study contributes to creating an increased understanding of the complexity of trade-offs within sustainable building design, where fire-safety acts as a key constraint. It emphasizes how sufficient interaction between stakeholders affected the project and in turn how the sustainability aspect was affected. The aim is to assess how the decision-making process is conducted and, in turn, how it affects the sustainability aspect of the project and how sustainability considerations are shaped within fire-safety requirements.

This thesis investigates the decision-making process in the building construction industry with a focus on sustainability and how it relates to fire-safety. The study is based on qualitative semi-structured interviews of a residential building located in Malmö, Sweden. The study gives insights on what trade-offs were made in the process and intended to create a nuanced picture of the sustainability aspect of the project.

The results show that the building process to a high degree is governed by existing rules and regulations, pre-existing procedures, and financial incentives. Adhering to fire-safety regulations is non-negotiable, while the sustainability aspect of the project generally is integrated within the provided framework limited by fire-safety measures. This in turn means that sustainability considerations often are adapted within the constraints imposed by the fire-safety requirements. Furthermore, the decision-making power for the project was unevenly distributed, with stakeholders responsible for occupant safety being implicitly prioritized.

However, the study shows that requirements to a significant extent are fulfilled through standardized methods, certifications, and pre-existing experiences, which contribute to the project's solid structure and sufficient outcome. Communication between stakeholders operated well, although some minor miscommunications, which led to retroactive alterations, could be identified. Digital tools, such as BIM software and communication platforms, played a significant part in the data management and coordination of the project.

Furthermore, the study indicated that the early stages of the design process were crucial for how well sustainability- and fire-safety measures could be integrated. Decisions made during the design and system documentation phase tended to have a substantial impact on the project. Alterations made during the production phase had limited room for maneuver and resulted in a greater environmental impact than needed. Finally, the study concludes that no negative systematic drawbacks could be identified relating to sustainability design and its decision-making process. However, the study indicated that potential improvements regarding optimizing coordination and continuity between stakeholders could benefit the project.

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Definitions and terminology

Table 1: Glossary of terms

English	Swedish
Analytical dimensioning	Analytisk dimensionering
As built drawings	Relationshandlingar
Briefing phase	Programskede
Building Permit	Bygglov
Cable ladders	Kabelstege
Construction documentation	Bygghandlingar
Common Regulations	Allmänna föreskrifter (AF)
Design phase/ Engineering design	Projekteringsfas
Design meetings	Projekteringsmöte
Fire safety protection description	Kravställande brandskyddsbeskrivning
Developer	Byggherre
Feasibility study/ Preliminary study	Förstudie
Final inspection	Slutbesiktning
Final permit/ Final notice	Slutbesked
Fire-safety class	Brandsäkerhetsklass
Fire-safety documentation	Brandskyddsdokumentation
Framework documentation	Ramverkshandlingar
Functional class	Verksamhetsklass
Functional demands	Funktionskrav
General requirements	Allmäna råd
Gross floor ares (GFA)	Bruttoarea (BTA)
Handover and facilities management (FM)	Överlämning och förvaltning
Nordic Svan Ecolabel	Svanenmärkning
Notice to proceed (NTP)	Startbesked
Planning and Building Act	Plan- och bygglagen (PBL)
Planning and Building Ordinance	Plan- och byggförordningen (PBF)
Program documentation	Programhandlingar
Residential floor area (RFA)	Boarea (BOA)
Sheet steel cassettes	Plåtkassetter
Spot checks	Stickprov
Steel truss	Stålfackverk
Subcontractors	Underentreprenörer
System documentation	Systemhandlingar
Technical review meeting	Tekniskst samråd
Turnkey contract	Totalentreprenad
Typical floor plan	Normalplan

1. Introduction

The building sector stands against one of its biggest obstacles in modern times. Globally the industry makes up for approximately 34% of the world's carbon dioxide emissions (United Nations, 2025), which makes it an important sector in need of improvement to create a sustainable society. To reduce the environmental impact, changes are needed in terms of building methods and material selection as well as energy-efficiency. As new improved technology is introduced, new challenges emerge, which can lead to issues regarding quality, cost, fire resilience, among other factors (UNEP, 2020).

Sustainability in the building sector incorporates a wide range of perspectives. From an architectural standpoint, sustainability signifies creating constructions that are functional and durable and suit demand while still minimizing energy demands (Brundtlandt, 1987). From an environmental perspective, the impact from emissions from the materials and energy-efficiency is the main focus, as well as recycling capabilities. A third perspective in terms of sustainability is the resilience of the structure, creating a structure that withstands time and thereby increasing its lifespan by being fire-resilient and durable against climate change. By increasing durability and resistance towards fires, floods, and other deteriorating factors. Fire safety is integrally linked to sustainability since it involves the selection of adequate materials that ensure the occupants' safety while still being environmentally friendly and feasible from a cost standpoint (Meacham & McNamee, 2020).

When designing a sustainable building, a wide range of stakeholders are involved that generally focus and prioritize different aspects of the building. The building process can be very complex and demanding, involving multiple stakeholders, in which their expertise and decisions needs to be accounted for. Whilst an increasing amount of building projects in Sweden are aiming for higher environmental standards and certifications. All while complying with existing regulations and requirements (Winch, 2010). This process often leads to conflicts of interest where the different trade-offs can lead to undesirable results.

Existing research indicates that fire-related issues have a high risk of being addressed late in the building process, which often leads to ineffective solutions and negative compromises. Furthermore, the research shows that issues regarding fire-safety in general are dealt with in a reaction to issues instead of in a preventive manner, which may lead to inadequate solutions (Meacham, B. & McNamee, M., 2020). Decision-making in regards to fire safety isn't strictly a technical issue but also one of collaboration and sufficient communication.

In regards to sustainable considerations and aims, it´s crucial to analyze how decisions interlinks with fire safety in a building project. More specifically, how the different stakeholders interact with each other to achieve sustainable goals whilst complying with fire-safety requirements and considerations. By analyzing the decision-making process through to create a detailed deep understanding of where information gaps occur and how to prevent them.

1.1 Background

1.1.1 Evolution of sustainability

Sustainability is often considered a new concept, but its core principles can in some cases be tracked back far back in history. It's defined as “A dynamic process that guarantees the persistence of natural and human and equitable manners” by the Intergovernmental panel on Climate Change (IPCC) (IPCC, n.d). Throughout history, sustainability mainly concerned the fact that resources were scarce, rather than environmental reasons. Materials used had to be in close proximity in order to allow for easy access (Agudelo-Vera et al, 2011).

In the building industry this meant that the constructions were adapted to the materials available. The buildings were designed for long lifespans and reusability, some are still in use today (Ramesh et al, 2010). This prevented the use of unnecessary resources.

During the industrialism in the 1800s, new technologies allowed for large-scale excavation of resources, which in turn sped up the building sector. Focus was mainly on efficiency and speed, while the environmental impact was mainly neglected. The introduction of new materials such as concrete and steel came with new potential possibilities. While also requiring more energy, thus resulting in a higher environmental impact. Later during the 1900s, the negatives from this started to show, and more emphasis was placed on reducing that environmental impact. The building sector was quickly identified as having a big impact, and this in turn resulted in new requirements to promote sustainability (Spence & Mulligan, 1995).

In 1987 Brundtland published a report where sustainability was thoroughly explained and designed (Brundtland, 1987). This contributed to the increased focus on the whole lifespan of a building, and methods such as life cycle assessments to analyze buildings environmental impacts systemically became integrated into the industry. In the current industry, sustainability is well integrated, with tested standards and procedures (UNEP, 2020). While it still is being expanded and developed, these standards are regulated by national and international laws as well as certifications. In today's society the concept of sustainability is constantly considered in a wide range of sectors and forces the industry to continuously make considerations.

The UN global goals are based on the Brundtlandt concept, with 17 goals integrating social, environmental, and economic development (UN, n.d). Goal seven aims for sustainable energy production, including improving energy efficiency and increasing renewable energy production. Goal 11 aims to make cities sustainable from both perspectives, such as quality of life and sustainability, and to work long-term to reduce climate impact. Goal 13 is about reducing climate change. The construction sector's emissions must be readjusted and influenced by point 13.2 "Integrate climate change measures into national policies, strategies and planning" (UN, 2026), to contribute to a sustainable construction sector that promotes sustainable strategies and solutions for the future.

1.1.2 Fire safety Incidents

Fires in buildings have throughout history posed a threat in societies across the world. The fires posed a threat to people's lives as well as their livelihoods. They've often been the catalysts for change in technical and regulatory settings. Fire safety has developed reactively in accordance with incidents and gradually improved over time (Meacham & McNamee, 2020).

From a social standpoint, this has affected the trust towards building companies and the government (Na´eem, 2026). Fires have also set economic constraints on societies since they usually spread and cause havoc, which in turn hindered businesses from operating at full capacity. In Sweden, city fires were a reoccurring event with great impact on how today's cities are formed. The fires led to new regulations introducing wider streets, restrictions on certain types of materials, and the foundation for the fire safety regulations prevalent in today's society (RISE 2022).

Fires in buildings aren't something strictly confined to the past. It's something that still remains in today's society, although to a smaller extent. In 2017 there was an incident at the Grenfell Tower located in the UK, where 72 people passed away due to insufficient design of the envelope, which in turn led to extensive regulatory revisions (UK Government, 2020). In Sweden there was a similar incident in 1998 called Discoteksbranden in Gothenburg that had a similar effect on society. 63 people passed due to the results of improper usage of the space, inadequate fire safety precautions, and not enough escape routes (Johansson, 1998). More recently, a fire at an amusement park project in Gothenburg also occurred while it was still in the construction phase, proving that fire safety needs to be taken into consideration in all phases of the building process.

1.1.3 Historical development of building rules and regulations

Rules and regulations have evolved gradually throughout time in response to advancements in technology and urban densification (Meacham, B. & McNamee, M., 2020). Reducing extensive fires and ensuring adequate structural integrity has been crucial in the process of regulating constructions through building materials and building height.

The earliest forms of construction rules were largely in response to severe cases and were thereby reactive rather than precautionary (Meacham, B. & McNamee, M., 2020). In the Middle Ages throughout Europe, local and national rules were implemented in response to city fires by regulating what materials were allowed and increasing distance between buildings (CIB, 2010). The rules were often local and lacked standardization but served as the framework for the modern-day rules. A clear example of this is that the height of wood constructions was restricted in city centers since there was an increased risk for fires. The rules were rarely based on calculation but rather on observed consequences.

In the 19th century, rules and regulations started to get regulated by law due to the rapid urbanization.
The urbanization led to increased occupant density, which in turn made eventual fires more substantial. Wood construction was classified as a risk material due to its flammability

(Andersson, 2012). During the 20th century, laws started to be formed that ensured sufficient function of the buildings. Rather than specifying exact requirements, laws were developed in order to reach a level of security. Such as reducing the spreading of fires and ensuring structural integrity (Boverket, 2025l). These regulations fostered the development of new techniques, while still relying on observed consequences rather than analytics. The modern regulations are primarily designed to reduce risks, while still leaving room for creativity.

During the last 50 years, incorporating sustainable strategies and goals have been an increasingly more crucial part of building design in Sweden. This includes adhering rules and regulations incorporating sustainable considerations, environmental certifications, and making continuous design choices which integrate energy-efficient buildings both in passive and active measures. This is visible in the rules by the increasing demands on embodied CO_2 as well as the new requirements on energy efficiency (European Commission, 2020). Furthermore, this has also resulted in stricter demands in mapping out one's environmental footprints through climate declarations and life cycle assessments (Boverket, 2021). Additionally, certifications further promoting sustainability have gradually been implemented with incentives, with the incentives being financial.

1.1.4 Problem statement

The building sector stands against increasing demands in regards to the development of sustainable and secure constructions. Early-onset design choices of a building project can make up to 70-80% of a long-term impact on a whole-life climate impact (Tu, Roberts & Zhuang, 2026). These decisions contribute to several influencing aspects regarding fire safety and its related outcomes.

Demands regarding reduced environmental impact and increased energy efficiency have resulted in new materials being developed and new design strategies and planning methods (Tu et al., 2026). The building process is characterized by being complex, where different disciplines possess different sets of knowledge in relation to traditional building knowledge and fire design strategies and considerations (Gann & Salter, 2000). This in turn gives rise to different interpretations of how the regulations and frameworks should be addressed. These challenges may subsequently lead to misunderstandings, delays in the construction phase and may minimize environmentally sustainable ambitions in the progress.

There is a need for further research into how sustainability and energy performance are integrated with fire safety strategies and considerations. Construction projects are complex and involve many decision-makers, with an industry increasingly demanding that sustainability be given greater prominence. How can the future building industry progress towards sustainable choices while ensuring fire safety?

1.1.5 Aims and objectives

The aim of this thesis is to explore how the design of energy-efficient, environmentally friendly, and sustainable buildings should incorporate the challenges posed by fire safety issues, determining the most significant aspects of the design and production process. This will be done by analyzing and evaluating the communication process, eventual trade-offs, and conflicts of interests from a case study.

The main objectives of the thesis are to:

- Analyze how environmental sustainability is weighed against fire-safety strategies and considerations.

- Identify which stakeholder takes precedence of the decision-making relating to fire-safety requirements and how this in turn affects the environmental sustainability of the case study.

- Determine how fire-related and sustainability requirements are met in the industry.

- Investigate if there are any information gaps and how, in turn this can affect environmentally sustainable and fire-safety strategies and considerations and how these are weighted against each other.

- Analyze what digital tools are used for building projects and how these tools can support environmental sustainability and energy-efficient building design and how this in turn affects fire-safety.

2. Literature review

2.1 Building process

The building process can generally be defined as a complex workflow following a set of predetermined sequences. The process is generally divided into five different phases in Sweden: the preliminary study phase, the design phase, the construction phase, the commissioning phase, and the operational phase (Mataki, n.d).

In the preliminary study phase where the buildings are proposed, rough cost calculations are conducted as well as the involved parties are contracted. The main goal of this phase is to propose a concept and determine its feasibility (Boverket, 2024a) . The design phase is where the building is planned, floor plans are drawn up, ventilation systems are planned out, among other things. The construction phase is where the project is executed. It's where the plans from the design phase are realized and where all the involved parties have to coordinate in unison to achieve the desired outcome (Boverket, 2024a).

The building process is a workflow involving a wide range of disciplines with different sets of knowledge. Each stakeholder is responsible for a specific aspect of the project and does not necessarily have full insight into the work of the other disciplines. The operation involves a lot of collaboration, negotiation, and compromise (Xianbo, 2017).

While the building process generally is divided into the five previously mentioned phases, it's not typically a linear process. These different phases overlap, and revisions are carried out progressively (Love et al., 2016). The sooner the problems are addressed, the better the outcome in general. The existing research indicates that creating an effective information flow between the different stakeholders is a reoccurring issue. Referring to a lack of proper documentation, undefined standards, and informal decisions that easily can be misinterpreted. The consequences of this ineffectiveness can lead to improper time management, trade-offs, and an increased chance for misunderstandings. The literature stresses that proper communication is of the uppermost importance to achieve sufficient results (Love et al., 2016).

The definition of alterations according to Boverket can be addressed as "The concept of alteration includes, among other things, changed use, extension, and reconstruction." An extension is a measure that increases the volume of the building. A reconstruction is a change that means that the entire building or a significant and delimitable part of the building is significantly renewed." (Boverket 2025h). The building alterations are not to be confined only to the production stage but can iteratively occur throughout the building process (Love et al, 2016).

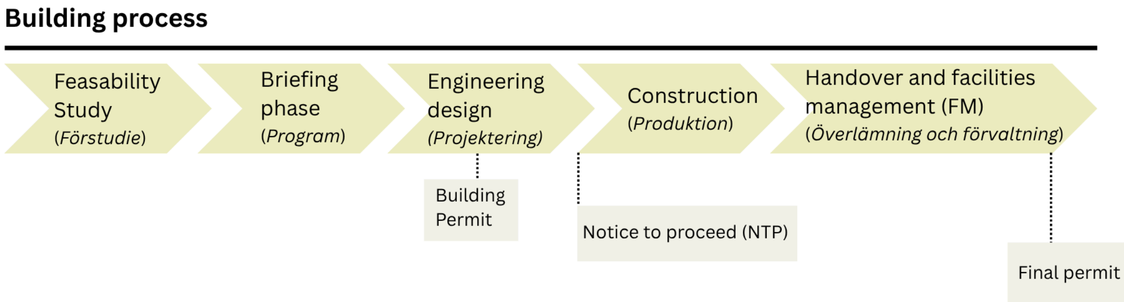

Figure 1: Building process in Sweden (Boverket, 2024a)

The building process in Sweden can be described through five official phases, which is described in Figure 1. However, the process is iterative, and the processes might overlap or be carried out progressively.

The preliminary study in the building process establishes that the building client defines the scope, visions, and goals for the building, which will be defined and specified in documents and drawings during the briefing phase (Boverket, 2025b). The briefing phase will contain the procurement, depending on the form of contractor hired for the project. In the case of a turnkey contractor, which runs the entire project, including the process of subcontractors, they will be eligible to provide the request form for the building permit (Boverket, 2025c). The building permit is vital in order to get the notice to proceed (NTP) to start the production phase.

The process from the engineering design phase to the production is described in Figure 2, which contains the technical review meeting, ensuring that fire-safety measures are established and verified (Boverket, 2025e). The blue color signifies that it's the contractor's responsibility, and the red indicates that the developer has the main responsibility. During the engineering design phase, the system drawings are set up, containing the large scope of the planning of the building, which is then used for the detailed design drawing as a later stage (Boverket, 2025f). The documents are essential for the general contractor to be able to procure subcontractors for the project. Throughout the production phase the building municipality will do site visits (Boverket, 2025f). Once the building production is finalized, the final permit is given, and a final inspection is held to ensure that the building has followed its building permit. This process involves the building municipality, which mandates that the BBR and its regulations be followed. After the building has been constructed comes the last phase, handover and facilities management (FM), where the building is handed over to the facility manager (Boverket, 2025g). The facility manager is given all required information about the building.

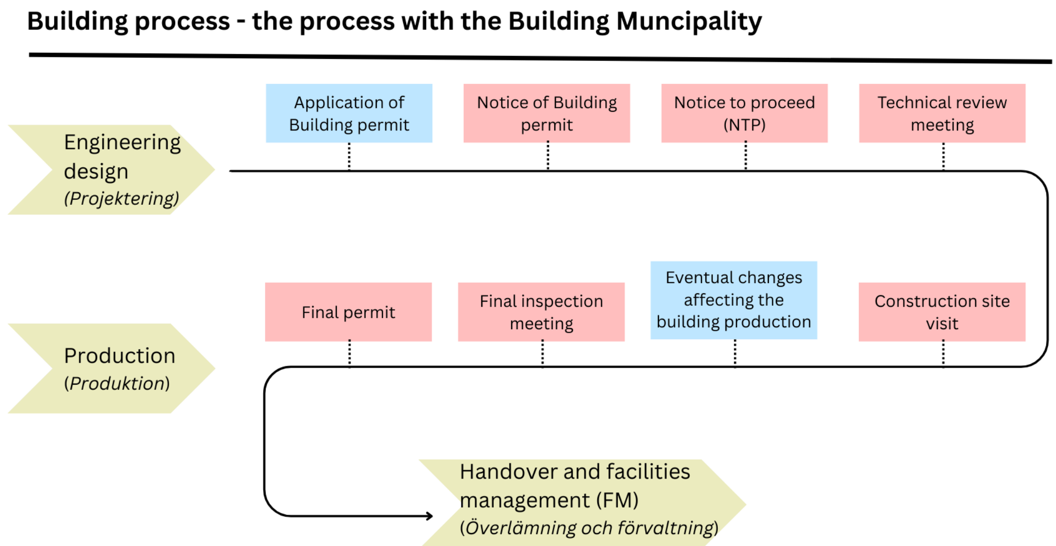

Figure 2: Building process within the municipality, blue color: contractor's responsibility. Red color: developers' responsibility. Green color: Building process phase (Boverket, 2025e).

2.2 Rules and regulations

In Sweden the laws for the building industry are regulated by the government through Plan- och Bygglagen (PBL) and Plan- och Byggförordningen (PBF) (Riksdagen, 2010). These specify general guidelines on how the building industry should operate, promoting safety and accessibility as well as sustainability. Boverket is the governing body that regulates and ensures that these regulations are implemented appropriately. Their regulations are called Boverkets Byggregler (BBR) (Boverket, 2024). They set requirements based on function rather than how they should be resolved, which gives involved actors leeway (Boverket, 2024). The building sector is regulated by laws and requirements to ensure safety for the occupants, adequate building standards, and promotion of sustainable and energy-efficient building design.

Fire safety is a central part of the regulations, it involves requirements on structural integrity, limiting the spreading of fire, smoke spreading and proximity to evacuation exits (Boverket, 2024). BBR also has requirements on reduced environmental impact through materials with less environmental impact, energy efficiency, and waste management. These requirements are connected to fire safety but do not always fully align since they can create conflicts of interest.

The rules and requirements work not only as restricting factors for the project but also as guidelines relevant for the decision-making process. They act both as a tool and a restriction in projects, ensuring that projects remain on the right track.

2.2.1 Applied in a Swedish context

BBR is a part of a hierarchy consisting of four stages. *Plan- och bygglagen* (PBL) is the law, followed by the *Plan- och byggförordningen* (PBF), followed by *Föreskrifter* (regulations) and *Allmänna råd* (general advice) (Boverket 2025d). Figure 3 below describes the hierarchy of regulations within the Swedish building industry, in Swedish and English, as well as who their governing agencies are.

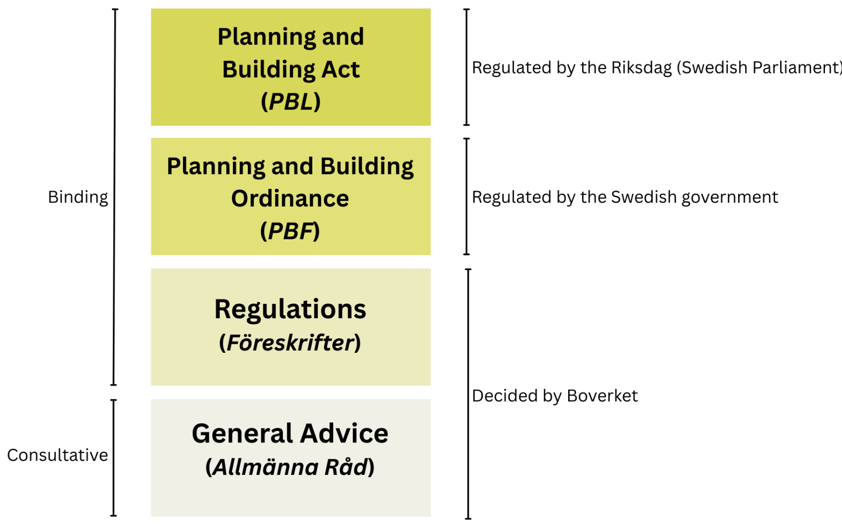

Figure 3: Building laws within in Sweden (Boverket 2025d).

These are recommendations and guides to facilitate the building industry. Boverket's structure regarding fire safety is divided into three parts:

- Section I. General provisions
- Section II. Construction of new buildings
- Section III. Modification of buildings

In which Section I refers to the project planning, control, and documentation. It also refers to rules and regulations on design and construction in regard to dimension and technical systems. Section II refers to rules and regulations for new constructions, and Section III refers to rules and regulations that apply to alterations to buildings (Boverket, 2025d).

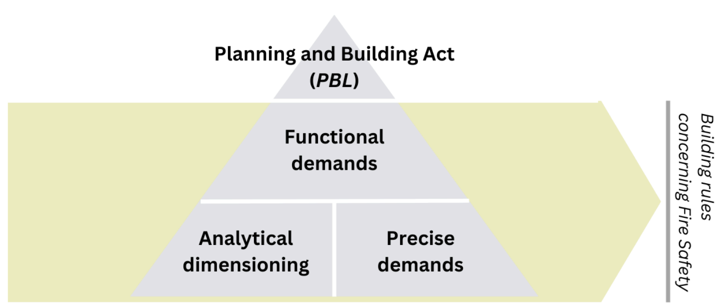

Figure 4: Building rules concerning Fire-safety

There are two verification methods to ensure fire safety regulations: functional demands and precise demands. Functional demands are to make sure that fire safety protocols are followed, and precise demands are used to apply function-based requirements to the extent available. The requirements are divided depending on the building class and activity class. Analytical dimensioning is used as a comparison to the precise demands in order to show the functional-based demands meet the same requirements (Boverket, 2024). Illustrations of verification hierarchy are visible in Figure 4.

2.2.2 Fire safety regulations applied in buildings

Depending on the building's protection needs and functional activity, different fire-safety classes will be assigned, which are described in PBL (2011:6), section 5:22 (Boverket, 2026). The complexity of the building is determined based on the number of floors of the building, with the initial classification starting at Br3 and the highest security level at Br1. Br0 is assigned when a building exceeds 16 floors, thus always requiring analytical dimensioning (Boverket, 2024). This classification is ruled as building classification, the classifications are visible in Figure 5 below.

The rules and regulations are also impacted by the functional use and activities in the building, in regards to if people are awake or asleep, the possibility of free movement, or awareness of the building geometry (Boverket, 2024). Fire cells are also considered in regards to determining a building's fire-safety class, as well as its purpose assigned beyond functional purpose; this is called "functional classification." The functional classes range from 1 to 6, where Functional Class 1 is where people are expected to be aware and have good local knowledge, while Functional Class 6 includes buildings and premises with a high risk of fire and the risk of spreading extensively. Functional Class 3 is assigned for residential housing in which people are expected to have good general knowledge and the ability to move independently but not be aware, which is divided into two subcategories, A and B (Boverket, 2024). Depending on the range of free movement of the building's residents.

A building can contain several functional classifications but only one building classification. If the outline of the building is unclear, the highest regulation should always apply, according to BBR section 5:23 (Boverket, 2026).

Figure 5: Fire-safety classification of buildings (Boverket, 2026).

2.3 Selection of sustainability perspectives

To contribute to a structured analysis of sustainability with emphasis on the building process of Västra Vakten, three specific sustainability aspects have been selected to be emphasized: architectural, resilience, and environmental sustainability.

These perspectives were selected based on two main factors. Firstly, they are central aspects within sustainability that are often brought up in the existing literature as well as in the industry, where focus emphasizes the architectural aspect of the buildings, the environmental impact of the materials, and the long-time performance of the building (Meacham, B. & McNamee, M., 2020) (Tu, Roberts & Zhuang, 2026). Secondly, it was based on the information gathered from the semi-structured interviews where the different stakeholders emphasized these aspects.

2.3.1 Environmental sustainability

Environmental sustainability is a fundamental requirement in order to create a sustainable society, it aims to minimize humans' negative impacts on the environment (UN, 2015). Typically through reduced global emissions, responsible consumption of natural resources, and other factors that foster a sustainable society. In the building industry this usually entails reducing embodied emissions from the materials and reducing energy use, as well as recycling available materials. This is especially relevant to the building sector since it accounts for about 34% of the world's global emissions (United Nations, 2025). The environmental impact doesn't only persist while the building is constructed but also during its operational phase through cooling, heating, ventilation, and electricity use. Furthermore, it also remains at the end-of-life phase (International Energy Agency, 2023). To prevent insufficient use of resources, a life cycle assessment (LCA) perspective usually has to be taken into account to obtain objective data. This has led to an extensive performance in how the industry approaches sustainable solutions (ISO, 2006a).

The willingness to reduce the building sector's environmental impact comes with new challenges. New innovative technical solutions have to be developed and adapted to fit the existing market. The environmental benefits have to be weighed against the financial situation (Love et al, 2016). Furthermore, there are other perspectives affected, such as fire safety and construction.

To reduce the building sector's impact on the environment, new guidelines have been implemented by the United Nations as well as separate ones at a national level, often in combination with financial incentives. The central one being the Paris Agreement from 2015, which declared that global emissions have to be reduced. This has resulted in more restrictive requirements in the EU, this has led to increased importance of certain certifications such as Miljöbyggnad and BREEAM (UNFCCC, 2015).

2.3.2 Resilient Sustainability

From a lifecycle perspective, resilience is a central aspect rarely brought up in terms of sustainability due to the term "sustainability" being broad and in constant change. Resilience in terms of sustainability is defined by the IPPC. “The capacity of a social, economical, and environmental system to cope with a hazardous event or trend or disturbance, responding or reorganizing in ways that maintain their essential function, identity, and structure while also maintaining the capacity for adaptation, learning, and transformation” (IPCC, n.d).

Buildings that can withstand deterioration over time from such damages as fire and extreme weather with minimal service by default improve their environmental sustainability over time since their lifespan increases. The correlation between fire-related damages and resilience is evident in existing research. Adequate resilience in buildings results in limited damage, which in turn reduces economical and environmental loads (Meacham, B. & McNamee, M., 2020).

Resilience is also connected to social sustainability by ensuring the occupants' safety and health (Choi et al, 2025). Resilience by itself is not easily quantifiable but is an aspect that overall affects the other aspects of sustainability.

In practice, conflicts often arise between environmental sustainability and resilience requirements (Choi et al, 2025). For example, usage of bio-based concrete, aerated concrete, and technical systems may be beneficial from an environmental standpoint but not a resilience one (Choi et al, 2025). Therefore, resilience shouldn't be regarded as a secondary goal but as a primary objective of high concern.

2.3.3 Architectural sustainability

Architectural sustainability refers to how the design and layout of the building can affect its function over time through performance and practical use. Contrary to technical and material applications, architectural sustainability is connected to design decisions that affect structural aspects and layout. This affects daylight conditions and flexibility (International Energy Agency, 2023).

Appropriate design solutions can result in decreased energy use, a comfortable indoor environment, and efficient use of resources. These are aspects that can be costly and complex to rectify once set. Another aspect of good architectural sustainability is the ability to switch the function. Central to a building's architectural sustainability is its ability to be used for multiple purposes with minimal intervention. Buildings with generous floor plans, high ceilings, and open spaces open up for the opportunity to use them for reuse and flexibility (Dalla Mora et al, 2018). This contributes to a longer lifespan through decreased need for renovations to fit the functional use over time and thereby reducing the environmental impact, in which architectural sustainability is closely connected to a building's lifecycle (ISO, 2006a).

The design of the building affects the building's energy performance, for example in ways of heating and cooling demand, need for electrical light, and material properties. Architectural sustainability interacts with the environmental, social and economical sustainability aspects in a passive manner. By providing sufficient working and living spaces, it increases the lifespan of buildings.

2.4 Process mapping - BPMN

Process mapping is an approach used for visualizing different kinds of flow through a specific operation. It's commonly used throughout companies and organizations to create a clear picture of critical activities as well as to determine what parties are involved. In complex organizations involving a variety of independent stakeholders, process mapping is frequently used to illustrate eventual advantages and consequences of the information flow (Lucidcharts, n.d).

Process maps follow a standard provided by the Object Management Group (OMG), *version 2.0 Business Process Model and Notation (BPMN)* (Object Management Group, 2014). Business Process Model and Notation (BPMN) is a standardized method for visualizing a process map to describe work and information flows. The method is well known and adapted to efficiently describe communication between stakeholders (Object Management Group, 2014). The standard defines symbols and pathways and ensures that the depiction is comprehensible and consistent. The symbols are illustrated in Appendix C.

The mapping procedure focuses on determining in what sequence the events occur as well as how they are conducted. For the building process, the system can be utilized to effectively map out the decision-making process and therefore identify eventual information gaps. The system is an analytic tool intended to illustrate analytical data in an effective, concise manner. The system uses defined symbols to represent different occurrences, with the aim of being coherent, user-friendly, and easily understandable. The different sequences are depicted as shapes in the process map signifying distinct events and are then connected by arrows to indicate direction (Xianbo, 2017).

2.5 Fire safety in a research context

Fire safety is a central part of the building industry. It ensures the occupants safety, property and gives rescuing services a good opportunity to minimize eventual damages. In the building industry, fire safety generally references technical solutions that contain the fire, proper escape routes for occupant, safety systems, as well as other factors (Meacham & Mcnamee, 2020) .

In Sweden, Boverket is the governing body for regulating the industry, ensuring adequate standards (Boverket, 2025a). They specify what requirements key components need to fulfill in order to ensure good quality.

Fire safety concerns all stakeholders in a building project. It affects the layout of the floor plan, the materials selections and thereby the environmental impact (Xianbo, 2017). Which in turn can affect the cost and structural capabilities as well as other factors. Since fire safety is an essential part of building design, it in turn affects all accompanying parties and thereby needs to be negotiated with all involved parties to ensure sufficient results while still complying with existing regulations.

Existing research indicates that fire safety issues usually are addressed in the later stage of the building process and often in order to address a problem instead of in a preventive manner (Meacham, B. & McNamee, M., 2020). This tends to result in suboptimal results for all parties involved since compromises have to be made. This often leads to fire safety components being implemented at a later stage that can culminate in time management not being met, expensive solutions which could be avoided, higher environmental impact. Furthermore, a lack of communication increases the possibility of these trade-offs occurring (Love et al, 2016).

2.6 Decision-making responsibility, allocation and, communication

Communication is a central part of the building process and is essential for it to proceed smoothly. Especially ones involving different disciplines with different interests (Love et al, 2016). Projects in the construction industry are known to be highly complex and a large number of actors, which makes effective communication crucial. Previous studies show that complex projects are efficient when integrating project and business processes inter-disciplinary, with a current lack of conceptual understanding and management practice between the disciplines (Gann and Salter 2000).

Building projects involve multiple actors, i.e. architects, structural engineers, fire consultants and project managers, which share different responsibilities throughout a project's development. When multiple actors are involved their influences from different viewpoints can further address projects through shared responsibility, thus increasing efficiency (Xu et al 2021). Xu's research highlights the need for multi-disciplinary communication between stakeholders, thus improving the building's energy efficiency. Lack of knowledge and experience, lack of information integrity and non- conformed responsibility have the highest influential impacts on energy efficiency management, and address the need for collaborative and clear communication between the stakeholders.

Communication in the building sector is carried out both in formal and informal situations. Such as documents publicized from meetings as well as verbal conversations. Formal communication is generally preferred since it leaves a trail and prevents misunderstandings, while informal communication generally is faster and more flexible (Alrasheed, Hassaneiah & Alselahi, 2023). Moreover, communication is a topic over the digital line in which “human chemistry” plays an important role between stakeholders (Hoezen et al 2006). The different ways of describing human chemistry were: Lack of trust, a rigid supply side within the hierarchy of stakeholders, and an objective of responsibility. Communication gaps can therefore be addressed in different ways, which can unfold many consequences for a complex property development. Misinterpretations, misunderstandings, and other forms of communication gaps can hinder construction development therefore, it's crucial to address it beforehand and establish inter-disciplinary communication between actors.

2.7 Life cycle assessment

The Brundtland report contributed to the increased focus on the whole lifespan of a building, and methods such as life cycle assessments to analyze buildings' environmental impacts systemically became integrated into the industry (Brundtland, 1987). In the current industry, sustainability is well integrated, with tested standards and procedures. While it still is being expanded and developed, these standards are regulated by national and international laws as well as certifications. In today's society, the concept of sustainability is constantly considered in a wide range of sectors and forces the industry to continuously make considerations (World Green Building Council, 2019).

Life cycle assessment (LCA) is a standardized method for evaluating a component, process, or service's environmental impact (Dhanesh, Balundu, Ravivarman & Padmanaban, 2026). LCA is usually divided into different stages evaluating different phases of the component environmental impact. In the industry, the term "cradle to grave" is widely recognized as assessing the specific component through all its stages from extraction of the raw material, manufacturing, installation, use, disposal, and in some cases even recycling (ISO, 2006a). The aim of an LCA is to facilitate data that recipients later enable decision-makers to make informed decisions about the environmental impact.

LCAs are standardized differently depending on the industry and its purpose. In the building industry, the rules are set by the International Organization for Standardization (ISO, 2006b). They define what aspects of the component should be assessed and how the assessment should be conducted for transparency and re-creation (Finneveden et al, 2009).

To conduct an LCA, several different aspects need to be defined in order to properly evaluate the product. Most importantly, the aim of the LCA needs to be defined in order to define desired results. Thereafter, the functional unit so the properties of the specific component are mentioned. The functional unit serves as a reference unit when comparing different components in LCA calculations. Lastly, the system boundaries need to be specified in order to know what parts of the lifespan are included.

The process is often divided into four different phases: goal, scope, and definitions, inventory analysis, impact assessment and the interpretation phase (ISO, 2006a). The goal and scope phase represents the stage where the aim of the analysis is defined. In the inventory analysis phase, all the environmental impact data from the component is collected. The impact assessment phase is defined by all the data from the previous phase is compiled and allocated into different environmental impact categories that affect the environment differently. Lastly, the interpretation phase is where the data is interpreted and where decisions are made.

Currently LCA is well integrated into the Swedish buildings sector, the current requirement demands that the manufacturing stages (A1-A5) should be documented, named as Climate declaration (Boverket

2024c), and stricter requirements are on their way . LCAs are becoming more central in order to work towards a climate-neutral building sector. Incorporating LCA's in all the life cycle phases of a building facilitates greater transparency and clarifies misunderstandings.

Re-use of materials and products is becoming an increasingly important aspect to consider in the building industry. However, there are still hindrances considering the reuse of materials that will be needed for fire-safety guarantees. The market is yet to establish how this should be integrated and which frameworks to set (McNamee et al. 2024). The study shows that there are two market hindrances that will decrease naturally over time regarding this topic. The barriers can be described as follows: 1st) there is a low supply and demand market for these products, and 2nd) limited knowledge regarding the effects of deterioration in products concerning fire-safety demands. Including a lack of experience of how deterioration of these products affects their life cycle and how these affect the expected life cycle of the worsened products.

The main hindrance to the reuse of materials and products can be deciphered as a number of key factors: hindrance of traceability for products, quality assurance, and a demand for the market (McNamee et al. 2024). Specifically linked to fire-rated products, the main theme can be described as how regulations and requirements affect the ability of a product to reach a market and be integrated into building fire protection.

By reusing products, there is a potential for carbon investment. Previous case studies show that a number of building products have potential to be used for re-use (McNamee et al. 2021)

- Beams and columns made of steel, concrete and glulam
- Prefabricated concrete elements
- Steel truss
- Sandwich elements
- Metal facade cassettes
- Roofing sheets
- Cable ladders
- Ventilation ducts
- Insulation
- Suspended ceilings
- Stairs

Standardized products have a higher potential of re-use, where quality assurance is generic and there are large volumes of these products, such as ventilation canals and their requirements are less comprehensive due to the product's complexity (Ghisellini et al, 2016). There is a large climate investment saving potential with the re-use of materials, however economic factors can downplay the climate cost.

2.8 Energy Use

The building industry makes up for one third of the energy consumption globally, and a quarter of CO_2 emissions, making it a substantial factor for global environmental impacts (González-Torres et al, 2021). Buildings consume energy mainly through heating, cooling, HVAC, and electricity for equipment. HVAC equipment makes up for 38% of a building's energy consumption, indicating that there is a need for re-use and retrofitting (González-Torres et al, 2021).

In Nordic countries the energy use mainly comes from heating due to the cold climate. The envelope's properties thereby have a large impact on the building's energy use (IEA, 2019). The impact of thermal bridges increases when the thermal resistance envelope of a building increases, making the building's thermal properties a keyholder for its energy impact (Berggren 2013). On one hand a well-insulated construction generally reduces the energy-need through reduced transmission and ventilation losses. On the other hand, it also may lead to greater financial strains (Ghisellini et al, 2016).

From an Life Cycle Assessment perspective, the energy use mainly constitutes the B stage, the operation phase (CEN, 2011). This has mainly been the focus when trying to reduce energy demand in buildings, since it's a constant over a building's lifespan. In more recent years more emphasis has been placed on the embodied energy, as in how much energy is needed to obtain the component. The initial environmental cost for the energy use of a building will be decreased in comparison to the annual energy use of heating (Sobolewska et al 2026).

Besides a building's physical properties, the internal aspects also play an important role. The occupancy schedule and the installations such as heat pumps and control systems also play a significant role. Systems such as adequate ventilation with efficient heat recovery have also proved to be crucial in order to reduce energy demand (Mysen, Schild & Mathisen, 2015). Energy demand for buildings can only be estimated through assumptions, calculations, and simulations and is almost always incorrect but can serve as an indicator of how the building will behave, this is commonly referred to as the energy performance gap (de Wilde, 2014). Determining energy use is a complex interaction between a building's internal and external properties. To obtain adequate estimations, informed estimations and detailed calculations have to be conducted.

The building sector is constantly evolving, with new technical advances as well as other complex solutions to mitigate current issues. The new developments are often not strictly limited to their specific disciplines but affect others by introducing new benefits and drawbacks (UNEP, 2020). Misunderstandings, trade-offs and miscommunications can lead to increased annual energy-need, undersized heating systems, thus giving reduced indoor and thermal comfort for the occupants (Berggren 2013).

Emerging technologies in material science can, for example, reduce environmental impact while compromising structural integrity, thereby introducing trade-offs. A concrete example of this is the relationship between environmental sustainability and fire safety, where bio-based materials can reduce the environmental impact whilst posing a fire hazard (Azari-Dodaran & Ahmadi, 2019). These trade-offs, thereby, mean that technical solutions are rarely judged from one individual standpoint. Instead, an overall assessment has to be made in order to get a better understanding of the implications. Evolving technical solutions, thereby, play a large role in the balance between sustainability and fire safety.

Further development in the building industry is the introduction of ventilation systems with heat recovery and PV panels that further reduce the energy consumption of buildings.

While a new implementation of a new system or material may be beneficial from one or more perspectives, it often has its drawbacks. That being one of several increased costs, reduced fire-safety or the introduction of uncertainties due to lack of experience handling it (Zhuang et al 2025) . All of these are factors that have to be taken into consideration when implementing new components, considering the building industry is traditionally conservative.

When implementing building installations such as PV-panels that can greatly reduce a building's environmental impact through renewable energy, other issues arise, such as fire-safety and strains on the structural integrity of the house . Noticeable in the industry is that while it's developing rapidly on some fronts, others may lag behind (ISE, 2018).

The introduction of digital tools to effectively predict a building's energy behavior through complex calculations and simulations,which have had a great impact on the industry. Through detailed models, existing issues can be caught significantly earlier, which can prevent errors (de Wilde, 2014). While also introducing room for error due to its complexity involving assumptions and estimations. Recent technological systems have contributed to increased resilience and reduced environmental impact while still constantly evolving. The optimization can also impact the so-called co-benefits, such as improved indoor air quality, natural lighting, acoustics, etc (Dalla Mora et al 2018).

2.9 Swedish Svanen Certification

A Svanen certification aims to look at a holistic view regarding environmental, climatic, and health aspects (Nordic Swan Ecolabel n.d.). The intent is to have reduced climate contributions within one area that cannot affect another area or part of its life cycle, which would be under the term *"burden shift."* A Svanen certification looks at the following main topics: energy, materials, quality, and waste. There are different points to collect for each parameter, which for a residential building can be collected up to 44 points for version 3.0. Svanen certification version 3.0 holds a total of 14 categories; the points are visible in Table 4 in Appendix E.

3. Methodology

3.1 Case study description

The project was selected since it was deemed an appropriate representation of a Swedish residential building. Furthermore, since the building was recently finalized, it allows access to stakeholders with refreshed memories, enabling accurate results.

Figure 6: Västra Vakten

Västra Väkten was completed in 2025, developed by PEAB, one of Sweden's major property developers. The building was ordered by PEAB Bostadsutveckling Syd, and the main contractor was Peab Bostad, the building is visible in Figure 6 above. The project is developed in the neighborhood Varsstaden, which is part of an industrial area located in Malmö city. The neighborhood is part of an EU initiative of urban regeneration with the aim to create and rebuild the area, with a focus on sustainability (EU Commission n.d.). The ownership of Varvsstaden is managed by two investors. The budget of public spaces is funded by the Malmö municipality, and commercial and residential projects are funded privately by the investor. The building is a nine-story residential building consisting of 96 residential units ranging from 35-102 m^2, with a structural system made of concrete and an ECO-concrete 4.0 developed by PEAB. Furthermore, two commercial spaces are allocated at the ground floor level. The exterior facade is brick and plaster toward the inner courtyard.

The initial building start was in October 2021, however due to the economic market and the pandemic, the project was put on hold. Västra Vakten is partitioned into three blocks: A-block towards the northeast, B-block in the center, and C-block towards the southwest. In April 2022, the project progressed with the addition of a floor in the B-block in the center, along with it.

Västra Vakten is a part of the company's internal long-term goal to produce sustainable buildings. Which in turn means that strict requirements are set on materials and energy efficiency. By default the building is also affected by existing regulations regarding fire safety.

The project aimed for environmental certification Svanen v.3.18 (Nordic Swan Ecolabel n.d.), in accordance with Peab's internal motions. Peab uses the Nordic Swan Ecolabel for their internal projects. The sustainability goals are implemented through their internal design review via follow-up, review, and design meetings during the production phase. The internal design review is an internal process implementation for Peabs projects.

Västra Vakten has recycled materials from the area of Västra Hamnen, which can be historically linked to mural and brick materials from its industrial era. The materials can be found in the groundwork, walking paths, and recycling houses located exterior to the residential building. None of these materials are associated with fire-safety demands, and the project relied on new products to ensure that such demands and regulations were met.

3.2 Interview Methodology

The theoretical framework for this study is based on thematic analysis, which is a foundational way to attend to a qualitative approach for semi-constructed interviews (Braun & Clarke 2008). The answers given from the interviews were recorded and transcribed, in which keywords were noted from the interviews. This was followed by assembling the data and intuitively finding themes based on the interview respondents. An inductive approach was selected for thematic analysis, in which the themes and key words are intuitively approached with no prior base. The output comes from the conducted material, and no prior baseline will be used when identifying and analyzing the expressed themes. An inductive approach is a flexible approach for qualitative data analysis, which emphasizes finding the patterns of the data through analyzing the material.

Key shareholders were interviewed based on their role in the project Västra Vakten, which was found using Dalux. The interviews were semi-structured and conducted individually online or in-person. The questions were based on digital material found from Dalux, with the intent to create an open conversation in which the interviewee leads the direction of the conversation. The aim of the interviews was to get a broad scope from the different stakeholders' perspectives, thus providing a broad range of information related to fire safety, project management, and related conflicts of interest of Västra Vakten, along with the timeline of the project. The interview format was chosen with the intent to create a wide range of answers suitable for different people from the industry and therefore get more information from an independent and intuitive exchange of conversation (Adams, W. 2015).

The interview informants were predominantly connected to Västra Vakten through its building process. They were selected to be covering a range of consultants involved in producing Västra Vakten; see the questions in Appendix D. The following professionals were interviewed:

- Environmental coordinator
- Environmental developer
- Structural engineer

- Architect
- Architectural developer
- Fire consultant
- Project developer
- Project contractor
- Project manager at construction site

Following expertise from Lund Technical University, we were also interviewed, see the questions in Appendix D:

- Professor at LTH, Institution of Fire technology
- Fire consultant & Phd student at LTH

They were both interviewed to get an academic point of view of fire-safety. To deepen the understanding of what the literature says regarding fire-safety. Furthermore, the combination of the fire consultant/Phd student provides an inter-disciplinary perspective since they have experience from both sides of the field.

3.3 Digital information and management system

PEAB's internal digital system, Dalux, is an information and management system, which is a part of the BIM systems and is a tool to streamline projects. Dalux was used continuously throughout the project's construction process.

The data gathered from Dalux was analyzed and quantitatively sorted through to organize and categorize the obtained information. The information was firstly logged and subsequently sorted to support the thematic codes, the matrix, the hierarchy chart, and the process maps.

The information was filtered based on the project's scope and limitations, thus only excluding information corresponding to the limitations of this project. Sensitive information from Dalux was redacted to maintain confidentiality.

Dalux has a documented timeline over the progress of Västra Vakten, in which involved stakeholders continuously document and follow up on the project. The system holds information of the project management, BIM information, and all other information related to the project.

3.4 Thematic codes

To analyze the results from the interviews, codes were made during the thematic analysis, where themes represent recurring subjects noticed throughout the thematic analysis.

The codes were divided into three main categories: Environmental (*ENV*), Decision-making (*DCM*), and Fire-safety (*FS*). Then subcategories to represent the findings from the interviews, visible in Table 2. Each main theme is representative of each discipline's impacts that arose through the interviews.

Table 2: Code definitions

Code		What was stated	Limitations on decision-making
Environmental	ENV-1	Material and products where environmental sustainability is the main argument	When fire-safety is the main reason or financial restrictions are involved
	ENV-2	General sustainability, more specifically resilience, architectural	Decision-making hierarchy
	ENV-3	Environmental certifications	Fire Safety
	ENV-4	Re-use of materials or products	Access constraints of materials and products.
Decision-making	DCM-1	Time, finance and naiveté	Environmental and fire-safety metrics
	DCM-2	Information is distributed in the projects and miscommunications occur.	If no miscommunication were mentioned
	DCM-3	Different trade-offs has to be made that affect the environmental sustainability negatively	If no trade-offs occured
	DCM-4	When different stakeholders' priorities affect associated stakeholders negatively	If no drawbacks were mentioned
Fire-safety	FS-1	When fire-safety requirements constrains and govern	When the decision-making process is in focus
	FS-2	Concrete solutions regarding fire safety affected associated stakeholders.	When no associated stakeholders are affected significantly
	FS-3	Verifications of fire-safety solutions	When no verification were made

The theme is a representative number of the impact of each discipline, in which the codes operate as thematic categories that collect statements with similar implications into one category. Through this thematic analysis the comparison process is alleviated. The codes work as structuring components for the material from the interviews and define what is important and relevant to the thesis. The codes will be an analytical tools to categorize the findings based on themes.

The impact of each category, from the interviews, is based on three subjects:
- *Frequency*, as in how often the theme arises in the interview.
- *Decision-making impact*, to what extent the theme affects the design of the project.
- *Precedence in conflicts of interest*, to what degree the observation is prioritized when it arises in comparison to other matters.

In order to enable sufficient comparison between the findings, the observations were converted into numerical values. The aim of this is to create a structured and transparent comparison that later will be visualized as charts. This analysis only involves the negative aspects mentioned in the interviews, those being limiting factors, problems that arose, or decisions that could create conflicts of interest or trade-offs.

Positive aspects are thereby excluded, with the motivation that the project aims to identify limitations, information gaps and problems that can affect sustainability and fire-safety.

Each observation is appointed a numerical value spanning from 0-10, with higher values indicating a greater impact on the project. It will be supplemented by an analysis for each discipline, relating to the different sub-categories. A value of 0 means that no impact was observed. Values between 1-3 indicate low impact on the project and can be considered neutral. Values between 4-6 indicate a moderate effect on the project. Values between 7-8 indicate high impact on the project. While values between 9-10 indicate great impact.

The different interviews were graded individually and will be presented as such in charts. The charts shall thereby be regarded as visual representations of how much the different identified negative aspects affected the project.

3.5 BPMN

To analyze and visualize the decision-making process, a Business Process Model and Notation map (BPMN) has been made for mapping out the process. The BPMN maps were created based on the information gathered from the interviews and Dalux. Where relevant information was identified.

The BPMN diagrams were created using Camunda. A digital software that is specifically designed for BPMN diagrams and already has BPMN 2.0 standards integrated. It was decided upon to streamline the process and reduce eventual errors. On one hand, BPMN diagrams allow for systematic and transparent visual depictions of the building process. On the other hand, it has to be mentioned that it represents a simplified representation of reality and almost never encapsulates all nuanced aspects of the operations.

The BPMN maps created for Västra Vakten contain the following features:
Pools and lanes, to represent different stakeholders and their areas of expertise.
Activities, to distinguish operations.
Start and finish symbols, to emphasize where in the process the operation is carried out.
Gateways, to depict the decision-making points.
Sequence flows, to describe the order of the stages.
Message flows, illustrate exchanges of information between actors.

The illustrations of the symbols are shown and described in Appendix C (Table 3). Furthermore, several activities were colored red, yellow, and green to signify activities regarding fire-safety, decision-making, and sustainability, respectively.
Several process maps were created, first in order to show the whole process and thereafter to depict every process separately in more detail. The process maps created were the following:

- General, describing the whole building process
- Early design phase, describing the feasibility study and start of the project
- Detailed design phase, describing the detailed design process
- Production phase, describing the construction of the building and eventual changes
- End phase, describing the closing and hand-over of the project

3.6 Identifying and assessing trade-offs

As a part of the project, an evaluating matrix will be conducted, with the aim of identifying potential trade-offs between sustainability measures conducted at Västra Vakten and how fire-safety has interfered with these strategies and considerations. The trade-offs are based on what information has been gathered through interviews, the Nordic Swan Ecolabel points, and Dalux. If the interviews or Dalux has failed to regard a correlation between two topics, it has failed to show the correlation between them.

3.7 Hierarchy chart

As a complement to the risk assessment, a hierarchy chart was constructed in order to make the positions of the different stakeholders more prevalent. The purpose of the chart is to illustrate which stakeholders' interests have the highest priority as well as how their wishes are weighed against each other in practice. The hierarchy chart is used as an analytical tool to determine in what order different priorities are and how they are addressed in eventual conflicts of interest.

The stakeholder with the most significant impact was placed at the top of the chart, and based on the thematic analysis of the interviews, the different stakeholders were placed based on their level of influence. More specifically, what decisions take precedence and how they are connected to the other stakeholders. The stakeholders with the highest level of influence were placed at the top, then gradually going down. Worth mentioning is that level of influence does not necessarily correlate with level of importance, since it's subjective. Instead, it corresponds with the level of precedence in the project, since some metrics are more absolute than others.

The information was gathered from the semi-structured interviews and represents how decision-making is conducted in practice rather than how it's designed by contractual agreements. The chart is used to visualize decision-making structures and pathways, and was produced in Canva (Canva n.d.).

4. Results

4.1 Themes and code words, related to interviews

The inductive thematic analysis identified and named three different main themes, described as *Environmental, Decision-making, and Fire-safety.* Ranking in themes is directly related to decisions and choices regarding the Västra Vakten, and does not take into account general comments from the interviews. Related or general opinions are included in the theme words if relevant to the theme.

The findings resulted in three charts, where each stakeholder has been designated a specific section, and their statements regarding the three previous themes have been visualized as colors and on a scale of 1-10. Each theme has been designated its own figure and color to indicate frequency and distribution.

4.1.1 Environmental

ENV-1 refers to how each discipline treats projects in relation to environmental sustainability and how materials and products are chosen, which is presented in Figure 7. The figure shows numerical grades of the consequences and correlations described within the interviews based on the interviewees answers. Higher values indicate a greater perceived consequence and influence on the project in a negative sense, while lower indicate a milder consequence as well as correlation. The value also correlates with the frequency of how often the theme is stated within the interview. It was observed that the environmental certification sets the conditional aim and becomes the guideline governing the involved contracted disciplines. The environmental aim begins with the ambition of the developer, in this case PEAB Bostad, which holds the Svanen certification as an internal set standard for their own development projects. The provided materials are consequently set by the environmental coordinator in a predefined internal list of approved products adhering to the standards and requirements of the Swan label. Discussions regarding materials and life cycle assessments and their frameworks, embodied emissions of the materials, the performance of the house regarding internal installations, and the potential of recycling and reuse of materials were mentioned.

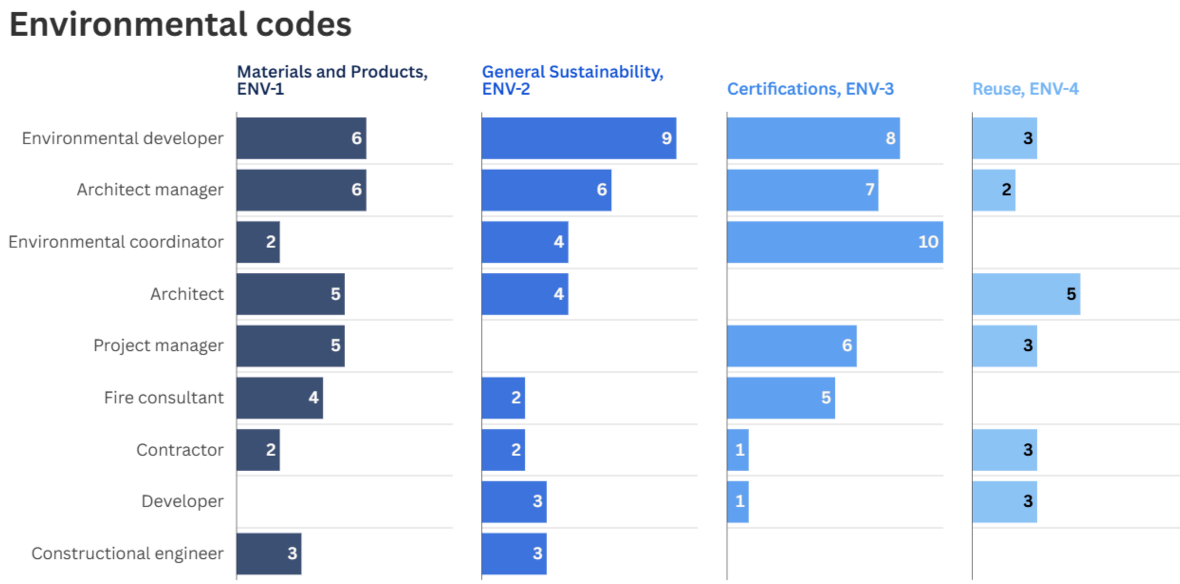

Figure 7: Tables, Environmental codes

The environmental developer's role for Västra Vakten began earlier than the then-planning and production of the project. It was described that the project was the first to include a new version of eco-concrete (ECO-concrete v.4). It was also discussed the re-use of brickwork, since Varvsstaden has a strongly linked identity to brick materials. Re-used bricks were used in complement buildings and in the walkway in the courtyard. However, no part of the building has re-used materials. The reason for this, linked to fire-safety, was that there was no guarantee for fire-safety or linked life cycle assessments of the past purpose of the material, making it a risk to use. This was linked to code ENV-2 and ENV-3.

Resilience in architecture was defined as choosing materials that hold over time, even though making a higher initial environmental footprint (constructional consultant). Architectural sustainability was mainly a task directed for the design of the building, coined as "Bruksarkitektur," translated to "Usage architecture" for residential living. It refers to creating livable spaces that can generate flexible space for the residents.

The architectural coordinator mentioned the use of mortar material being the driving difficulty behind re-using bricks due to being time-consuming and financially heavy factors. The product C-mortar was described as an alternative material to regular mortar, potentially reducing time, due to the preparation of materials based on the product's material composition, however it was not considered for Västra Vakten.

Regarding ENV-3, it was noted that a future framework for re-use of materials can be beneficial in order to recycle more materials for future projects. The main issue noted was that materials lack information of past use and a fire-safety guarantee (structural engineer, architect, and fire consultant). The fire consultant noted that it would need testing of the limited number of products to state a fire-safety guarantee, however this would also be contradicted due to there being a limited number of products to re-use, in theory. The environmental developer stated that a legislated framework for re-use and recycling of materials can give an alternating hindering of re-use, and should be kept in an open context for the developer to set the aim and goal for projects.

The financial gain was a central theme for the ambitious level set for each stakeholder. This was an impact seen throughout all disciplines throughout the interviews. This was the main reason for trade-offs relating to sustainability.

The trade-offs for Västra Vaken that were mentioned during the interviews were the following, relating to code ENV-4:
Direction of doorway in the stairwell. This was due to the accessibility of reaching the push button linked to opening the doors. The decisions breached the fire consultant's trust who reviewed and approved the change.

Change from steel to wood in window construction. The change was made during the production of Västra Vakten, and the architect failed to be announced. The change was made to reduce embodied emissions and reduce environmental impact. The architect emphasized this by stating the following statement “Here we tried, in the commercial spaces, to say that we wanted inward-turned bricks on site. You could ask whether it was worth the effort, considering that the sheet metal ended up being so damn large anyway. And for various reasons that we didn’t have control over, the reveal flashing was supposed to go into the groove of the window frame and stick up so that as little of the brick as possible would be visible."

Change of ventilation duct in connection with elevator shaft. The concrete wall was changed to a lightweight plaster wall. The change was made due to the fact that the construction was difficult to implement. The construction consultant was involved in the change and stated that there was a need for improving the design in order to make it buildable, but that a sufficient solution was reached at the end

Furthermore, a trade-off between a design decision of turning the bricks inwards was pointed out by the architect, where the design wishes from the architect would result in a more aesthetically pleasing solution while on the other hand introducing thermal bridges. Ultimately the suggestion was rejected in order to create an energy-efficient envelope.

4.1.2 Decision-making

The common theme recognized throughout the interviews shows that the decision-making process is a complex system where the financial aspect, influence, and time management have to work effectively in unison in order to reach a desired outcome for the developers' contract, illustrated in Figure 8.

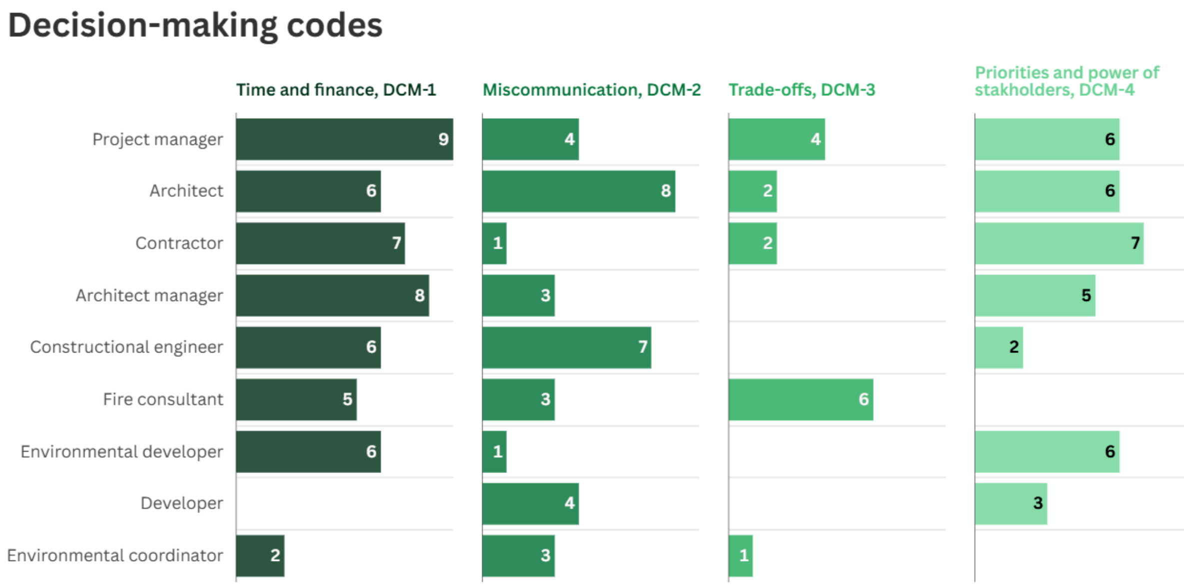

Figure 8: Tables, Decision-making codes

Throughout the interviews time management and financial incentives were described as the underlying driving factors behind a majority of the decisions for Västra Vaktens production, linking it to code DCM-1. Several stakeholders describe how the financial factor is a determining cause for the ambition and aim of the project and thereby what materials and products are selected for use. Decisions that are motivated by environmental-, architectural, or resilient sustainability, or other factors are weighed against their financial cost and thereafter deemed favorable or otherwise. Another recurring theme was experience and a prior working relationship between the different subcontractors. Past experience was an appreciated skill for subcontractors, and a common network was relevant to having gained trust between the disciplines. Trust as a concept demonstrated a higher likelihood of direct, and trusted communication characterized by having pre-established contact prior to the project of Västa Vakten (fire consultant, construction consultant).

Another central aspect in the decision-making process is how information is communicated between involved stakeholders, relating to DCM-2 regarding statements on communication. The interviews described that miscommunications occur when naiveté and stress are introduced into the process. Certain stakeholders described that decisions occasionally are made with incomplete information due to misunderstandings from insufficient communication, for example, in the case of the tambour doors. Often because certain stakeholders gradually get disconnected from the project and not documented decisions made through communication channels such as verbal or written communication. This can in turn lead to delays and increase the environmental impact of the project since work-arounds and late-stage modifications have to be made in order to meet existing demands and requirements.

Code DCM-3 relates to the information gathered from the interviews, which shows that the process comprises a lot of trade-offs between different stakeholders. Where different stakeholders' priorities take precedence over others due to their significance in hierarchy and if their aspirations are backed by regulations. In several of these trade-offs the environmental aspect has to be sidelined. That being in cases when materials don't meet set standards or the financial burden is too immense. Each stakeholder's decision affects the others, and it became evident that a significant portion of the involved actors focus on their discipline and rarely work together. As an example, the structural engineer rarely worked with the environmental coordinator, even though their decisions affect each other indirectly. It was stated that when these decisions are made in the late stages of the building process, the possibility for high-quality adjustments is limited, and involving all stakeholders as early as possible generally results in the best outcome, although at higher costs.

Furthermore, the different stakeholders' focus, aims and considerations affect the outcome of the project, linked to DCM-4. The architect focuses on the design and accessibility of the building. During the system design phase, the architect is responsible for managing and integrating the other subcontractors decisions into the official construction documents. However, the fire-safety consultant still has precedence over the design outlet from this. This turn affects the project when different priorities take precedence over others. An example of this from the interviews was when the site managers decided to switch the position of the tambour door without the architect's knowledge, which resulted in accessibility issues. This was done in order to provide a sufficient escape route for occupants in the event of an eventual fire.

4.1.3 Fire-safety

The interviews show that fire-safety serves as a clear regulatory aspect of the project. The fire-safety consultant described that he mostly works in a passive manner to ensure that set requirements are met. That being through design recommendations, calculations, and demands through digital documents, this is backed by simulations, radiation calculations as the analytical dimensioning required by the Boverket. This was emphasized by the fire-safety consultant by explicitly stating that they never prescribe how to conduct a task and that the same issue may have several different solutions. Contrary to the analyzed material, all the stakeholders stated that the fire-safety consultant is involved early in the project (design briefing) and wouldn't desire an earlier entrance into the project. This is highlighted in Figure 9, relating to the theme of fire safety.

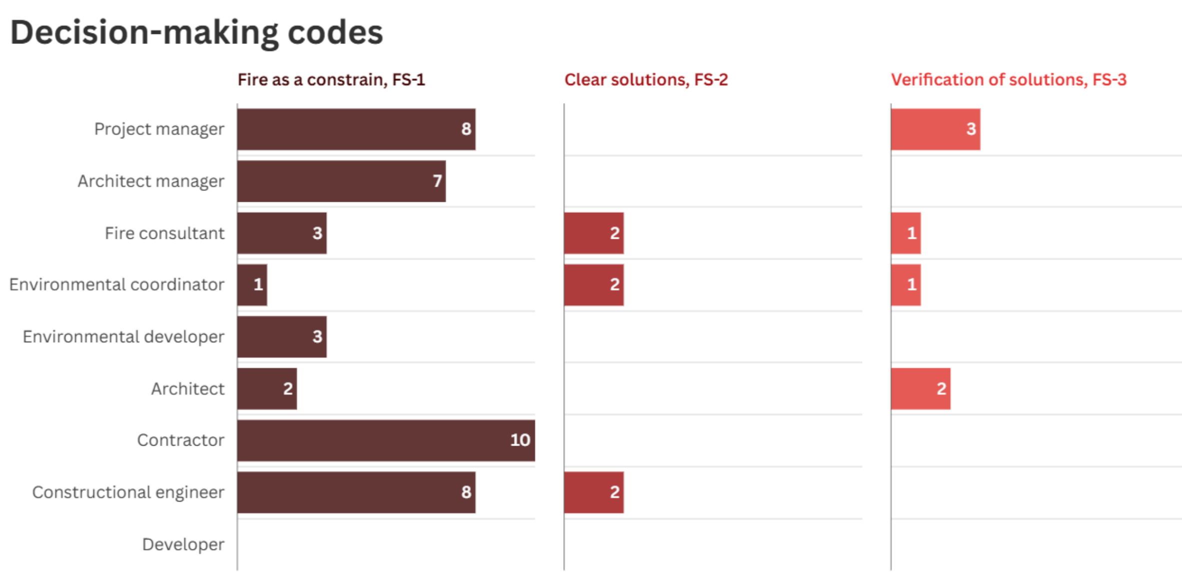

Figure 9: Tables, Fire-safety codes

Throughout the interviews it was stated that the fire-safety aspects of the project are governed by the regulations set by BBR and are non-negotiable, as described in FS-1. Several stakeholders describe the fire-safety consultant's demands as absolute and rarely side-stepped due to the cost of the services from the consultant, and that responsibility would then fall on them. The architect emphasized this by stating that even though accessibility and sustainability are also regulatory requirements, fire-safety requirements generally take precedence.

Västra Vakten has the fire-safety class of BR1 and a function classification of 2A and 2B. Two measures were designed through analytical dimensioning: one radiation calculation from the recycling building and one verification linked to window openings with 1.2 meters of distance between them in the facade. The building was described as an ordinary residential building, with no qualities out of the ordinary. The interviews also show that fire-safety takes priority before other metrics since it's a hard requirement needed in order to allow occupants to move in. Examples stated in the interviews were that changes to the floor plan and design are rarely made if they compromise the fire-safety in any significant manner.

The fire-safety consultant is described as having a supportive role to the remaining disciplines and helps with, for example, selection of material, and ensuring proper escape routes. At the same time their role is emphasized as assisting, and each subcontractor is responsible for their own technical solutions.
Once the construction phase begins, the fire-safety consultant's role transitions into a supervisory function, by visiting the site regularly throughout the construction phase for control checks and advisory assistance to other stakeholders, linking it to code FS-2

The materials used in the project are affected by the fire-safety requirements to a certain extent, but not necessarily by what specific materials they use, only that they fulfill the requirements related to code FS-3. This can in practice mean that the materials would need additional chemical treatments, which sometimes add a lot of embodied carbon to the product. The building industry generally adheres to standardized, commonly used solutions, and in terms of fire-safety this means materials are rarely adapted to fit set requirements. Instead, they tend to use already existing, tested solutions in order to counter problems. The interviews emphasize that fire-safety consultants mostly affect projects in a passive manner, meaning that in general they affect the nonvisible aspects such as dimensioning, surface finish, and ventilation.

4.2 Svanen certification and energy-saving measures

The Svanen Nordic certification contributed to governing the project towards the implementation of energy-efficient solutions as well as the usage of environmentally sustainable materials. One of the main focuses was to reduce the energy use of the operative stage. This in turn meant that several different disciplines had to work structurally together in terms of verifying products, documentation solutions, and adhering to the certifications requirements. The effort incorporated continuous follow-up in regard to selected materials and installations where each respective discipline had to ensure that they followed set requirements according to the Nordic Swan Ecolabel points.

Several measures incorporated installations of energy-efficient systems as well as the use of renewable energy sources, such as PV panels, and energy-efficient kitchenware. Which contributed to earning points from the certification system, visible in Table 5 in the Appendix E. These solutions contributed to the project's overall energy performance, as well as introducing aspects in need of attention to detail in regard to fire-safety to reduce eventual trade-offs, such as ensuring that the PV-panels did not contribute with a fire-safety risk.

Furthermore, the certification set requirements on the types of materials allowed for usage in the project, which contributed to increased demands on the control process. This affected the work process by creating additional steps in the design and production processes, where deviations had to be identified and handled continuously.

4.3 BPMN

To create a structured picture of how the decision-making process of Västra Vakten was in relation to sustainability and fire-safety, five process maps in the form of BPMNs were created. The models are based on the information gathered from the involved stakeholders as well as existing documentation from PEAB's internal interface, Dalux. The process models show important activities as well as when they take place.

One general process map was created, including a general oversight of the projects timeline. Secondly, a map overviewing the detailed design phase, for the early design, one for the production phase, and one for the end stage of the project. The general and end-stage process maps are illustrated in Appendix B, Figures 14 & 18. The results focus on design- and production maps since they have the most significant impact on the decision-making process, as visible in Figures 15, 16 & 17 in the Appendix.

The process map regarding the design phase describes how the project developed from an initial idea where the feasibility of the project was assessed to system documentation and later a received building permit. The process began with stating the ambitions for the project, including the sustainability goals connected to the environmental certification as well as the energy performance of the building, in line with the requirements of Boverket's energy declaration. At the same time financial calculations were carried out in order to determine the project's viability. In the case of Västra Vakten, these calculations led to changes in the layout in terms of living area in relation to building area as well as the adding of an additional floor in order to make the building more financially profitable.

After the general guidelines for the building were set, the design phase of the project started, where early architectural drawings, structural design, and fire-safety strategies were introduced. The architects were mainly responsible for the layout and coordination between involved stakeholders. While the structural engineers mainly were concerned with the structural integrity of the building. At the same time as these were carried out, the fire-safety consultant analyzed the early design and came up with specific requirements for the building in the form of passive documents describing the required fire-safety class for components. During this process environmental requirements were integrated into the project, mainly in the form of assessing what points the building was eligible to take from the environmental certification as well as adhering to existing requirements from BBR. This process was mainly carried out by the environmental coordinators through proper documentation and meetings. When the design had reached a sufficiently detailed level, it was compiled into system documentation that was later the foundation for receiving the eventual building permit.

As for the production phase of the building, it described how the building was realized in the form of start meetings, proper inspection, and prevalent problems encountered within the production phase. In Västra Vakten's case, there were changes to the window constructions, elevator shaft, and the positions of the doors. The production process began with the project leader establishing an organizational structure to create proper coordination within the production. This was done with building- and coordination meetings that were carried out continuously throughout the process but are visualized as single events in the process maps due to limitations of the BPMN system.

Simultaneously as the production of Västra Vakten was carried out, several types of controls were carried out to ensure proper execution of the design specification. For Västra Vakten no trade-offs directly linked or correlating to the environmental and sustainable performance, aims and strategies were found within these inspections, nor any conflicts relating to the fire-safety aspect of the building.

The process maps make up a broad summarization of how the decision-making process was carried out within the making of Västra Vakten. Although it needs to be stated that not all of the events project were included, since it was deemed too excessive and would reduce the readability of the process maps.

4.4 Sustainable trade-offs at Västra Vakten

The matrix is presented in Appendix F, which illustrates the relationship between sustainability measures and fire-safety strategies from the project Västra Vakten. The results are collected from the conducted interviews, fire documentation, and findings from Dalux, along with the collected points and strategies from the Svanen Nordic Ecolabel.

A white color indicates no correlation between sustainable measures and energy performance strategies, and fire-safety. Green marks indicate that there is a correlation between the categories, however a trade-off was not discovered, i.e., the established fire cells are not limited to the design of “factor in," meaning that marginals won’t affect the fire cells' borders, which is shown in the matrix (Figure 10). Yellow marks indicate a moderate trade-off, and red marks indicate a big trade-off.

Sustainability has been coded into three main themes: environmental, architectural, and resilience, in regards to mapping out the trade-offs that have been made to fire-safe choices. The sustainability codes were divided into three sub-categories, further relating to findings in Dalux and the interviews to grasp the different aspects of the sustainability scope. Noticeable findings from Dalux, the interviews, and the points scored from the Svanen certification are marked on the x-axis. Blue color indicating it’s a finding from the interviews, beige from Dalux, and green from the Nordic Svan Ecolabel. It ranges from components, i.e., PV panels, to physical attributes, i.e., roof ridge detail.

Fire strategies and considerations are illustrated on the y-axis, based on the academic interviews from LTH with the different measures listed from the fire documentation from the project. Measures marked with a blue color indicate that it was a change or alteration of Västra Vakten.

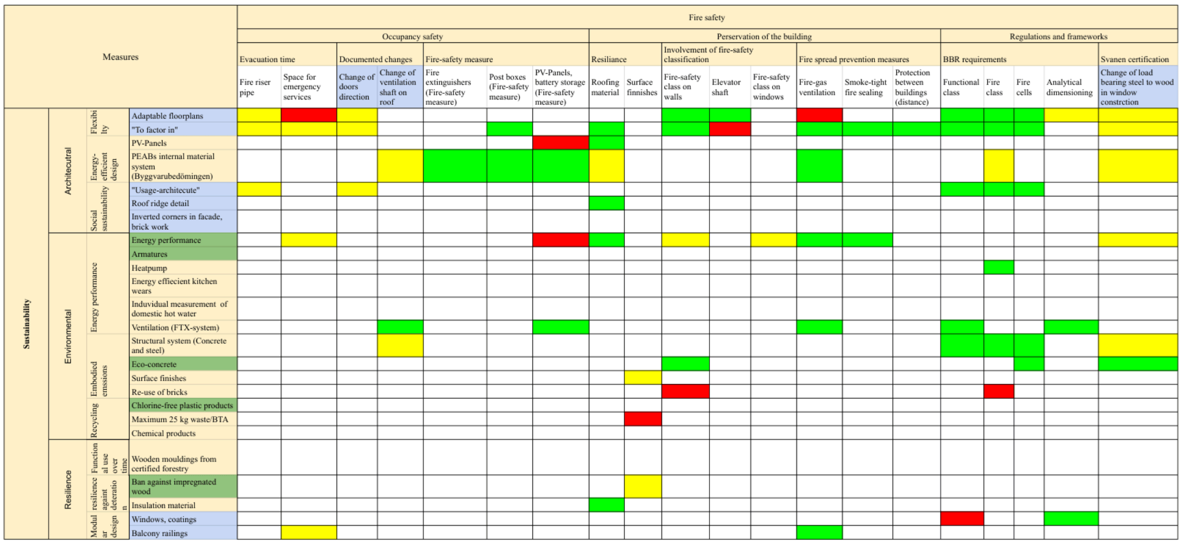

Figure 10: Trade-offs sustainability and fire-safety matrix

4.5 Hierarchy chart

The pyramid chart (Figure 11) illustrates the subject and its connected disciplines in relation to which holds heavier influence. It shows the decision-making power in the project and highlights which stakeholders' influence takes precedence over others. With the stakeholder with the most power located at the top and the least power located at the bottom, further, the organizations marked in yellow show external influences affecting the decision-making power. The project's developer and contractor have an essential role for the development of Västra Vakten and are therefore placed at the top, indicating that a large portion of the sustainability decisions are governed by these stakeholders. The developer is the initiative starter and is in close contact with the contractor since these are two subsidiary companies. Furthermore, the fire-safety consultant and structural engineer are placed second due to having high impacts on the development of Västra Vakten, in which their decisions take precedence, according to the interviews conducted. Their requirements are absolute and have a strong impact on occupant safety. The environmental coordinator makes the decisions to verify the Svanen certification and environmental goals for Västra Vakten regarding the choice of materials and aims for sustainable goals but does not hold primary decision-making authority. The subcontractor of installations and the architect are placed on the same level as the environmental coordinator since their decision-making influences are on a similar level and their decisions are dependent on higher-ranking stakeholders. The site manager has operational responsibility and thus has to adhere to the other stakeholders' demands in order to fulfill the function. The chart thus replicates the degree of decision-making power rather than the stakeholders' significance to the project, rather than overall importance of each stakeholder to the project.

The project is also a part of Varvstaden, initiated by the Malmö municipality, which also holds the right of overrule of the ground sold to the developer, along with it being a part of an EU commission project. The underlying discipline will be the Boverket along with its rules and regulations of Swedish law.

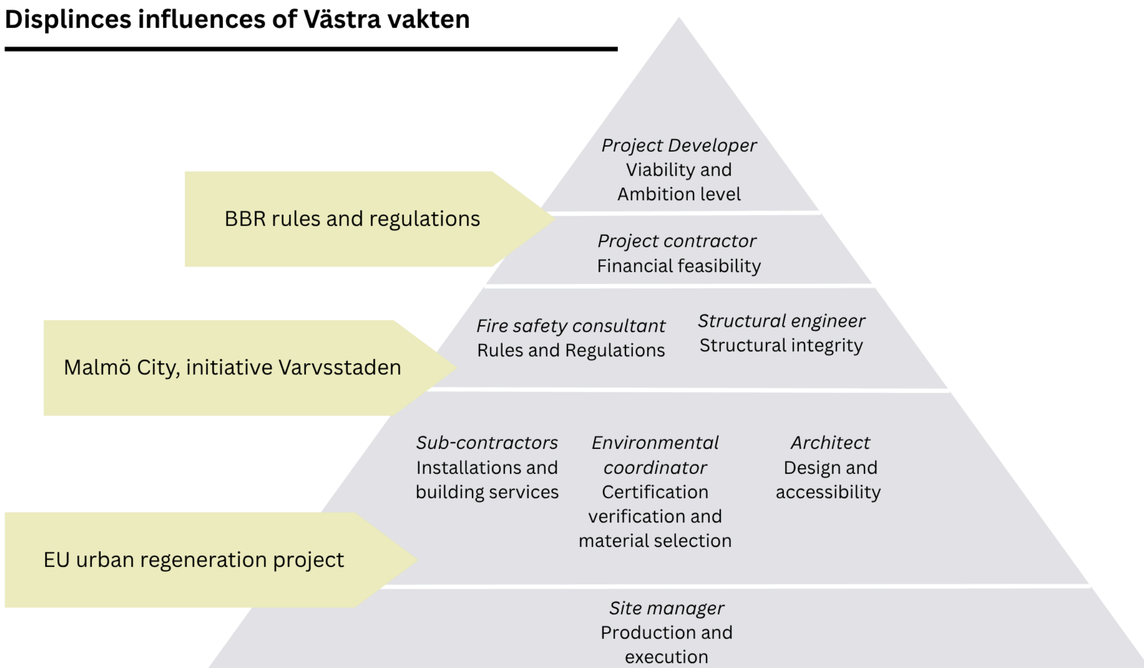

Figure 11: Hierarchy chart of decision-making process

4.6 Dalux

4.6.1 Environment

The environmental goals and aim for the project were defined in the company's environmental design document. This is where the aims for energy performance, requirements on materials and documentation, as well as the intended environmental certification were established, forming the basis for the project´s environmental performance. The document stated that their ambition was to comply with Svanen's energy performance requirements.

The energy performance of the building was simulated with IDA ICE 4.8, where an IFC model representing the building was constructed and several design solutions were implemented in order to achieve sufficient results. The company used climate data from Malmö and occupant data from BEN 3, which indicates that the model was simulated under standard conditions. Although the report emphasizes uncertainties relating to cold bridges, internal loads, and occupant schedules, which may influence the reliability of the environmental performance assessment. Therefore, certain additional margins were added to the results for good measure.

The results from the energy simulation for Västra Vakten show that the primary energy for the buildings is 57.5 kWh/m,^{2} which means that it's 17.4 kWh/m^2 and 9.9 kWh/m^2 lower than the BBR and Svanen requirements, respectively.

When conducting the simulation, a geographical adjustment factor was implemented for Malmö (0.8), which was implemented based on the BBR requirement. The adjustment factor accounts for the climate differences between northern and southern parts of Sweden, which in turn makes the requirement a bit stricter in Malmö. Furthermore, a safety margin factor of 5% and a primary energy factor were used to differentiate between electricity (1.8) and district heating (0.7) to show that installations using electricity affect the primary energy more than the ones using district heating. Additionally, a 25% margin was added to account for cold bridges.

The envelope had an average U-value of 0.4 W/mK. To reach this, additional insulation had to be added in order to achieve sufficient heat transfer. The additional insulation results in larger embodied emissions as well as more transportation emissions. While on the other hand, reducing energy consumption continuously throughout a building's lifespan, illustrating a trade-off between short-term and long-term sustainability.

The FTX ventilation system installed in the building has a reported heat recovery of 83%. This reduces the required need for additional energy needing to be supplied to the building, while on the other hand it increases the complexity and initial cost, highlighting a balance between performance and environmental impact. The specific fan power (SFP) was reported as 1.5 kW/m/s this affects the efficiency of the system.

The tap water use accounts for a substantial portion of the total energy consumption, approximately 22.5 kWh/m^2. Therefore, fittings with the classification of A were implemented in order to reduce the energy consumption by approximately 10%.

Internal loads such as electrical lights and appliance electricity were based on the recommendations from BEN 3.0. Although their report emphasizes a need for measurements in order to detect eventual deviations. The environmental design and energy simulation show how the project worked systematically towards being more environmentally friendly. However, the findings indicate that thse measures were largely driven by certification requirements rather than by broader environmental ambitions.. By first setting goals, then gradually working towards them in a structured manner

4.6.2 Decision-making

The project's decision-making process has primarily been conducted through PEAB's internal communication software, Dalux, as well as through meetings in person and e-mail and phone when needed. Through analysis of the available material, it's evident that Dalux is regarded as a user-friendly interface, functional for a majority of the stakeholders, although it was introduced relatively late into the market and has a slight learning process. The interface was described as seamless, even though improvements could be made relating to assessment of the material.

The interface is structured in a way that makes it easy to distinguish between whether measures has been addressed or if they're still in progress, supporting structured decision-making. This shows that the decision-making process is thoroughly structured in the system and connected to documented status changes.

It's stated by several stakeholders that the software is in need of improvements. For example, it's stated that it can't differentiate between spaces in a Revit model, which complicates the creation of remarks in the system. The system's technical structure, therefore, makes it more challenging to document issues, which may increase the possibility for miscommunication. It was suggested by one stakeholder to implement the creation of zones and alternative object definition in order to improve the software and reduce misunderstandings.

From the meeting notes it appears that timely delivery was a big issue from the subcontractors. It was stated to cause issues relating to time management and cost consequences and introduce stress. Delays in the schedule and redesigns could give rise to improper resource management and, thereby increased environmental impact.

Within the available material, several technical redesigns are mentioned. For example, the fire-safety zones were changed, and the thickness of the wall was changed in the production phase. These alterations have a direct impact on the amount of material needed and, thereby, indirectly, on the environmental aspect of the building. Furthermore, collisions between HVAC and plumbing are mentioned as an issue in need of coordination, which may lead to higher energy use and reduced system efficiency. Inadequate solutions within this discipline may give rise to higher pressure losses and re-dimensioning of the system, which could give rise to higher electricity use.

Statements regarding alterations in the envelope's structure and if they would affect the results from the energy simulations indicate that there is a need for additional communication between the involved stakeholders. There are also comments in the system regarding the mismanagement of waste and materials through the project, which negatively affects environmental outcomes. Statements regarding re-use of bricks and wood pallets state that improvements need to be made regarding recycling. The statements describe how operative decisions affect the project. Waste management is connected to both resource management and the requirements from the environmental certification. Poor management may in turn result in materials not being re-used to the extent planned for.

It was stated that the decision-making process was perceived as more efficient when a representative from the development team was present. Dalux is used as a documentation and distribution tool, which means that the technical deviations and related requirements are present in the software. The system's functions both limit and enable proper information distribution.

4.6.3 Fire-safety

The aspects regarding fire safety are mainly described in the Fire-safety description (Brandskyddsbeskrivning Västra Vakten 2022-02-20) and other documents describing the individual measures in detail. The building has the fire-safety classification BR1 building, which means that it has the highest fire-safety rating in BBR. The classification entails that the building has high requirements on structural integrity during eventual fires, limitation of the spread of fire, and ensuring safe escape routes for occupants, which strongly affects the building's design.

In the document the function classifications of the different spaces are illustrated. That being VK 2A is two rooms on the entrance floor, which entails that the occupants are expected to be awake while also being able to escape on their own accord, although they do not know the layout of the building. The apartments have a function class of VK 3A, which means that they are expected to be asleep some of the time with good knowledge of space and to be able to escape on their own accord. The basement has the classification VK 1, which means that occupants are expected to be awake with good knowledge of the space while also being able to escape on their own accord. Although the function classes ensure occupant safety, they may in turn limit the architect's possibility to design the floor plan for flexibility.

The fire-safety requirements are mainly passive and refer to the existing BBR requirements, while still verifying that the solutions adhere to the regulations through analytical dimensioning. The fire-safety description has a fire-resistance class of R90, R60, R30, R15 and R0. This entails that the building shall maintain its function for that specific amount of time in minutes. The building is designed with a concrete structural system which doesn't burn easily, so it's not directly affected by the resistance class. However, the adjoining components may be affected, which can in turn lead to increased material volume, while on the other hand improving the building's resilience.

The documents also show the fire compartment zones in the building and the classification. Their specific classification entails different kinds of requirements that the walls, intermediate floors, and seals need to adhere to. The requirements also affect the installations present in the building. This affects the dimensioning of the building and may lead to a greater environmental impact.

Furthermore, the document states requirements on the fire-safety classification on the surface finish on certain spaces. Which limits the type of materials available for the project and the architects' design options and flexibility. Moreover, the documents also set requirements on distances of escape routes, sprinkler systems, and smoke ventilation.

The fire-safety requirements include how the building design is affected by the fire-safety precautions and indirectly how they affect the sustainability aspects. It's evident that fire-safety plays a substantial part into how a residential building is constructed. Although in general through passive regulatory descriptions rather than strict demands on what specific components should be used.

4.7 Interviews with academics

Two interviews were conducted with academics within the fire-safety department of LTH, with one professor and one Phd student/fire-safety consultant. The interviews contributed with a research perspective, with a focus on material selections, the decision-making process and eventual conflicts of interest. The respondents represent the research perspective of the building industry, the Phd student also provides a bridge between the industry and the research worlds due to having 20 years of experience in the field.

A recurring theme from both of the interviews was that fire-safety is treated as a specialized expert area within the building sector. Meaning that in the industry it's common knowledge that fire-safety design requires a specialist. At the same time this entails that connecting stakeholders has a limited amount of knowledge of fire-safety regulations in some sense relies on the fire-safety consultants guidance. This leads to fire-safety regulations being treated as a separate issue in the design phase rather than being fully integrated.

Several statements indicate that the point in time when the fire-safety consultant is integrated into the process greatly affects the outcome of the results and can mitigate eventual trade-offs. Through the interviews it became apparent that fire-safety dimensioning began first after central design decisions regarding the building's shape, material choices and technical systems were made. Furthermore, it was mentioned that the fire-safety consultants room for leeway was affected. Which in turn means that fire-safety design in practice is carried out in relation to already established solutions. The fire-safety professor stated the following to emphasize it “but one of the things that I believe affects fire safety most negatively is that fire safety, or fire safety dimensioning, is introduced when a lot has already been decided. As a result, there is not much room for maneuver for the fire safety design. So it becomes a very limiting factor.”

Material choices was identified as an area of where trade-offs between fire-safety design and sustainability may occur. Biobased materials such as structural systems of wood or biobased insulation material were mentioned as areas of concern. Due to their risk of being flammable, it was also mentioned that it may be hard to verify if they can withstand fire long term and that insurance companies generally keep that in mind which may be the cause of eventual trade-offs. From a sustainability standpoint it was mentioned that building like these generally may be more sustainable from a short-term perspective but not always from a long-term one. The interviews also mentioned that fire-safety design needs to be regarded more as a system rather than by each specific component in order to ensure sufficient results.

Furthermore, the interviewees mentioned that fire-safety design has limited consideration in regards to LCA and climate declaration and the same goes vice versa. Fire-safety measures are often regarded as material and installation costs in the climate calculation. Instead of viewing it as measures that could save the building from eventual damages and minimizing restoration thus improving its resilience.

In relation to re-use of specific materials for fire protection, the interviewees mentioned that it is relatively difficult since a lot of verification methods includes destroying the materials. Furthermore there is often a lack of documentation that can guarantee that the products fulfill existing fire-safety regulations and the possibility of connecting the building properties to Building information models (BIM) was suggested as one way of combating this issue.

Together the interviews shows that the relationship between fire-safety and sustainability in the building industry is extensive and characterized by trade-offs in available materials, implementation of technical systems and a variety of compromises, which Figure 12 is an illustration of.

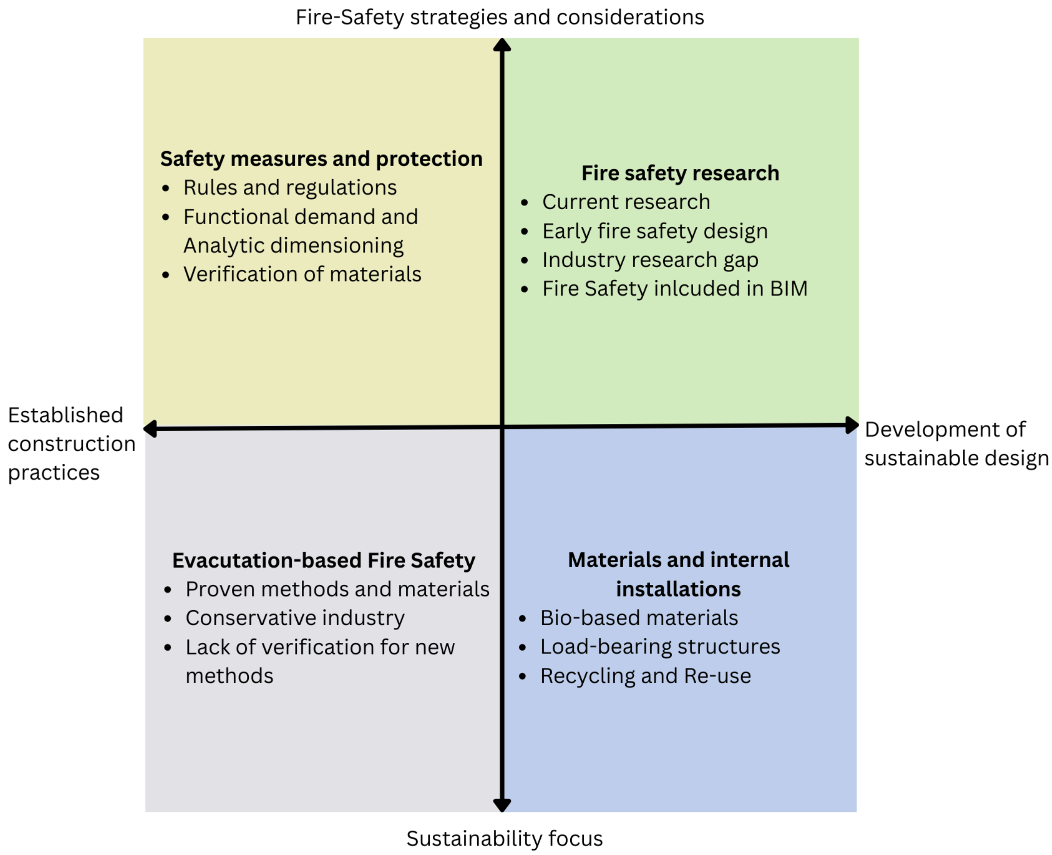

Figure 12: Interview with academics

5. Discussion

5.1 Sustainability in the design and construction process of Västra Vakten

The results from this study indicate that sustainability to a great extent is driven by the developer, often through specific goals such as environmental certifications, climate declarations assessing the building´s carbon emission and internal guidelines.-Sustainability generally is more flexible and correlates with ambition level, where the level differs between projects.This suggests that sustainability implementation is highly dependent on priorities of the developer.

For Västra Vakten, it was stated that the sustainability effort is largely guided by the Svanen certification. This system operates as a framework for how sustainability measures should be implemented and followed up throughout the project, whose sustainability goals and its process started early on for Västra Vakten, Figure 15. By breaking down the general requirements into concrete solutions such as material choices and chemical content, the process becomes structured. However, this also risks to limiting sustainability efforts to predefined certification frameworks.

A central stakeholder in the project was the environmental coordinator, whose role was to ensure that the project would fulfill the established sustainability goals. The interviews showed that the environmental coordinator worked as a mitigator between the different stakeholders and was responsible for documentation, adhering to regulations and communicating them to the other stakeholders but was not a decision maker. This indicates that environmental coordination functioned more as guidance than governance.

5.1.1 Financial incentives and its outfall on sustainability

At the same time the results suggest that sustainability goals not only are affected by the system but also financial incentives. Several interviewees describe how material choices and technical solutions are balanced with cost accessibility and practicality. This highlights how financial feasibility strongly influences sustainable implementations. This can mean that sustainability ambitions are adjusted and reprioritized, especially if it means that it has a higher financial cost. In the case of Västra Vakten, this was done in the cases of the balcony railing and the reuse of the bricks.

The interviews indicate that the environmental certification and the climate declaration are implemented in order to fulfill requirements from governing authorities or to enable the project rather than to achieve maximum environmental sustainability, although environmental certifications themselves are voluntary. This in some cases means that the stakeholders choose the points from the environmental certifications that are the most cost-efficient rather than the ones that contribute the most to a sustainable building. Even the environmental declarations are largely conducted in order to fulfill existing requirements rather than used as an active tool in the design phase. Sustainability tends to have the risk of being reduced into a parameter within the financial picture of the project. This reflects the asymmetrical regulatory structure between sustainability and occupant safety.

In relation to fire-safety this dynamic becomes especially evident, since fire-safety requirements are non-negotiable. This reflects the asymmetrical regulatory structure between sustainability and occupant safety. When fire-safety is an aspect that is never side-stepped, sustainability to a large extent has its trade-offs. This in turn means that sustainability goals in some situations are adjusted to the technical limitations set by the fire-safety design, although in Västra Vakten there were none. For example, materials that are advantageous from an environmental perspective sometimes need to be complemented or even replaced in order to fulfill fire-safety requirements.

Furthermore, the results show that sustainability efforts often are integrated early in the project, which may contribute to less reduced conflict in the later stages of the project. The developer plays a crucial role by defining the project ambition level already within the feasibility study. The interviews showed that decisions regarding, for example, environmental certification, project strategies, and other important decisions often are made before the design phase. Which gives the project a clear direction and enables the involved stakeholders to make appropriate decisions.

Even though the results indicate that sustainability issues sometimes are treated as isolated issues in contrast to fire-safety design. Several interviewees describe how different stakeholders mostly consider their own responsibilities. This may limit holistic decision-making during the design process. For example, the environmental coordinator rarely is in contact with the structural engineers or the fire-safety consultant, which can limit the possibility of interdisciplinary solutions. This can mean that potential solutions between all involved parties are overlooked or not utilized to their fullest potential.

5.1.2 Sustainable measures in Dalux

Another aspect that is evident from the interviews as well as Dalux is that sustainability generally is interpreted differently between the different stakeholders. While some are mostly concerned with reduced emissions, such as the environmental coordinator, others are more concerned with the resilience and architectural aspects, in Västra Vakten's case, being the architect. The resilience aspect can in some cases be connected to the fire consultant's efforts as well, that being mitigating damages of an eventual fire.

A building that fulfills the fire-safety regulations will have better resilience, that being a kind of sustainability. At the same time, additional technical installations and material use mean higher environmental impact, which indicates that there is a complex balance between the viewpoints.

The results showed that sustainability is handled through a combination of early decision and continuous monitoring throughout the process. In relation to fire-safety this in practice means that sustainability often needs to be adjusted to the demands of fire-safety requirements but that there is potential to integrate the two. In order to facilitate this, an interdisciplinary dialog needs to be held continuously throughout the project, where all interests are integrated together rather than separately. This demonstrates how parallel workflows may reduce opportunities for interdisciplinary collaboration.

5.2 Fire-safety requirements in decision-making

Fire-safety has been a central role in the decision-making process of Västra Vakten and works as a regulatory framework in which the remaining design needs to adhere to. The results from the interviews show that fire-safety design is integrated as a combination of technical guidelines, regulatory requirements and experts assessment. The BPMN map (Figure 15) illustrates fire-safety being integrated at the design phase, accounted for early in the process. This in turn means that fire-safety design is treated as a rudimental requirement within a project rather than something that needs to be optimized together with other design and sustainability goals.This may limit interdisciplinary optimization during the design process.

A central aspect of fire-safety design is the consultants' part in the organization. The interviews emphasized that the fire-safety consultants worked in a passive manner, contributing with documents containing requirements and rarely specific solutions. This creates flexibility although it may reduce opportunities for integrated sustainability strategies. Which could limit the integration of sustainable solutions, since detailed design could promote sustainable options being implemented to a greater extent. The fire-safety consultant's main task is to define the rules that the project needs to adhere to, verifying fire-safety class, etc. The fire-safety consultant described how several different solutions could fulfill the same requirement, although the choice is often made by another stakeholder and that the financial and technical aspects play a big part. This highlights how fire-safety solutions are influenced by more than purely regulatory considerations.

Several interviewees describe how they largely rely on the fire-safety consultants expertise in order to adhere to rules and regulations, although they still have an appropriate understanding themself. On one hand, this may promote efficiency in the project, although on the other hand, it may entail that fire-safety design is treated as an isolated subject within the design phase, while it could be connected to the sustainability and architectural aspects simultaneously.

In regard to sustainability, this correlation becomes especially relevant. Sustainability in the construction industry mainly incorporates the aspect of minimizing the building's environmental impact through material selections, resource efficiency, and energy efficiency (Uddin et al, 2025). The interviews stated that these aims and requirements were introduced as environmental certifications or climate goals by the developer in this project. At the same time, these ambitions need to be implemented within the technical and regulatory aspects of the project in regards to fire-safety. In practice, may lead to trade-offs where environmentally beneficial materials require additional technical modifications to comply with fire-safety requirements. One example stated in the interviews was how some materials with low environmental impact needed additional alterations in order to comply with standards. In practice, this meant that they needed to be treated with chemicals to be fire-resistant. Which introduced a sort of trade-off within the project, as seen in Figure 19, Appendix F, with chemical substances, since the chemicals themselves have an environmental impact. This demonstrates how technical compliance measures may introduce secondary environmental consequences.

This means that due to regulations fire-safety design and energy use often are prioritized before other project requirements, since they are a requirement in order to allow occupants to move in and obtain a building permit. Although it means that sustainability goals sometimes need to be side-stepped.

Occupational safety, such as fire-safety and structural integrity, takes precedence over, for example, architectural and environmental qualities. Although at the same time the interviews show that there are more than just trade-offs between fire-safety and sustainability and that they sometimes contribute with an improved fire-safety classification, in Västra Vakten's case being the ECO-concrete, that didn't need any additional treatments. In these cases fire-safety design may even promote innovation in order to comply with demands.This indicates that fire-safety and sustainability are not exclusively conflicting objectives.

Another important aspect of fire-safety design is the connection to when the fire-safety consultant enters the project., as is in the early design planning phase. Contrary to existing research all interviewees stated that the fire-safety consultant enters the project early and that there is no need for earlier entrance. With the Phd/Fire-safety consultants adding that it has gradually gotten better with time and although it depends on the specific construction company. The fire-safety consultant was stated to be included already in the program documentation, with regulatory guidelines and remained in the project doing detailed technical suggestions and design and inspection.

From a sustainability perspective this has an especially big impact, since a majority of the big decisions are made in the early design phase (EU, 2026). If fire-safety and sustainability issues are treated separately, a potential risk for conflicts of interest is evident, especially since the interviews indicated that the involved stakeholders rarely interacted due to working in parallel processes.

The results indicate that fire-safety regulations mainly guide the project in an advisory manner. However, it affects the project's sustainability aspects indirectly by demanding alterations and additional resources. The interviews show that good communication in the early stages of a project reduces the chances for eventual trade-offs.

5.3 Stakeholders influence in the design phase

Västra Vakten involved several different disciplines through its design process, which meant that several different perspectives, including sustainability and fire-safety, needed to be coordinated. Most disciplines that were interviewed were part of the design phase, except the project manager that is required on-site. The preliminary study sets the initial sustainability goals and aspirations regarding the design outlet of Västra Vakten, which is also regulated through Malmö municipality's detailed plan of Varvsstaden. However, the project developer (Peab Bostad) will determine the feasibility of the project in the early stages before major design decisions are made, which is a key point for determining the sustainability ambition of the project. This indicates that sustainability ambitions are strongly dependent on early-stage financial decisions. Västra Vakten did have a major alteration before the main engineering design phase began, with the addition of another floor. This decision was led by the developer to make the project financially feasible. This demonstrates how economic considerations may outweigh sustainability ambitions during early planing. Since the developer and the contractor are two subsidiary companies, they are involved early in the process of the design and production of Västra Vakten and therefore have a great impact on the governing of sustainability and financial decisions of the project. The architect was the next major stakeholder involved with the design of Västra Vakten, see Figure 11, in which they were involved from the briefing phase throughout the design process. They were responsible for conducting the drawing and linked documents in which subcontractors need to be adjusted and accounted for. The developer sets the ambition and goals, determining the economic feasibility, environmental certification, and strategic planning are the main driving forces for Västra Vakten. Ambitious environmental goals set the governance for the contractor along with the consultants throughout the project.

The fire consultants are involved in the engineering design process. Since the architect has prior experience, this reduces the need to change once the fire-safety consultant is involved. It indicates that prior experience from past projects is beneficial when planning in the early stages and reduces the need for major changes once the engineering design phase begins for Västra Vakten, thus promoting sustainability indirectly. This suggest that experience-based planning may reduce the need for resource-intensive redesign. The architect was noted to take marginals, for example, the thickness of walls, to establish that the structural integrity and fire-safety classification would adhere to the requirements.

To be noted is that the environmental aspirations set limitations for Västra Vakten regarding material choices and surface productions (in regard to toxins as linked to Svanen 3.0). The aim and aspirations are set by the developer, which holds the main goals of Västra Vakten already in the preliminary design. When the framework documentation is presented, the major decisions have been set. The environmental coordinator’s role for Västra Vakten was to be a guideline and support the production phase to choose approved and certified products.

The three major changes made in the project, *Direction of doorway in stairwell, Change from steel to wooden in window construction, and Change of ventilation duct in connection with elevator shaft,* were due to different circumstances and involved different disciplines. However, the main actor that needs to approve of the decisions is the developer since the actor has the main responsibility of the handover of the established product to the facility manager.

The direction of the doorway in the stairwell had the architect make the final decision due to ensuring accessibility for the occupants. This change involved the fire-safety consultant, who had to ensure that the fire escape route was not compromised. The change from steel to wood in window construction was due to minimizing CO_2 emissions of the materials of Västra Vakten. This was determined by the contractor (Peab Bostadsutveckling), with the consequences of the change of color and height of the steel frame for the windows being changed, altering the architect's vision. The architect was not included in the process of change due to it being decided in the construction phase of Västra Vakten, where the architects are not under influence in the decision-making process.

A change of ventilation duct in connection with the elevator shaft was performed during the construction phase due to the drawings not accounting for the building capability of the shaft. Therefore, the wall had to be changed. This decision involved the contractor and the structural engineer, with the approval of the fire-safety consultant. The main decision was made by the structural engineer by adjusting the correct load-bearing structure of the walls and a new detailed drawing of the ventilation shaft on the roof.

Consultants through the production of Västra Vakten's aims are advisory to the contractor and take decisions in accordance with the developers' ambitions alongside the regulations and requirements of

BBR. However, the architect performed heavier decisions in the early stages of the design phase but was excluded in the construction phase of Västra Vakten.

5.4 Communication gaps in the construction process

No major miscommunications were discovered for the project of Västra Vakten, however, it was noted that communication gaps occur in general with inexperience, naivety, or lack of engagement throughout a project. Lack of miscommunication for Västra Vakten can be linked to the different disciplines having prior contact established. This suggests that established professional relationships may improve coordination efficiency. By looking at the BPMN maps, meetings are held regularly through both the design planning and the contraction of the project. It was noted from the interviews that regular contact with involved actors decreases the risk of miscommunication while also establishing broader communication between the disciplines and a foundation of trust.

Despite the overall impression of sufficient communication throughout the process, several minor concrete shortcomings were identified. This indicates that even well-functioning projects remain vulnerable to isolated coordination errors. Such as with the balcony railings and the tambour doors that were previously mentioned. These affected the sustainability aspect of the buildings since they needed to be removed, therefore using an unnecessary amount of material as well as transportation. These weren't systematic errors, instead they were individual lapses in judgment that indicate that the process is well-functioning, although minor oversights occurred. It was also revealed that Dalux may impede identification and interpretation of problems, since context sometimes is missing. It's also worth mentioning that the interviewees generally were reluctant to bring forward errors within their own process.

Another important observation was the difference between formal and informal communication, where the former proved more efficient for solving problems. From a sustainability standpoint, it was evident that even the minor oversights can lead to re-work and inefficient use of resources, which can lead to unnecessary spill.

Dalux was in general an appreciated tool, in which the use-friendly system makes it easier for a learning process for involved stakeholders when entering a project; this can, however, create a breach in the initial learning process, thus affecting how efficient communication can be, see Figure 16. It also provides an easy way to follow the construction process of status of phases (i.e. deliveries of materials, schedule, and time plan management). Dalux does not involve the design planning stages of the project, which are left to communication by BIM systems, correspondence by email and phone, and meetings. It was noted that direct contact with key stakeholders is the most efficient and necessary throughout, particularly during design alterations and technical coordination.

The communication between different technical disciplines highlights the importance of keeping early interdisciplinary communication in the design process. An example of this would be the change of wall by the ventilation shaft, which could have been intervened earlier in the process between the main contractor and the subcontractors. This connects to the study's aims and objectives regarding communication gaps, as they indicate that adequate communication routes reduce misunderstandings and improve coordination. Late design changes are common in the building industry, see Figure 17, but highlights the importance of keeping clear contact from the design planning phase and construction until the handover of the property management. This emphasizes the importance of continuity between the design and production phase.

5.5 Trade-offs between sustainability and fire-safety in the industry

5.5.1 Changes made—sustainability impact

The matrix of trade-offs illustrates that there were several sustainable measures performed at the project, with some correlation to fire-safety, which is presented in Appendix F. Re-use of bricks for the main building was discarded due to the CE guarantee that re-used materials can't be provided, which interfered with the fire-safety classification on walls.This demonstrates how regulatory uncertainty may limit the use of reused materials. It was also noted during the interviews that surface finishes for brick facades go against the sustainable marked products (in general), which is necessary for fire-safety. This illustrates how technical compliance requirements may conflict with environmental ambitions. This was stated as a general opinion and not linked specifically to Västra Vakten. This illustrates how technical compliance requirements may conflict with environmental ambintions.

Environmental sustainability, i.e., heat pumps, ventilation systems, and other building services, shows a general low grade of conflict of interests, whilst choice of materials has higher trade-offs in connection to resilient sustainability, as illustrated on the x-axis in Appendix F, Figure 19. The architectural sustainability i.e. flexibility, energy-efficient design, etc., in which categories show a higher indication of trade-offs in comparison to the other main themes.

Ultimately the major trade-offs are illustrated in the material choices and architectural design of the project, while internal building services had fewer trade-offs. This suggest that sustainability conflicts were more promintent in material-related decisions. Late changes, such as thickness of walls, change of materials, and structural design, will in turn affect the three sustainability themes coined: *Architectural*, *Environmental*, and *Resilient*.

The redesign changes that were done at Västra Vakten weren't in direct regard to fire-safety concerns. However, the fire-safety consultant was still involved in the process of these changes due to their indirect effect on fire cells (change of walls), fire escape routes (door opening direction), and structural integrity (change of steel to wood beam by window). The eco-concrete also reduced embodied emissions and was in a long-term development process before being used at Västra Vakten, making an impact on the environmental sustainability and resilience of Västra Vakten. The materials were in alignment with requirements.This indicates that sustainability improvements are possible when technical and regulatory demands align.

These trade-offs in the design choices affect the fire-safety demands of Västra Vakten and can conflict with sustainable measures required to reach the Svanen certification. Which ultimately means that there were some trade-offs in regards to sustainability. The sustainability aspect had to take a back seat in order to adhere to the fire-safety requirements. The Svanen certification focused mainly on structural integrity materials and building services, as well as sustaining the material demands regarding eco-labeled products and other environmentally hazardous components.

The changes highlight that fire-safety takes precedence over decisions in regards to sustainability measures made throughout this project, due to fire-safety regulations requiring specific solutions or strategies to ensure and comply with the demands. However, late changes can introduce heavier embodied emissions or increased material consumption or, for example, require higher energy use whilst under construction (i.e., when the eco-concrete was to harden, it took longer to dry, and manual machines were used for this). Finally, simulations regarding energy are beneficial assets to help design sustainable buildings, but they quickly become irrelevant if pushed aside by building regulations that are non-negotiable, such as fire-safety requirements.

5.5.2 Sustainability in correlation to fire safety

The interviews of the fire-safety consultant stated that the role was advisory to the different stakeholders of Västra Vakten, with the aim of offering solutions when changes were necessary. The environmental coordinator also holds a similar purpose of advising correct products and ensuring that sustainable goals are met according to requirements. However, fire-safety takes precedence over sustainability, which was stated in a majority of the interviews. Fire-safety as a product and subject has greater relevance to the project in order to be able to be handed over from the developer to the manager.

The fire-safety consultant had several interactions with Västra Vakten as a project through its production. Figure 13 shows a simplified illustration of the Västra Vakten's timeline and how the fire consultant interacted with the project over time.

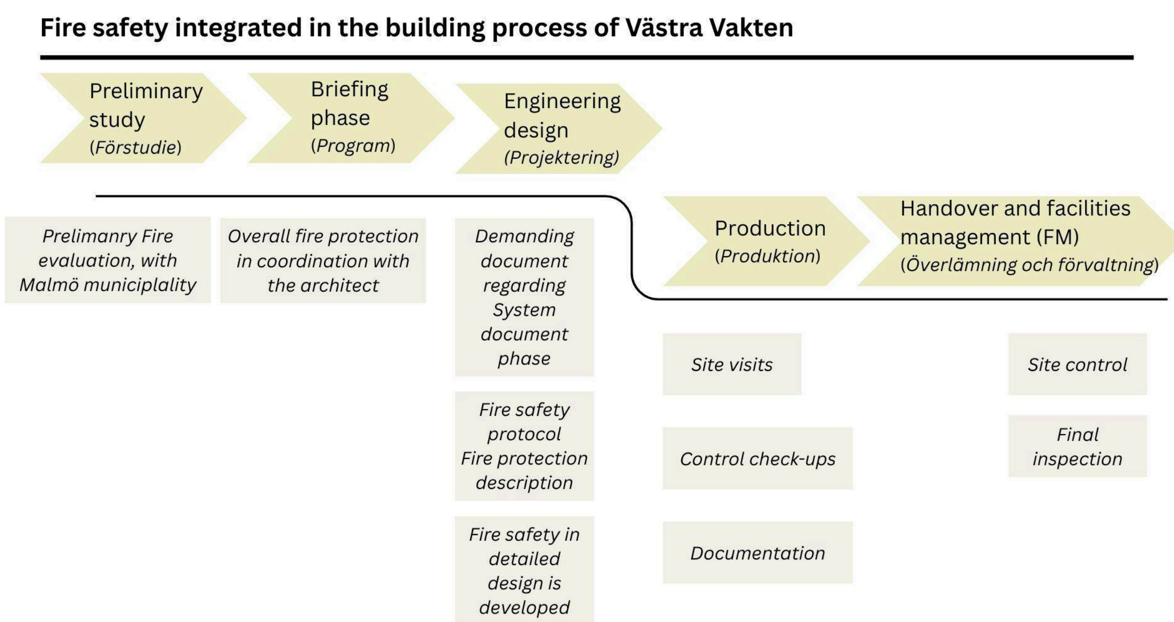

Figure 13: Fire-safety integrated in the building process of Västra Vakten

However, resilience linked to sustainability can be one aspect of fire-safety in correlation with the structural integrity of the building, linking it with its life cycle and the resilience of materials, such as when a different sheet metal niche was chosen to cover window gaps (*change from steel to wooden by the window frame*).

Furthermore, fire-safety also affects the operational performance of Västra Vakten with the building services. Poorly planned building services can affect the operational energy demand, creating a largely real-life energy gap (de Wilde, 2014). The change of the ventilation shaft, where the dimensions were increased during production and halted the process, is an example for Västra Vakten. Highlighting the importance/need for keeping an interdisciplinary design approach of the different disciplines where fire-safety, energy performance, and buildability are simultaneously considered instead of individually assessed. This suggests that fragmented decision-making may negatively affect long term building performance.

Trade-offs between the fire-safety consultant and the environmental coordinator have further room for improvement in such ways that if integrated early on in the planning process, it can be easier to address sustainable tactics for Västra Vakten. Varvsstaden is initially addressed as a location with material resources that can be reused and recycled, however these materials were not used for Västra Vakten. The professor at LTH also links this as an issue to verify materials in order with required demands. The developer also mentioned that using recycled bricks has a higher initial cost per item. By implementing early recycling strategies for future referenced projects, this can reduce the material impact of emissions and identify both regulatory requirements and environmental objectives in regard to fire-safety (Meacham, B. & McNamee, M., 2020).

5.5.3 Developer's governance regarding sustainability

The developer's internal governance regarding sustainability is the Svanen certification, well-established for its public image and familiarity within the company process for property development. From the interviews it was concluded that the developers' aim is what targets the environmental goals through each actor involved, which in turn is based on the financial feasibility of the project.

The framework provides clear environmental targets within each discipline's scope, setting a clear target of practice and decision-making in regards to sustainable choices. However, these can also be seen as a limiting factor regarding that the points and demands being only conceded to the Svanen certification and do not encourage each actor to initiate their own demands for sustainability. Therefore, it lies within the ambition of the developer to further cast governance for development projects. Environmental sustainability is balanced against financial constraints, which in turn can be linked to fire-safe choices and considerations i.e. materials, choices of recycling and re-use etc.

5.6 Limitations in methodology

Since the data collection was partly built upon the semi-structured interviews, there is a certain risk for subjectivity within the respondents' answers, which could affect how the sustainability aspect is perceived. Several stakeholders could have incentives to emphasize the positive aspects of the project, which in turn can result in eventual shortcomings or mistakes being minimized. This is supported by the fact that a portion of the interviewees seemed reluctant to recall and discuss problems within the project. To reduce the risk of this, the interviews were complemented with documentation from the company's internal communications software, which created an underlying reference. By backing up the statements within the interviews with existing documents, patterns were more easily characterized in order to validate the gathered information.

Another central limitation with the chosen methodology was that it was a singular case study, where a majority of the stakeholders worked within the same company. This reduces the chance of finding systematic errors regarding sustainability matters, since employers generally are reluctant to bad-mouth their employees.

Furthermore, it needs to be stated that the ones conducting the interviews were students that lacked experience regarding interview techniques, which could have limited the resulting output. However, the interviews allowed for flexibility and adaptation to the respondent within the process, which proved valuable. Another aspect worth mentioning is the way the questions were interpreted by the respondent, which could affect the response. To reduce the risk of limiting the respondents interpretation, it is important to validate the purpose and scope of the interview questions, by using a clear format and follow the provided frame-work for thematic analysis (Braun & Clarke 2008). This improves the reliability of future research. Overall the choice to conduct semi-structured interviews was deemed as successful, since it proved valuable when identifying shortcomings and positive aspects of the project.

A further limitation of the methodological approach is that the analysis of the result is greatly affected by the authors subjective interpretations. The codes created, as well as the themes decided upon, set certain guidelines to what results were being highlighted. To minimize this, the analysis was made based on existing theories and empirical data.

5.7 Limitations

This study will not consider a detailed economic analysis, which means that economic aspects correlated to sustainability will not be assessed in great detail. It will only consider multi-family residential buildings. The study will primarily focus on the planning and production stage of the property, excluding the operational and recycling stages of the building life cycle. Furthermore, fire safety and sustainability measures will be referred to indirectly, maintaining the focus of the information gathered from the interviews. The study is a qualitative study containing semistructured interviews; the respondents are limited to key stakeholders with prominent influence on the project.

The analysis focuses on the decision-making process, collaboration, and communication between the stakeholders, thus in turn disregarding any eventual technical aspects such as simulations, calculations, or dimensioning. Rules and regulations are treated from the stakeholders' perspective instead of comparing the results to existing requirements.

6. Conclusion

This thesis has aimed to investigate a case study in the Malmö municipality, in which interviews were conducted to investigate how the decision-making process towards sustainability was planned in regards to fire safety in the studied case. The communication process, trade-offs, and conflicts of interest between the disciplines have been evaluated and analyzed. The results show that the building industry to a high degree, is institutionally and regulatorily driven, with regulatory requirements, certifications, and financial incentives. At the same time complex collaboration between all involved parties is constant throughout the process, where the existing hierarchy is somewhat diffuse. The study indicates that fire-safety is considered as an absolute requirement, while the sustainability aspects have to adhere to the provided framework. Even though the communication generally was sufficient within the project, the results indicate that the process is somewhat fragmented and limits the integration of interdisciplinary solutions. Ultimately, the following conclusion could be drawn, each corresponding directly to the study's aims and objectives:

- The analysis shows that fire-safety systematically is prioritized throughout the building process, meaning that sustainability is strictly integrated as long as there aren't any trade-offs regarding occupancy safety. This creates an unofficial hierarchy within the process where sustainability is secondary to fire-safety. This means that sustainability is adjusted within the framework provided by the fire-safety aspect of Västra Vakten.
- Decision-making is functionally divided into clear unofficial hierarchies where the fire-safety consultants expertise is prioritized regarding security issues. Sustainability is closely related to the developer's ambition and often needs to be adjusted retroactively.
- Fulfilled requirements are often conducted through standardized processes, which are closely related to the project's environmental certification and established pre-existing procedures, within this project. This ensures sufficient outcomes in regards to compliance with existing rules and regulations. Although this kind of structure limits the incentives for innovation, which in turn makes it so that involved stakeholders rely entirely on proven methods.
- The study indicates that the transfer of information generally is sufficient, although some miscommunications occurred at Västra Vakten. These weren't systematic shortcomings, rather they were isolated instances correlating with the fluctuating involvement of the stakeholders within the different building phases. The consequence of this is that some information gets fragmented, which affects how integration of sustainable and fire-safe solutions works.
- The use of digital tools such as Dalux and BIM software facilitates transparency and traceability within the project. Although the use of informal communication paths may affect the project negatively. In practice they are supportive rather than governing.

Finally, it can be determined that the project in general had a well-structured solid structure, where no major systematic shortcomings could be identified. The miscommunications identified were minor, and connected the fluctuating involvement of the stakeholders within the project and also had a low impact on the sustainability aspect of the project. This indicates that the process in its entirety is functional and working well, although fragmented in character, which limits the possibility of integrated solutions. This contributes to a broader understanding of how sustainability and energy-efficient building design is carried out in practice, particularly in relation to regulatory constraints such as fire-safety design.

6.1 Future work

For future studies it would've been valuable to include more subcontractors in the interviews, since they constitute a central link within the design and production phases. Furthermore, an addition of the daylight aspect improves the understanding of how the sustainability aspect operates within the design phase.

Also, integrating energy simulations as a comparison to the case study could be a future line of work to assess how design choices affect the energy consumption of a building and the alternatives can be altered whilst considering fire-safety. Lastly, including a renovation project could be relevant to analyze relevant differences, which could show alternative limitations and trade-offs.

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Appendix

Appendix A

Summary of interviews.

Fire-safety consultant:
An interview was carried out with the responsible fire-safety consultant of the project. The consultant has 20 years of experience in the industry and was involved in the project from start to finish and shared the responsibility with one other consultant.

The interviewee had an overall responsibility in making sure that the building aligned to the existing requirements in regards to fire-safety. The consultant provided fire-safety documents throughout the project. Where specifications for certain zones and materials were defined. The stakeholder mainly worked in a passive manner by referring to regulations and assessing layouts. Rather than actively working on the project, the stakeholder instead supported the other stakeholder with inputs regarding fire-safety. The interviewee also ensured that certain metrics were met through calculations, site visits, and meetings. The interviewee stated the following during the interview " I support the involved stakeholders throughout the project by answering their questions regarding fire-safety with relevant documentation and calculations".

The work at Västra Vakten was mainly carried out by following BBR's general rules. As stated during the interview " Most of the requirements regarding fire-safety are covered by the general BBR general recommendations". Further, the interviewee points out that no compromises are made in regards to fire-safety since the laws are absolute. Instead, it's mentioned that they try to be as mitigating as possible, and that is most easily done by being involved as early as possible in the project and through good communication. The interviewee mentions that no trade-offs were made in regards to environmental sustainability since it isn't anything they look at.

Architect 1:
The interviewed stakeholder was the head architect of the project and was present in the project from start to finish. Although gradually less as the further the project progressed. The role involved the development of the floor plans and volume studies as well as coordination involving stakeholders. The architect had a central role in the design phase of Västra Vakten and was responsible for realizing the developers' demands while still adhering to existing detailed plans and technical specifications.

The architect emphasized that the options for change gradually were limited further into the project. As described during the interview " The further the project has progressed, the less opportunity their is for corrections". In the design stages there was big freedom for influencing the design, and as more stakeholders got involved and installations and disciplines introduced their requirements, the ability to influence decreased. The interviewee stated that the early design decisions on material, structure, and shape have great influence on the building from a sustainability and fire-safety standpoint.

The relationship between architect and fire-safety consultant was described as of high importance. The interviewee emphasized that “ Fire-safety design measures are difficult to compromise with since they are strict requirements regarding the occupants safety”. The requirements in regards to fire-safety are often absolute and often challenging, and in turn, compromise with them. This often leads to compromises from the architect's side, since their metrics generally are softer. Which could hinder the architect's ambition and demand workarounds.

In regard to sustainability, it was stated that the architect to a great extent works towards it by designing flexible buildings for multiple purposes. As well as in their choice of materials, which generally are sustainable from an environmental and resilience standpoint. Although these ambitions often are limited by technical and regulatory requirements. The interview gave great insights into how proper coordination can affect a project.

Architect 2:
The interview was carried out with a project manager working on the architectural firm responsible for designing Västra Vakten. The project manager's main responsibility is to be a mitigator between the architect and the construction company. Allowing the architect's vision to stay intact throughout the building process while still allowing for compromises where needed. The final design was referred to the architect, while realizing the design through evaluating different materials and mitigating it with different stakeholders was the project manager's responsibility.

The respondents described their main responsibilities as assessing time, budget, and technical solutions. A recurring problem identified in the interview was the different incentives motivating the stakeholders. The architects were mainly concerned with creating an aesthetically pleasing design that represents the firm well. While other stakeholders mostly prioritized money, which in turn could cause conflicts of interest. These conflicts of interest led to some shortcomings in the design of the building certain materials were not used, and the time plan was not met since miscommunication occurred and wrongful assumptions were made. An example of this from Västra Vakten was wrong railings in the balconies and bad window sill flashings. The interviewee mentions that fire-safety and accessibility work as strict requirements and are prioritized before softer design decisions. The interviewee emphasized this by stating that “Fire-safety and accessibility are requirements that cannot by negatioted with to a great extent”. Environmental ambitions are mainly driven by the developers and the environmental coordinators. It was also mentioned that architects in general have less mandate to initiate big changes since they're a small stakeholder in the projects. Sustainability solutions are generally limited by financial incentives and a general willingness to use already existing, tested solutions.

Project manager:
This interview was conducted with a project manager at PEAB, who is responsible for the early development of the project. The respondent was mainly involved in the design phase of the project, where financial calculations, time management, and building permits were procured and design ideas formalized. In this specific project the financial incentive was leading in the design phase. The building was deemed not profitable enough, and the recession affected the industry as a whole. An extra floor was therefore added to the early design to ensure sufficient profit margins.

The financial point of view was described as the leading incentive, forming all other aspects indirectly. As stated by the respondent “the costumer is the most important aspect of the project, since it has to be finacially feasible”. The relationship between usable space and non-usable space was a main concern in order to make the project feasible, and acquiring the building permit was deemed a critical point for the project since Malmö municipality has a 20-week processing period.

The communication was mainly carried out through Dalux, and important decisions were made in person through meetings. While urgent matters were dealt with through phone and e-mail. The respondent emphasized that fire-safety requirements are absolute and rarely are sidestepped without proper reason since they are expensive and difficult in general. Instead, it's often the architect's wishes that get compromised, since they generally are softer and adequate workarounds are easier. Sustainability is mainly dealt with through design measures by slimming down the structural system, mainly through less use of materials, as well as experimenting with new materials while still adhering to existing requirements. The process is shaped by evident hierarchies, where the financial incentive goes first and other regulatory requirements mainly are deemed as necessary in order to build rather than as goals by themselves.

Environmental coordinator 1:
The interview was conducted with an environmental coordinator at PEAB. The respondent's main responsibility is ensuring that the project meets the set environmental requirements. The respondent has mainly contributed with guidance regarding the environmental certification through climate declarations and validating that procured materials meet standards. As described in the interview “our role is mainly to ensure that the project fulfills the environmental requiremnts that has been agreed upon”.

The project had an aim to have Svanen as their environmental certification. To meet set certification, 15 of 40 points have to be fulfilled; stakeholders mainly ensured this by ordering the right types of materials in the production stage. Since subcontractors generally order their own materials, the coordinators' task is to confirm that they meet set standards. It was mentioned during the interview that the biggest issue in the production phase is proper documentation from subcontractors. The respondent emphasized this by stating that “ obtaining correct documentation from the subcontractors are one of the biggest challenges”. This is prevented by educating the involved actors and logging all materials in inspections and spot inspections.

The interviewee described that environmental parameters have been prioritized more over time by earlier collaboration with structural engineers and other significant stakeholders. The connection between fire-safety and sustainability was described as indirect since the two departments generally don't communicate. Although they affect each other by their specific requirements, fire-safety consultants have to use environmentally permitted materials, and the coordinators have to procure materials that are approved from a fire-safety standpoint.

Environmental coordinator 2:
This interview was carried out with an environmental coordinator at PEAB, responsible for the development of sustainable solutions. The stakeholder has over 10 years of experience in the field, and

their main responsibilities are to strategically work towards creating more environmentally friendly buildings by implementing new technical systems. The actor's part isn't project-based but general for the entire company and also involves adjusting the company to new legal requirements and industry standards.

In Västra Vakten the stakeholder was involved by introducing a new climate-improved concrete developed by PEAB. As stated in the interview " Västra Vakten served as a pilot project for the new climate improved concrete". The project was ongoing for three years and aimed to develop a new, improved concrete recipe as well as an efficient production method. The challenges with the new concrete weren't the cost of the material, but instead the increased hardening time could affect the time management. The solution resulted in a workaround where other components present in the building were handled in the meantime. When developing the new concrete, site workers were involved since they're the ones that are ultimately going to work with the concrete. This was done to increase understanding and transparency within the concrete. The effort resulted in a successful new concrete where Västra Vakten acted as a pilot case, the concrete ended up being cheaper and more environmentally friendly.

The stakeholder emphasizes that the most crucial environmental decisions are set early in the projects, in the early design stage. The interviewee stated that "the most important sustainability decisions are made in the early stage of the project". Dalux was deemed a useful interface, with sufficient capabilities for improving transparency and efficiency in the company. The biggest limitation in the projects was defined as stress due to the strict time plan. The developer was also mentioned as the main contributor to the creation of a sustainable building, with high ambition and early design demands that encourage sustainable buildings.

Fire-safety is handled early in the design phase and was mentioned as being equal to structural aspects in terms of priority. Fire-safety and structural integrity were stated as taking precedence before aesthetic and environmental aspects since there are strict requirements there to ensure the occupants' safety. Conflicts of interest between fire-safety and environmental goals were described as rare since they don't work directly together.

Lastly, the coordinator emphasized that a general perspective is key in order to achieve long-term sustainability. Certain materials may lead to short-term efficient solutions on paper but degrade and cause issues over time. Sustainability therefore demands the balancing of trade-offs of different aspects such as climate impact, function, lifespan, and circularity.

Developer:
The interviewed stakeholder was the responsible developer for the project and had a central role in the project. The role involved the most rudimentary aspects of the project. Such as investigating the feasibility of the project, early financial calculations, hiring subcontractors, etc. The stakeholder was mainly involved in the design phase of the building in a passive manner. It was also responsible for purchasing the building site, obtaining the building permit, and continuously following up with different actors during the construction process.

In the interview it was stated that the developer is the one who sets the general requirements for the project, such as environmental certification, financial restriction, and other ambitions. As stated by the respondent " we are the ones who set the ambitions and goals for the project to beggin with". As for Västra Vakten, the Svanen environmental certification was set with a clear goal, while other targets, such as energy use, were set according to existing regulations. Re-use of available materials and the use of a new kind of environmentally friendly concrete were also set with clear objectives. Moreover, general specifications on structural system and material use are defined by the developer while specific components are left to the subcontractors.

In regards to fire-safety and environmental sustainability, it was stated that they make up a core part of the project. The environmental aspects of the project had a strong connection to the Svanen certification; the project involved environmental declarations. It was further stated that the environmental measures mainly are decided upon based on the specific project's existing conditions. The measures generally involved the use of specific materials or technical implementations. The guidelines from the fire-safety consultant were generally deemed absolute and were given priority over aesthetic objectives. The interviewee emphasized this by stating that "fire-safety requirements are not something that simply can be disregarded, they must be fulfilled". It was also mentioned that fire-safety and environmental sustainability are the perspectives that are prioritized early in the projects, even though details and changes may occur later. The actor stated that the most influential aspects of a project are time, money, and reaching set goals.

Fire-safety Professor:
This interview was conducted with a professor in fire-safety at Lunds University, in the institution for technology. The professor's main research topics involve how fire-safety is regarded throughout the world and how it affects the industry, as well as its shortcomings.

The interviewee describes that fire-safety consultants generally are introduced too late into the building process, which may lead to ill-fitting solutions and costly mistakes. As stated during the interview "fire-safety is often addressed to late in the process, when many important decisions have already been made" Furthermore, it's mentioned that the decisions that are beneficial from an energy-efficiency and environmental perspective are not always so from a fire-safety one. Alterations such as changing insulation or introducing new materials may sometimes come with drawbacks. It's further mentioned that LCAs and climate declarations should take the benefits of fire-safety into consideration since it improves the resilience of the building.

The professor mentioned that the correlation between fire-safety and sustainability rarely is made, although in practice they are closely aligned. The respondent stated that "fire-safety and sustainability are often discussed seperatly, even though they are closely connected". Since large fires may result in social distress and demolition, which in turn require the building of new buildings, further straining the environment. It was also mentioned that from a research perspective fire-safety should be correlated with the resilience of the building, rather than something strictly correlated to laws and regulations. Fire-safety has generally been something that has been developed through demand and not in any preventative manner. Furthermore, it was described that fire-safety shouldn't be looked at by each material's fire resistance rating but instead as part of a system. It was further emphasized that analysis of different materials needs to be developed to better emulate degradation over time in real life.

Building information modeling (BIM) software was pointed out as necessary to effectively combine the disciplines of fire-safety and environmental friendliness. It would allow for further transparency and overall perspective.

Fire-safety PhD student:
The interview was conducted with a PhD student at LTH within the department of fire-safety technology, the interviewee also has about 20 years of experience as a fire-safety consultant in the building industry. The participants' main subject of study is how fire affects occupants and the environment, which includes how emissions from fire affect humans and the ecosystem.

The interviewee describes that the knowledge regarding fire-safety varies with different stakeholders throughout the industry. It's mentioned that there generally is a good understanding that fire-safety consultants need to be involved early in the projects to be able to work effectively. During the interview it was stated “there is generally a good understanding today that fire-safety consultants should be involved early in the design process”. Although it may differ with smaller or more inexperienced contractors. The respondent mentioned that the involved stakeholders generally have a good understanding of fire-safety regulations and that they mostly work on ensuring that the requirements from the regulations are met.

An aspect that was described as needing more attention was the correlation between sustainability and emissions from fires. It was stated that “ The environmental consequances of fires are often overlooked in sustainability discussions”.When fires occur, emissions are emitted as particles and as gas, thus polluting nearby lakes and soil. The correlation between fire-safety and the environmental aspect in the industry was described as indirect, and those involved parties generally do not communicate in any significant manner. Although the communication between the remaining parties was described as sufficient. In regards to if fire-safety is introduced early enough in the process, the interviewee could recall that the situation has improved gradually over the years, but it still is in need of improvement in some cases.

The respondent also described that sustainability measures sometimes may create new challenges in regards to fire-safety and that they may give rise to certain trade-offs and uncertainties. For example, the introduction of bio-based materials was deemed positive, although in need of more testing since it's difficult to determine if the quality can withstand the test of time. Furthermore, the insurance companies were mentioned as having an impact on the design choice since they don't cover all types of solutions.

Structural engineering:
An interview was conducted with the structural engineer at Västra Vakten, who was responsible for the load-bearing aspects of the project. That includes the dimensions of the structural frame, as well as verifying its capabilities through calculations. The role involves close coordination with the architect and developer as well as the other stakeholders.

During the interview it was evident that the structural engineer worked based on the framework provided by the architect. It was stated that” the architect has usually already defined the building volume and layout before we become involved”. Where the building volume, floor plan, and structural spans already are specified. These aspects are considered somewhat locked, already before the structural engineer is involved. But may be changed if need arises. The structural engineer stated that their main focus is on ensuring that the load-bearing qualities are sufficient and that environmental aspects largely are omitted. The interviewee stated the following “ our main responsibilty is to ensure thst the structure fulfills the required load-bearing capacity”.

The fire-safety requirements were described as important and deceptive, although most are not a concern. The interview showed that the structural engineers' contributions towards sustainability mainly are indirect, by reducing thickness when dimensioning the buildings as well as ensuring a long lifespan by improving their resilience.

Site manager:
The interview was conducted with a site manager working at Vätra Vakten, who worked at the project for 1.5 years. During the project the interviewee was responsible for the installation and ordering of key building components. The stakeholder was only involved in the production and end-stage of the construction process and thus had limited influence on the design of the building.

The stakeholders' work is described as operative and coordinative. The interviewee stated that “a large part of the work consists of coordination, follow up and ensuring that the project keeps the schedule”. typical day involved meetings, assessments, and controls at the site as well as ensuring that time and quality were upheld. Documentation was described as a key role in order to meet the environmental certification.

The work mainly involves realizing the architect's, structural engineers', and developers visions. It was mentioned that fire-safety rarely is compromised since the consultant is expensive and it generally is easier to make changes in the architect's design, but this may also lead to mistakes. An example mentioned in the interview was when doors switched around without the architect's approval, which compromised the accessibility and resulted in it needing to be changed.

The decision-making process was described as being carried out through a variety of methods. The important decisions were generally made in meetings, while small decisions were made in Dalux, and quick urgent meetings required phone calls or sometimes e-mails if they involved specific details. This was described as generally being sufficient, while introducing the possibility for mistakes everything isn't documented.

In regards to sustainability, re-use of materials was regarded as beneficial since it had a low environmental impact. But also demanding in practice since it requires assessing the quality of the materials. The site manager had no influence on the type of materials used, only what specific brand.

Appendix - B

BPMN maps

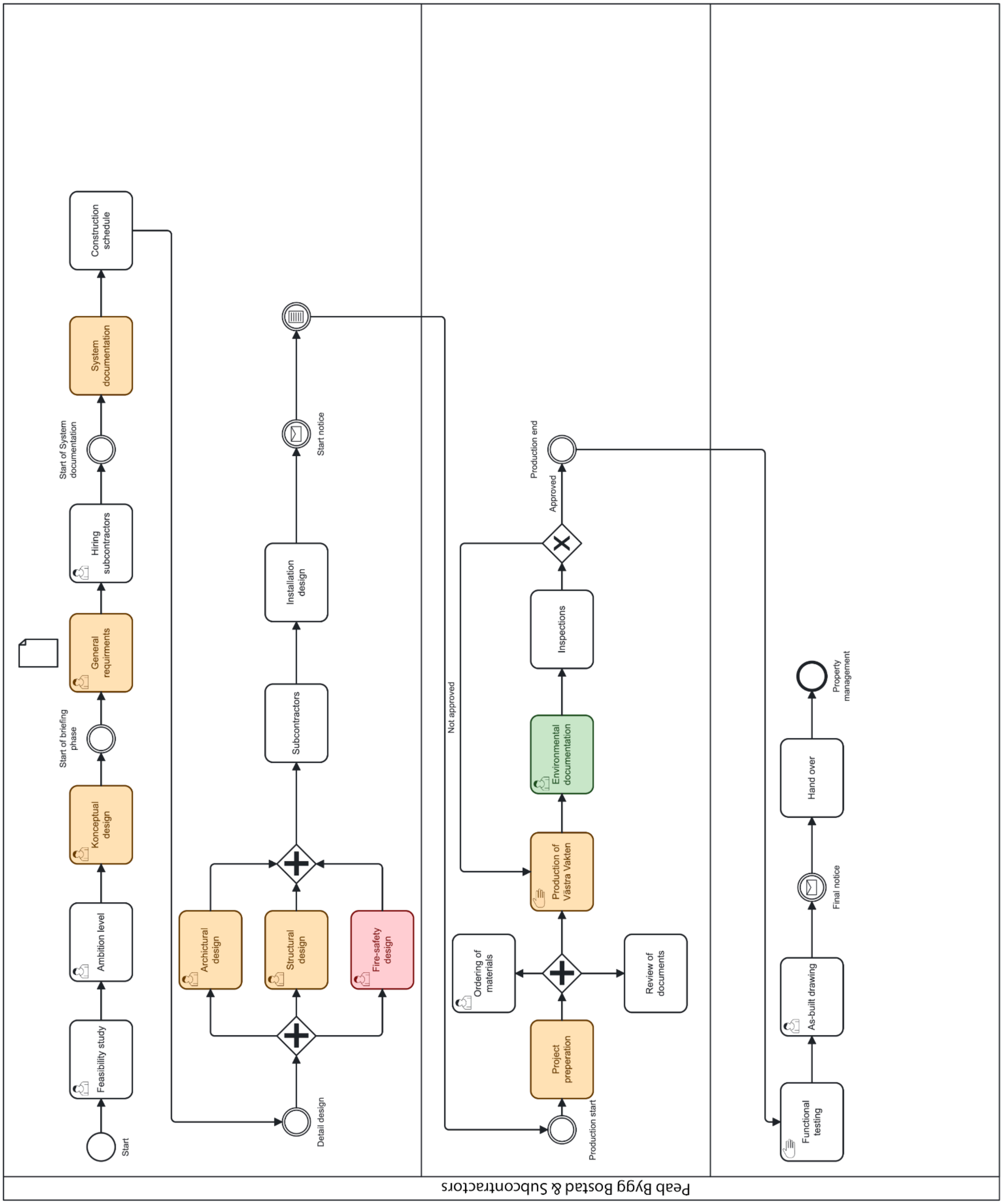


Figure 14: General BPMN chart

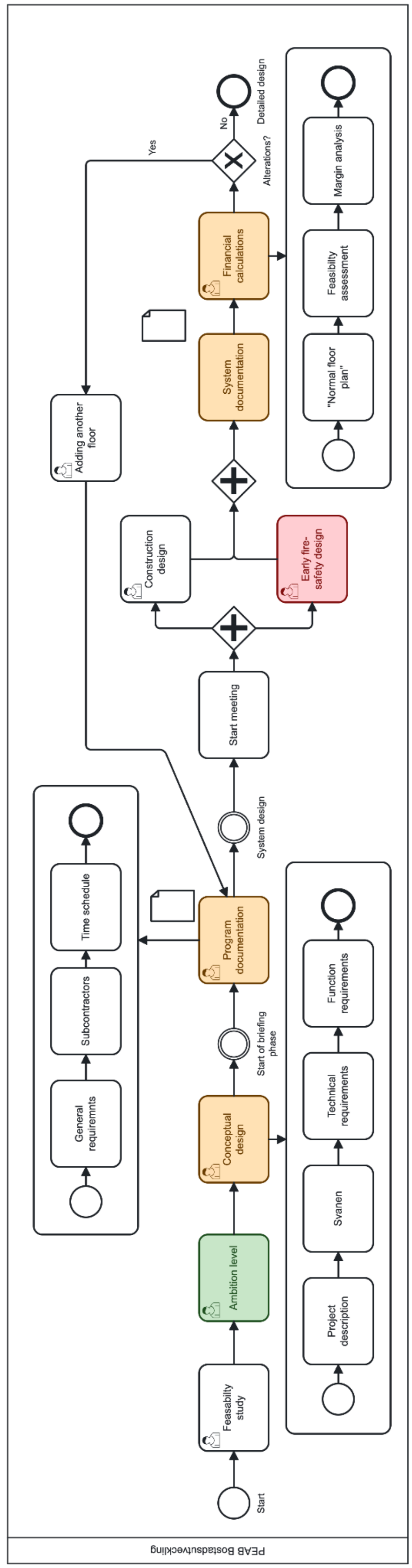


Figure 15: Early design phase BPMN

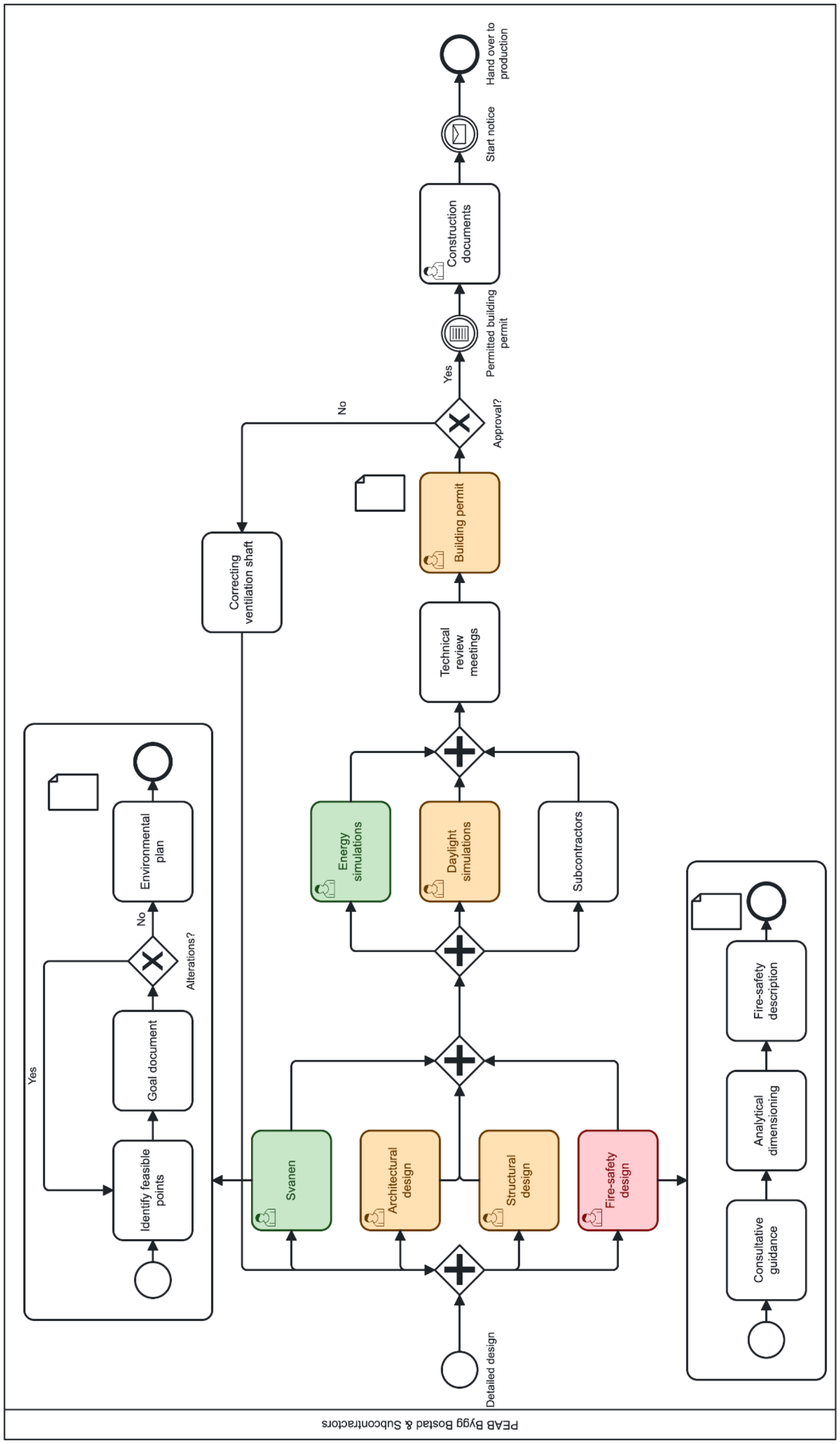


Figure 16: Detailed design phase

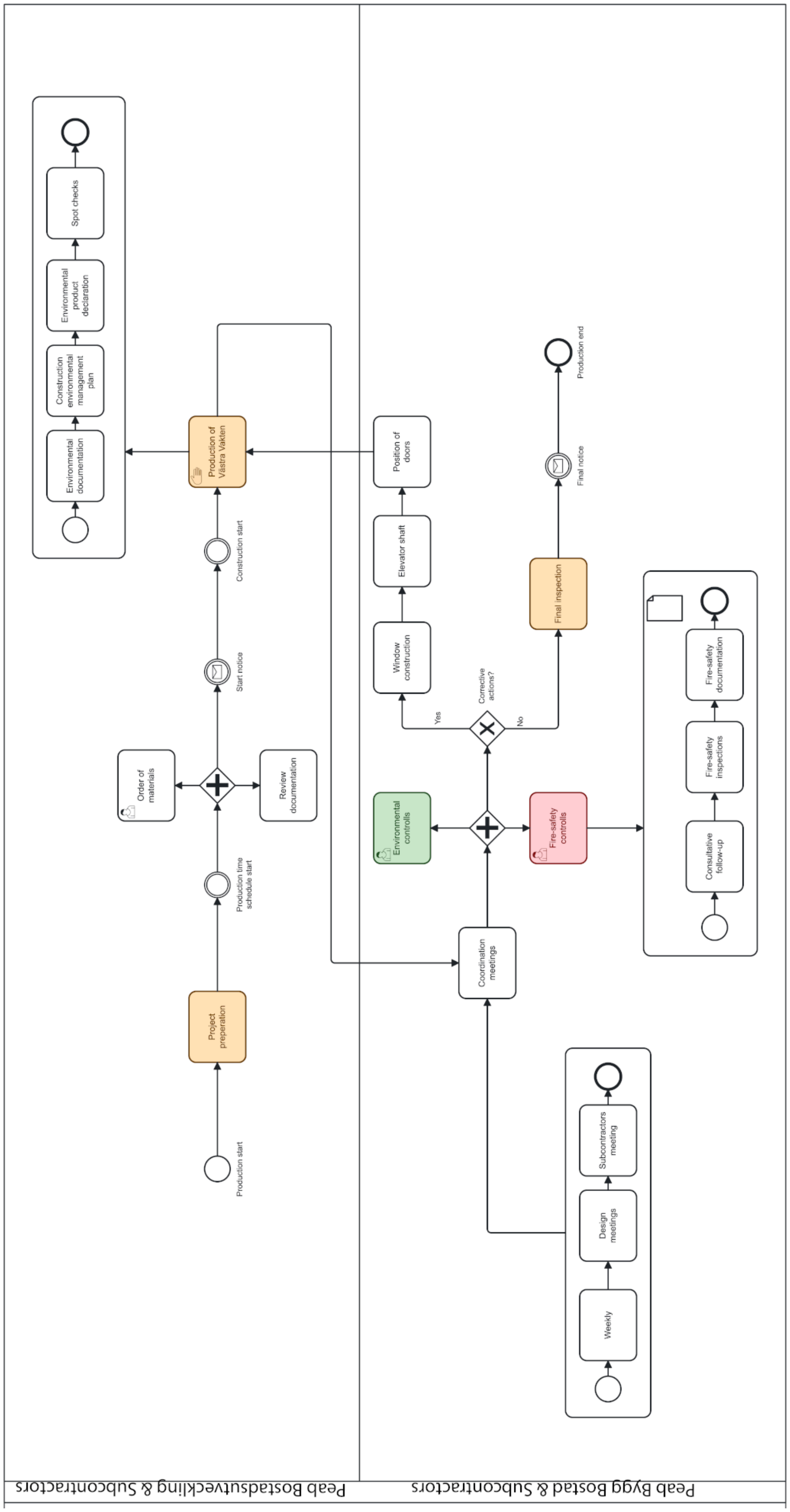


Figure 17: Production phase, BPMN

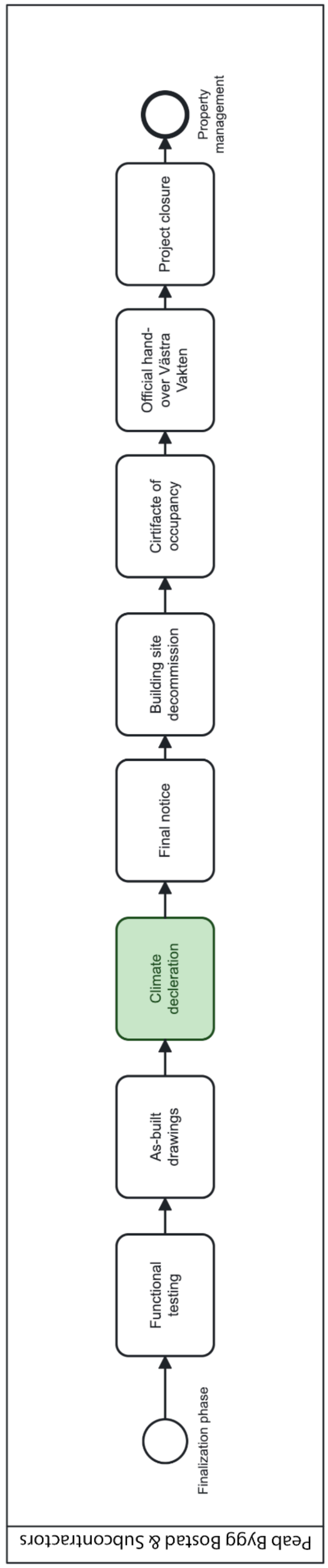
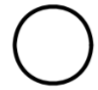
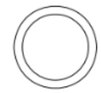
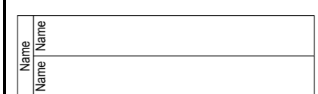
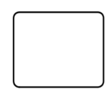
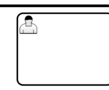
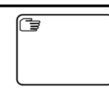
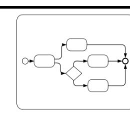
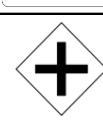
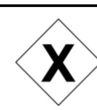


Figure 18: Project closeout BPMN

Appendix C

Table 3: Symbols BPMN charts (Object Management Group, 2014)

Name	**Definitions**	**Symbols**
Start event	Signifies the start of a project	
Intermidiate event	Signifies transitional events	
End event	Signifies the end of a project	
Intermidiate message event	Signifies a transition event that includes a message of significance	
Intermidiate conditional event	A event where a specific condition first needs to be met in order proceed	
Pools	Represents collaboration between stakeholders	
Lanes	A subpartition within a pool	
Task	Describes activities carried out	
User task	Describes activities carried out through a computer by a person	
Manual task	Desbries activities done by physical labour	
Subtask	Describes a task in more detail	
Parallel gateway	Shows when two activities occur simultaneously	
Exclusive gateways	Is used to create alternative paths based on decisions or outcomes	
Sequance flow	Shows the direction of the sequences	
Data object reference	Provides information of what tasks needs to perform or produce. (Not vital to the process map itself)	

Appendix D

Interview questions:

Decision-making (DCM)

1. Could you shortly describe your role in the project and what parts you were responsible for?
2. In what phase were you involved in the project?
3. How long did you work at Västra Vakten?
4. Did you perceive that different stakeholders had different influences on the project? How was it noticed?
5. How did the decision-making process work? What worked and what didn't?
6. What were the biggest challenges in the project, and who was involved?
7. What was the most critical point in the project?
8. How has communication worked between the different disciplines?
9. How were situations handled when stakeholders missed knowledge of anothers feild?
10. Did any conflicts of interest occur, for example, between the architect and structural engineer? How were they handled?
11. When in the project did you have the most influence to affect the development of the project?
12. Could you give concrete examples of when your decisions had a significant impact on the project?
13. How do you use digital tools?
14. Have any communication gaps occurred due to the digital tools? In that case what?
15. How has the functional review process influenced the decisions?

Environmental (ENV)

16. What sustainability strategies were used to reach the Svanen certification?
17. Have LCAs and climate declarations been a part of the project?
18. How has energy performance and climate impact been handled in the design phase?
19. Did any conflict occur in regards to energy and climate goals?
20. How big of an impact has these issues had on the buildings design
21. How and when in the project are you involved, and how do you take sustainability into account in your work?
22. Did the project need to come up with any special solutions in order to reach the Svanen certification?
23. Did any conflict of interest occur between environmental- and fire-safety goals?

Fire-safety (FS)

24. How and when is the fire-safety perspective introduced in the project?
25. Do you perceive fire safety as an active and present aspect in the design process?
26. What potential problems did you encounter in regards to fire-safety in the design process?
27. Has any design decision been altered because of fire-safety demands?
28. Were these linked to PEAB's internal critical issue questions, mentioned in PEAB's internal guidelines?
29. How did the hand-over from production and fire-safety work from a fire-safety perspective?
30. How was fire-safety treated during the final inspection?

31. How was risk management handled in the event of a fire in Västra Vakten? Can you describe how the process has developed from the early design stages to the completed building?

Appendix E

Points gathered from the Nordic Eco Swan Label at Västra Vakten.

Table 4: Svanen points gathered and considered.

Category		***Collected points***	***?***	***Disincluded points***	***Max points***	***Comments***	***Points***
P1	Energy supplement from local energy source or energy recycling	0	0	6	6		
P2	Individual metering of domestic hot water	1	0	0	1	IMD	
P3	Calculated VVC losses	1	0	0	1		
P4	Kitchenware, energy class	1	0	2	3	Combined fridge/freezer class E, 1p.	1
P5	Energy-efficient sanitary fixtures	2	0	1	3	Kitchen mixer 1p, washbasin mixer 1p.	2
P6	Cement and concrete with reduced energy and climate impact	2	0	0	2		
P7	Wooden construction	0	1	1	2		
P8	Sound environment	0	0	3	3		
P9	Eco-labeled building products and building materials	9	1	0	10		
P10	Products in chlorine-free plastic / Conscious product choices	2	0	0	2		
P11	Wooden moldings from certified forestry	2	0	0	2		
P12	Recycled or reused materials in building products	0	0	3	3		
P13	Material recycling of construction waste	2	1	0	3		
P14	Environmental measures	2	1	0	3		
		24	4	16	44		
	Requirements for apartment buildings	17					

Table 5: Svanen points gathered and considered.

No.	Requirement	Applicant Score	Max Points Residential Housing	Max Points Single-Family Housing	Max Points School/Preschool
P1	Energy contribution from local energy source or energy recovery	6	6	6	6
P2	Individual metering of domestic hot water	1	Not relevant	Not relevant	Not relevant
P3	Calculated DHW circulation losses	1	Not relevant	Not relevant	Not relevant
P4	Appliances of the best energy efficiency class	3	3	3	3
P5	Energy-efficient sanitary fixtures	3	3	3	3
P6	Cement and concrete with reduced energy and climate impact	2	2	2	2
P7	Wood construction	2	2	2	2
P8	Improved acoustic environment (applies only to single-family and multi-family housing)	3	3	Not relevant	
P9	Ecolabelled building products and construction materials	10	10	10	10
P10	Products made from chlorine-free plastic	2	2	2	2
P11	Wood mouldings from certified forestry	2	2	2	2
P12	Recycled or reused material in building products	3	3	3	3
P13	Material recovery of construction waste	3	3	3	3
P14	Green initiatives	3	3	3	3
Total		44	42	39	

Appendix F

Trade-offs between sustainability and fire-safety measures.

Measures			Fire safety																			
			Occupancy safety							Perservation of the building								Regulations and frameworks				
			Evacuation time		Documented changes		Fire-safety measure			Resiliance		Involvement of fire-safety classification			Fire spread prevention measures			BBR requirements				Svanen certification
			Fire riser pipe	Space for emergency services	Change of doors direction	Change of ventilation shaft on roof	Fire extinguishers (Fire-safety measure)	Post boxes (Fire-safety measure)	PV-Panels, battery storage (Fire-safety measure)	Roofing material	Surface finnishes	Fire-safety class on walls	Elevator shaft	Fire-safety class on windows	Fire-gas ventilation	Smoke-tight fire sealing	Protection between buildings (distance)	Functional class	Fire class	Fire cells	Analytical dimensioning	Change of load bearing steel to wood in window constrction
Sustainability	Architecutral	Flexibi lty	Adaptable floorplans																				
			"To factor in"																				
		Energy-efficient design	PV-Panels																				
			PEABs internal material system (Byggvarubedömingen)																				
		Social sustainability	"Usage-architecute"																				
			Roof ridge detail																				
			Inverted corners in facade, brick work																				
	Environmental	Energy performance	Energy performance																				
			Armatures																				
			Heatpump																				
			Energy effiecient kitchen wears																				
			Induvidual measurement of domestic hot water																				
			Ventilation (FTX-system)																				
			Structural system (Concrete and steel)																				
		Embodied emssions	Eco-concrete																				
			Surface finishes																				
			Re-use of bricks																				
		Recycling	Chlorine-free plastic products																				
			Maximum 25 kg waste/BTA																				
			Chemical products																				
	Resilience	Function al use over time	Wooden mouldings from certified forestry																				
		resilience againt deteratio n	Ban against impregnated wood																				
			Insulation material																				
		Modul ar design	Windows, coatings																				
			Balcony railings																				