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ENVIRONMENTALLY SUSTAINABLE PROJECT MANAGEMENT IN INDUSTRIAL BUILDING PROJECTS

Master's Thesis
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ABSTRACT

Veeti Wiheriäkoski: Environmentally sustainable project management in industrial building projects
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To achieve a more environmentally sustainable built environment various measures are needed to mitigate negative environmental impacts of the building and construction sector. The main objective of this thesis was to find out how industrial building projects can be managed in a more environmentally sustainable way. In the context of this study, industrial buildings are defined as buildings that facilitate industrial operations, and environmental sustainability refers to minimizing the negative environmental impacts of building projects.

To achieve the research objective, a literature review was conducted in the theoretical framework, focusing on identifying project management's main activities during a project, the concept of environmental sustainability in the building and construction sector, measures employed to enhance environmental sustainability in the sector In Finland, and how project management can influence the environmental sustainability of industrial building projects. In the empirical part of the thesis, a case study was conducted to find out how environmental sustainability was incorporated in the project management process in a recently implemented food industrial building project in Southern Finland.

Based on the theoretical findings, project management measures towards more environmentally sustainable industrial building projects are similar to those that are already utilized in other building typologies. However, the study revealed that industrial building projects face specific challenges related to environmental sustainability, primarily due to the industrial activities conducted within these buildings. Additionally, the legislation governing the energy efficiency and climatic impacts of industrial buildings is behind several other building typologies. Despite these challenges, project management was identified to have several means to integrate and improve the environmental sustainability of industrial building projects.

The empirical part of the study revealed that in a recently implemented industrial building project, environmental considerations were not treated as a success criterion or as a central aspect of the project or project management. Most project management decisions regarding industrial buildings were based on process, functional, and regulatory requirements, as well as on solutions used previously in a similar project. However, environmental sustainability had been considered during selection of suppliers for execution phase. Additionally, harmful environmental impacts of construction activities had been addressed and project-specific environmental goals had been set for these activities to mitigate those impacts.

To improve the environmental sustainability of future industrial building projects a project management checklist was formulated based on the research findings. Especially, planning and design phases, which significantly impact the buildings operational and product-related environmental impacts, show a great potential for enhancing the industrial buildings environmental sustainability in the future. Project management can influence these and other environmental impacts by increasing clients' awareness of the benefits that environmental sustainability can have for the project, setting and supporting environmental objectives and goals for the project, employing steering mechanisms and methods for managing the project's environmental impacts, and by recognizing the potential impact that project stakeholders, particularly internal stakeholders, can have on environmental sustainability of the project.

Keywords: environmental sustainability, industrial building, project management

The originality of this thesis has been checked using the Turnitin OriginalityCheck service.

TIIVISTELMÄ

Veeti Wiheriäkoski: Ympäristövastuullinen projektinhallinta teollisissa rakennusprojekteissa
Diplomityö
Tampereen yliopisto
Rakennustuotanto
Elokuu 2023

Ympäristövastuullisemman rakennetun ympäristön saavuttamiseksi erilaisia keinoja tarvitaan vähentämään kiinteistö- ja rakennusalan haitallisia ympäristövaikutuksia. Tämän opinnäytetyön tavoitteena oli selvittää, miten teollisia rakennusprojekteja voidaan hallita ympäristövastuullisemmin. Tässä yhteydessä, teollisilla rakennuksilla tarkoitetaan rakennuksia, jotka mahdollistavat teollisen toiminnan, ja ympäristövastuullisuudella tarkoitetaan rakennusprojektien haitallisten ympäristövaikutusten minimoimista.

Opinnäytetyön tutkimustavoitteen saavuttamiseksi teoriaosuudessa suoritettiin kirjallisuuskatsaus, jonka tarkoituksena oli löytää projektinhallinnan keskeiset aktiviteetit projektin eri vaiheissa, mitä ympäristövastuullisuus tarkoittaa rakennusalalla, minkälaisia toimenpiteitä Suomessa on hyödynnetty ympäristövastuullisuuden parantamiseksi kiinteistö- ja rakennusalalla sekä miten projektinhallinnalla voidaan vaikuttaa teollisten rakennushankkeiden ympäristövastuullisuuteen. Empiirisessä osuudessa tutkittiin esimerkkikohteen avulla, miten Etelä-Suomeen hiljattain toteutetussa elintarviketeollisuuden rakennushankkeessa rakennusten ja rakentamisen ympäristövastuullisuus oli otettu huomioon projektinhallinnassa.

Teoreettisen osuuden pohjalta tunnistettiin, että projektinhallinnalliset menetelmät kohti ympäristövastuullisempia teollisia rakennusprojekteja ovat pääosin samankaltaisia, joita hyödynnetään jo alalla muihin rakennustyyppeihin. Tutkimuksessa kuitenkin havaittiin, että teolliset rakennushankkeet omaavat erityisiä haasteita ympäristövastuullisuuteen liittyen. Nämä haasteet johtuvat pääosin rakennuksissa tapahtuvista teollisista toiminnoista. Lisäksi lainsäädäntö, joka ohjaa rakennusten energiatehokkuutta sekä ilmastovaikutuksia on teollisten rakennusten kohdalla jäljessä useita muita rakennustyyppejä. Haasteista huolimatta projektinhallinnalla tunnistettiin olevan useita menetelmiä, joilla voidaan integroida ja parantaa teollisten rakennusprojektien ympäristövastuullisuutta.

Tutkimuksen empiirinen osuus paljasti, että hiljattain toteutetussa teollisessa hankkeessa rakennusten ympäristövastuullisuutta ei ollut huomioitu projektin menestystekijänä tai keskeisenä osana projektia tai projektinhallintaa. Suurin osa teollisiin rakennuksiin liittyvistä projektinhallinnallisista päätöksistä perustuivat prosessi-, toiminnallisiin- ja sääntelyvaatimuksiin sekä aiemmassa samankaltaisessa projektissa tehtyihin ratkaisuihin. Kuitenkin toimittajien valinnassa toimittajien ympäristövastuullisuus oli otettu huomioon. Lisäksi työmaatoimintojen ympäristövaikutukset oli otettu huomioon ja niille oli asetettu projektikohtaisia tavoitteita.

Ympäristövastuullisuuden parantamiseksi tulevaisuuden teollisissa rakennushankkeissa tutkimustulosten perusteella laadittiin projektinhallinnan muistilista. Erityisesti suunnitteluvaiheilla, joilla on merkittävä vaikutus rakennuksen elinkaaren aikaisiin käyttö- ja tuotekohtaisiin ympäristövaikutuksiin, on suuri potentiaali tulevaisuuden teollisten rakennushankkeiden ympäristövastuullisuuden parantamisessa. Projektinhallinta voi vaikuttaa näihin ja muihin ympäristövaikutuksiin lisäämällä asiakkaiden tietoisuutta ympäristövastuullisuuden tuomista hyödyistä hankkeelle, asettamalla ja tukemalla ympäristövastuullisuuteen liittyviä tavoitteita, käyttämällä ohjausmekanismeja ja menetelmiä rakennusten ympäristövaikutusten hallintaan sekä tunnistamalla projektin sidosryhmien, erityisesti sisäisten sidosryhmien, mahdollisuudet vaikuttaa hankkeen ympäristövastuullisuuteen.

Avainsanat: ympäristövastuullinen, teollinen rakentaminen, projektinhallinta

Tämän julkaisun alkuperäisyys on tarkastettu Turnitin OriginalityCheck –ohjelmalla.

PREFACE

Hello,

While reading through a lot of literature for the research, I also read through a lot of prefaces. At some point I noticed that majority of the prefaces were very repetitive, and I got *tired* of reading those as I got a feeling that the prefaces did not add any value to my reading experience. After noticing this, I started to question how it is even possible that so many unique persons come up with such similar combinations of words. After thinking about that, I promised for myself that I will write a personal preface.

Although, I want to thank the thesis supervisors for their support during the project. Also, I want to thank my friends, family and favourite artists for their continuous support during university studies and overall, in the life, especially in times when I have been *rolling in the deep*. Especially I want to thank my brother with whom I had the opportunity to re-experience living together for the past 8 months. I assume that not too many people get to experience living together with their sibling(s) after childhood. I'm very grateful that I had the opportunity to do that, despite the brotherly fights :D. I love you, Wallu.

I remember confronting the burden of the environmental challenges first time when I was in elementary school. It feels like it was *million years ago*, but I still remember it clearly. I was picking up blueberries with my mom while my dad was driving with a quad bike in the same forest. As my dad drove by, I smelled the exhausts and started to cry. He then asked what was wrong and I answered that the globe is warming and if you would not ride the quad bike, it would help the Earth to survive. He then answered that the ride of the quad bike does not have any affect in Earth's survival and that many other things would have a way greater significance on tackling the global environmental challenges. Luckily, I got the point that my dad made, and I remember enjoying braaping the quad bike later that day. However, even still to this day every now and then I face the personal burden on global environment.

The essence of the story is that, in my view, it is not right for individuals, particularly children, to be burdened with concerns about the environmental consequences of their legal actions. The entities accountable for addressing environmental challenges should be the research community, the business sector, and policymakers. This thesis aims to support the research community's endeavors and to delay the beginning of *Skyfal*l.

The research was conducted as an assignment for AFRY Finland Oy.

Tampere, 7 August 2023

Veeti Wiheriäkoski

CONTENTS

LIST OF ABBREVIATIONS

BAT	Best Available Technology
BIM	Building Information Modelling
BRE	Building Research Establishment
BREEAM	Building Research Establishment Environmental Assessment Method
EIA	Environmental Impact Assessment
EMAS	Eco management and Audit Scheme
EMS	Environmental Management System
ESG	Environmental, Social and Governance
GHG	Greenhouse Gas
HVAC	Heating, Ventilation and Air Condition
LCA	Life Cycle Assessment
LCI	Life Cycle Inventory
LCIA	Life Cycle Impact Assessment
LEED	Leadership in Energy and Environmental Design
PMBOK	Project Management Body of Knowledge
TBL	Trible Bottom Line
WGBC	World Green Building Council

1. INTRODUCTION

The built environment is associated with several adverse environmental impacts. Approximately 50 % of the Earth's natural resources and around 40 % of primary energy are utilized in the building and construction sector. Moreover, the sector globally generates approximately 35 % of greenhouse gas emissions and 30 % of waste. (Ympäristöministeriö, n.d.-a) In Finland, solely buildings account for approximately 40 % of total energy consumption and generate over 30 % of all emissions (Rakennusteollisuus RT ry, n.d.). The World Green Building Council (WGBC) (n.d.) advocates to achieve a 40 % reduction in embodied carbon in all new buildings by 2030, with the requirement for these buildings to operate at net zero carbon, and total decarbonization of the sector should be achieved by 2050. Furthermore, Finland has set a goal to achieve carbon neutrality by 2035 (Climate Act 432/2022, s. 2). To attain these ambitious targets, all segments of the building sector must fulfill their respective roles, including the industrial building sector.

Based on floor space, industrial and mining buildings comprise around 10 % of total building stock in Finland (Tilastokeskus, 2022). Industrial buildings are typically customized to meet specific customer needs, and the environmental actions and functional requirements associated with industrial processes impose challenging constraints. Additionally, the buildings are primarily constructed to serve the needs of the industrial processes. These factors make it hard for governing bodies to assess industrial building's environmental performance reference levels, which could be used to control the buildings environmental effects. The primary law controlling building and construction sector in Finland is Land Use and Building Act (132/1999). Section 117 g (16.12.2016/1151) of the Act mandates that buildings should be designed as nearly zero energy buildings, however this requirement does not apply to industrial and mining buildings. Additionally, this exemption seems to persist in the new Land Use and Building Act that is set to take effect on 1st of January 2025. Furthermore, the new Land Use and Building Act requires new buildings to have a climate statement, yet this seems not to govern industrial buildings. (Eduskunta, 2023) For these reasons, other measures are needed to improve the environmental sustainability of industrial buildings. Consequently, this thesis provides means for project management to improve industrial building projects environmental sustainability.

1.1 Background and motivation

Based on current knowledge, sustainability is built upon three main pillars: Environmental, Social, and Governance (ESG), also known as the triple bottom line (TBL). The term environmental sustainability has been known since the 1980s, when concerns of human activities' environmental impacts began to emerge as a major issue. The concept of environmental sustainability gained wider attention in the 1990's, with the publication of the United Nations' Agenda 21, a blueprint for sustainable development that emphasized the need for environmental sustainability. (Purvis et al., 2019) Since then, environmental sustainability has become an increasingly important topic in global discussions and policies, as the world is confronting challenges such as global warming, deforestation, and resource depletion.

Given that environmental sustainability has become a more and more politicized topic, it is crucial to base sustainable choices on factual evidence. In the past, even non-sustainable practices have been portrayed as sustainable due to lobbying and other forms of influence. Sustainable solutions should be grounded in analytical and transparent comparisons among different options. Failing to base sustainability measures on factual evidence would be misleading to individuals, societies, and the environment. Although environmentally sustainable solutions are already available, organizations seem to lack the knowledge and motivation to implement these methods in their decision-making processes. Moreover, while global discussions predominantly currently focus on climatic effects, it is essential to remember other environmental impacts such as natural resource consumption, effects on biodiversity and waste generation.

1.2 Research objectives and definition

The main objective of the thesis is to find out how industrial building projects can be managed in a more environmentally sustainable way. To achieve this research objective, the following primary research question and corresponding sub-questions are formed:

1. How can the project management affect the industrial building project's environmental sustainability?

    1.1 What are the main tasks of project management in building projects?

    1.2 How is environmental sustainability approached in the building sector?

    1.3 How is environmental sustainability considered in the industrial building sector currently?

To answer these research questions, a literature review is conducted to explore relevant topics, and a case study is undertaken on a recently implemented industrial building project in Finland. The literature review is used to address all research questions, while the case study serves to illustrate how environmental sustainability has been addressed in a recent industrial building project. Based on the literature review and case study, the ways to enhance industrial building projects environmental sustainability through project management are identified. While project management and environmental sustainability have been extensively researched, limited research has focused on environmentally sustainable project management in the building sector, and especially in the industrial building sector.

It is essential to acknowledge that this thesis concentrates solely on the aspect of environmental sustainability within the medium and large-scale industrial building projects, thus excluding considerations related to the environmental sustainability of the industrial processes or the products generated. However, it is important to underscore that comprehensive assessments of environmental sustainability necessitate the inclusion of both process and product dimensions. Moreover, even though the thesis primarily focuses on environmental sustainability, the social responsibility and governance aspects of sustainability should not be forgotten.

El-Reedy (2011, p. 126) asserts that the selection of the most appropriate project organization type depends on specific circumstances, and there are no rigid guidelines for determining the needed organizational structure and project development process. Therefore, this thesis will provide general principles of environmentally sustainable project management that are not contingent on organizational structure. However, it is assumed that projects should always have a manager or management organization that can be held accountable for the project's success, and failure by the responsible party to effectively execute project tasks will result in an unsatisfactory outcome for both the client and the project (El-Reedy, 2011, p. 128).

Project delivery methods can serve as strategic tools for achieving sustainable building objectives. Although various project delivery methods exist, some offering more advantages and some more disadvantages for achieving environmentally sustainable outcomes, sustainability can be achieved through various project delivery methods. (Construction Specification Institute, 2013, pp. 140-152) Consequently, in this thesis environmentally sustainable project management methods are considered as universal approaches to achieve environmentally sustainable projects, independent of the specific project delivery method chosen for the project.

1.3 Research structure

From hereafter the thesis is divided into seven chapters. Chapter 2 of the thesis illustrates the basics of project and standard project management process, involving elements typically found in building projects. The chapter elucidates project management's activities during project and involves clarification of standard project objectives and goals, project stakeholders and project life cycle. Chapter 3 involves foundations of environmentally sustainable building, environmental regulation governing building and construction sector and assessments used in the sector to address environmental impacts. Chapter 4 introduces environmentally sustainable project management in the industrial building sector, involving measures for project management to address environmental sustainability in the sector. The chapter 5 examines with the help of case study how environmental sustainability has been addressed in recently implemented industrial building project in Finland. Chapter 6 discusses the research findings of this thesis and reveals the limitations of the research. Chapter 7 concludes the thesis by summarizing the research findings of the thesis and provides recommendations for further research.

2. PROJECT MANAGEMENT PROCESS

The concept of project management encompasses various interpretations, as highlighted by the Chartered Institute of Building (CIOB) (2014, p. 2). According to the definition provided by the Project Management Institute (2021, p. 1), project management can be described as the proficient utilization of knowledge, skills, tools, and techniques to effectively manage and execute project-related activities, ultimately ensuring the fulfillment of project requirements. This definition emphasizes the significance of employing a systematic approach and leveraging project management knowledge and techniques to effectively execute projects. Moreover, project management is an ongoing process throughout the project's entire life cycle, encompassing various tasks such as understanding project requirements, establishing clear objectives and goals, developing comprehensive plans, managing resources, monitoring progress, mitigating risks, and adapting to changes that arise during the project. A key aspect of project management is maintaining a holistic perspective and remaining focused on achieving the project's objectives and goals. Additionally, project management involves possessing the necessary expertise to determine what can be done, when it should be done, and who is best suited for conducting each task. (Project Management Institute, 2021) Next in the thesis, the basics of the project and project management will be clarified, including typical elements commonly found in building projects.

2.1 Project objectives and goals

Artto et al. (2011, p. 18) defines project as a unique entity that aims at a predetermined objective, it is formed by complex and interconnected tasks and is limited at least in terms of time, costs, and scope. Generally, projects are large entities that involve groups of people and other resources that are temporarily bound to accomplish specific tasks. Moreover, projects can be conducted independently or be integrated within a program or portfolio framework. (Project Management Institute, 2021) Building projects are typically associated with a fixed location, encompassing a wide range of stakeholders and employing an external project delivery team to the client, including a separation between the designers, contractors and vendors (Chartered Institute of Building, 2014, p. 2).

The objectives of the project are the future states to which the project implementation is aimed at (Artto et al., 2011, p. 22). Considering this definition, it is crucial for the project organization to have a comprehensive understanding of the future states that the project endeavors to attain. When establishing project objectives and goals, it is essential to actively engage and consider input from various stakeholders. Moreover, for project objectives and goals to be achievable they need to be confined in a mutual understanding (Artto et al., 2011, p. 87). Early stakeholder involvement enables consideration of relevant information, allowing the objectives and goals to be defined already in the early stages of the project in a practical and achievable manner. In figure 1 is illustrated the reasoning for the project objectives and goals to be defined clearly in early phases of the project.

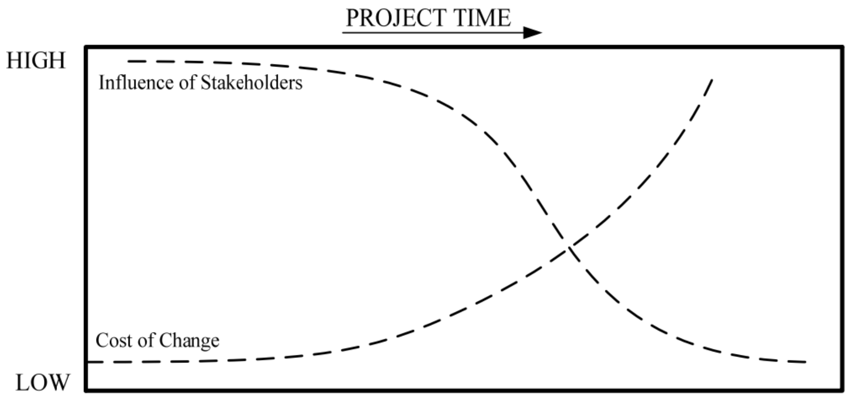

***Figure 1**. Stakeholders' influence and cost of change as the project progresses (Se, 2010, p. 4).*

In figure 1 is presented the effects that progress of the project has on stakeholders' influence and cost of change. As can be seen from the figure the stakeholders' influence decreases as the project progresses. It is important to notice that while stakeholders' influence decreases, the costs associated with implementing changes increase. This phenomenon is crucial to remember during the early phases of the project. The graph of stakeholder influence could also represent the possibility for change, which decreases likewise the stakeholder influence as the project advances.

Typically, project objectives are constrained by project goals. In conventional project models, these goals commonly encompass cost, quality, scope, and time dimensions, as illustrated by the project management triangle concept in Figure 2.

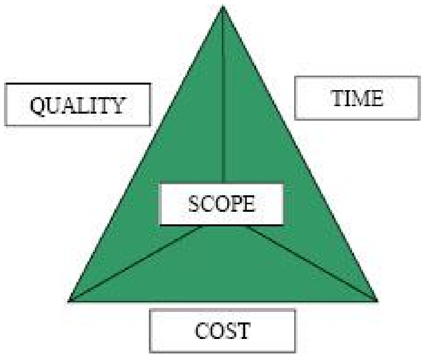

Figure 2. *Project management triangle (Caccamese & Bragantini, 2012).*

In figure 2 the traditional project constraints are presented by project management triangle, also known as the triple constraint or iron triangle, which is widely adopted way of illustrating the relations of traditional project goals among the field of project management. The triangle as representation symbolizes the fact that the constraints are interrelated and involve trade-offs – one side of the triangle cannot be changed without impacting the others and that the results of the project are formed by the combined effect of the goals. Although the triple constraint can have various interpretations, a general agreement is that project scope, time and cost comprise the three key project constraints, while project quality takes root in these three constraints and is affected by balancing the three factors. (Van Wyngaard et al., 2012)

The time goal is related to the period that starts from the project definition and ends in demarcation of the project. Project has a predefined schedule that indicates the planned achievements of milestones, while the most important milestone for the project is the milestone in which the end product is ready and available for the project's client. Time can be seen as a clear limitation factor for the project since calendar time cannot be stretched as such. For individual tasks the required time can be influenced, for example, by adding resources or using more efficient labor work. (Artto et al., 2011, p. 24)

The cost goal of a project is intricately connected to the predetermined budgets established prior to project execution. These budgets encompass various resources, such as working hours and materials, which can be used in cost goal derivation. Notably, the cost objective should be viewed as a target rather than just as a constraint; it represents a target that necessitates ensuring the appropriate allocation of costs and resources are used. Moreover, the cost goal is linked to the profit target aligned with the project's business aspect, as the project must attain the specified margin between income and costs to generate sufficient profit. (Artto et al., 2011, p. 24)

The scope goal pertains to adhering to predefined plans and specifications within a project. It is described as the product to be implemented as a result of the project and the requirements set for it. The scope objective includes both technical and functional characteristics of the product. Technical properties encompass, for example, the necessary components, materials, and structures required for project implementation, while functional characteristics relate to aspects such as performance, usability, and maintenance of the product. (Artto et al., 2011, p. 23) It is important to note that in this thesis, the scope and quality objectives are treated as independent entities, although the scope objective may include qualitative aspects as stated by Artto et al. (2011, p. 23).

The quality goal is associated with the degree to which a project fulfills the specified requirements and adheres to established standards. Quality goals entail specific targets set by the project to ensure the quality of products delivered. These targets may encompass metrics such as defect rates, customer satisfaction ratings, or compliance with industry standards. Additionally, achieving high quality can enhance the value of the project for the customer. (Artto et al., 2011, pp. 181-182; Project Management Institute, 2021)

Balancing these shifting project constraints, while maintaining stakeholder satisfaction, is project managements' ongoing activity throughout the project's life cycle. For instance, the project's time and cost goals exert limitations on the product's features and quality, thereby impacting the project's scope and quality goals. Achieving a reduced time target may necessitate increased costs or compromises in scope and/or quality goals. Due to the interrelated and potentially conflicting nature of these goals, prioritization becomes essential (Artto et al., 2011, p. 27). At times, balancing activity may include meeting with the customer, sponsor, or product owner to present alternatives and implications for project goals. Other times, the project team may be given the authority to make decisions and trade-offs to achieve the desired outcome. Irrespective of the approach, this process of balancing the constraints remains for project management responsibility throughout the project's entire life cycle. (Project Management Institute, 2021) In some projects, the primary factor may be meeting the cost objective, while in others, achieving the time target assumes greater significance. Building projects with a social aspect, such as churches and museums, often prioritize the cost objective, as the owner's investment is less susceptible to significant impacts resulting from time extensions. Conversely, industrial building projects prioritize the time goal, as unanticipated delays in project completion can considerably affect the owner's projected profits. (El-Reedy, 2011, pp. 6-7)

2.2 Project stakeholders

Achieving project objectives and goals involves satisfying the needs and expectations of various stakeholders. The project's stakeholders are all different parties, for example, organizations, associations, and individual persons, who are either affected by the project or who have an opportunity to affect the project and its success. Stakeholders' needs and expectations can be recognized as stakeholder requirements relating to project objectives and goals. Although the objective of the project serves mostly the goals of the project's client, success is required also to consider the requirements of other stakeholders. For example, the project team is an important stakeholder that affects efficiency of the project. (Artto et al., 2011, pp. 26-37) In figure 3 various possible project stakeholders for building projects are represented.

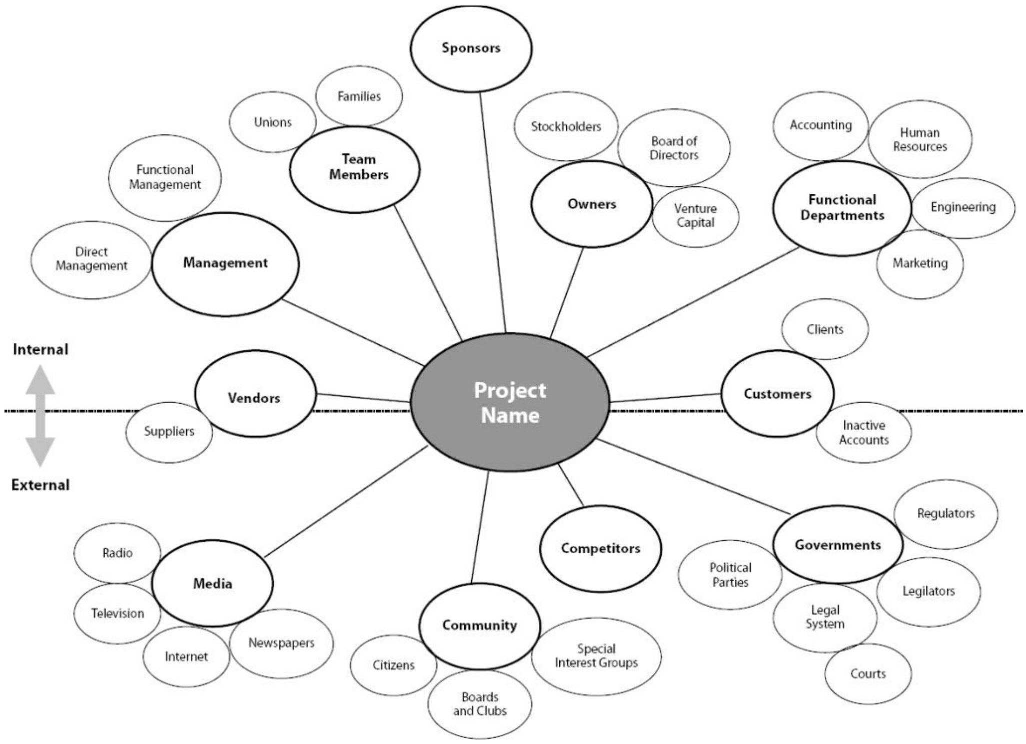

Figure 3. *Possible internal and external stakeholders of projects (Smith, 2000).*

Figure 3 illustrates the diverse array of stakeholders who can either be influenced by or that can have influence on the project. These stakeholders have been classified into two distinct groups: internal stakeholders and external stakeholders. Internal stakeholders are directly involved in the project and possess the ability to directly affect its outcomes, whereas external stakeholders may indirectly influence the project or be impacted by its outcomes (Artto et al., 2011, pp. 26-37).

Given the presence of these and other various stakeholders with potentially divergent and conflicting requirements, project management plays a crucial role in aligning objectives and goals through mutual understanding. Stakeholder requirements, particularly their expectations, may sometimes go unrecognized, and it is the responsibility of project management to identify and acknowledge these unrecognized requirements. This recognition enables stakeholders' incorporation into the decision-making process, which provides better possibility to consider stakeholders requirements during decision making process. (Artto et al., 2011, p. 32).

Additionally, it is the project owner's or owner's representatives, such as project management's, responsibility to gather enough information about the previous work experience and capabilities of the suppliers chosen for the project, and whether they have performed similar projects in the past. (El-Reedy, 2011, p. 238) This is important for the project's success as the project stakeholders influence several project success criteria. (Project Management Institute, 2021)

2.3 Project life cycle

A project life cycle is defined by the series of logically related phases that a project passes through from its initiation to its closure. The phases are generally sequential, and their names are determined by the management and control needs of the organizations involved in the project, the nature of the project itself, or its area of application. The phases can be broken down by their functional or partial objectives, intermediate results or deliverables, specific milestones within the overall scope of work, or financial availability. Phases are generally time bounded, with a start and ending point, the end of the previous phase and start of a new phase might be lapping. (Artto et al., 2011; Project Management Institute, 2021) Project phases' often have to go through phase gate reviews, also known as stage gates, to check that the desired outcomes or exit criteria for the phase have been achieved before proceeding to the next phase. Exit criteria may be tied to acceptance criteria for deliverables, contractual obligations, meeting specific performance targets, or other tangible measures. (Project Management Institute, 2021) Depending on the circumstances, nature, purpose, and value of the project, each phase has its own importance and impact on the project as a whole (El-Reedy, 2011, p. 239).

In general, any project starts from the creation of the project charter. The project charter is described in the PMBOK guide (Project Management Institute, 2021), but its name can be different from one company to another. Project charter's authorization can be held as a project's official initiation and it is important for getting a project moving in the right direction. (El-Reedy, 2011, p. 12) After authorized project charter, the project phase categorization chosen for the thesis are planning, design, execution, and closing, as illustrated by figure 4.

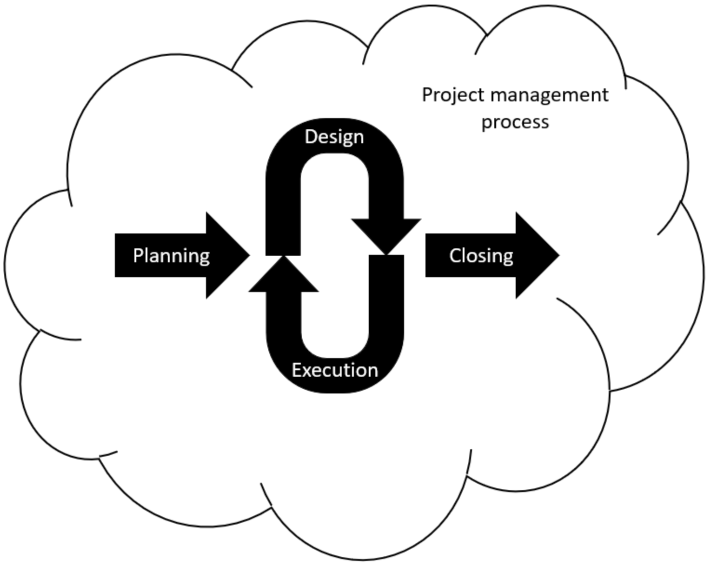

Figure 4. *Project phases.*

The phase categorization in figure 4 depicts the phase categorization used in this thesis after the project initiation. The reasoning for the chosen categorization is its ability to provide a general illustration of the phases typically encountered in building projects. Notably, the overlapping nature of the design and execution phases is illustrated by the looping arrows, reflecting the common need to revise designs after new information arises during the execution phase. Additionally, the cloud surrounding the chosen principal project phases represents the ongoing project management process encasing the entire project life cycle. Next in the thesis the main contents of each project phase are described.

Planning phase

The entry criteria for the project's planning phase consist of the approved business case and the authorized project charter. The primary objective of the planning phase is to develop plans that align with the project objectives and goals. During this phase, a high-level roadmap for the project is created, initial funding requirements are established, project team and resource requirements are defined at a high level, feasibility studies and other relevant assessments are conducted, a target milestone schedule is formulated, and other necessary plans and processes are undertaken. It is not uncommon for the initial project objectives and goals to be clarified or even modified during the planning phase. However, it is essential to have clearly defined objectives and goals by the end of the planning phase to ensure that all stakeholders have a comprehensive understanding of the project's pursued objectives and goals. Prior to concluding the planning phase, the final investment decision should be made based on the information gathered from the assessments conducted throughout this phase. (Project Management Institute, 2021)

A feasibility study serves as a preliminary evaluation of the viability of a proposed project, considering the project's predetermined requirements. The purpose of conducting a feasibility study is to determine if the project is feasible and whether it should be pursued further. (Mesly, 2017) It involves an analysis of various aspects of the project, particularly in the context of building projects, such aspects are considered as site location, technical requirements, potential risks and benefits, and financial viability. (Oberlender et al., 2022a) Typically, the feasibility study is carried out with the assistance of an engineering office or consultants hired by the project owner or its representative (El-Reedy, 2011, p. 238). At the conclusion of the feasibility study, a report is generated that provides information regarding the project's feasibility to help decision-makers in determining whether the project should proceed to the next phase, needs improvements or be terminated. (Mesly, 2017) During the feasibility study multiple criteria can be evaluated and the most viable combination should be selected. If the feasibility study indicates that the selected option for the project is viable and should be pursued, the project progresses to the pre-engineering phase.

The pre-engineering phase, also known as the Front-End Engineering Design (FEED) phase, involves the development of a more detailed project plan that outlines the scope, budget, schedule, resources, and other crucial aspects of the project. Just as significant as the feasibility study phase, pre-engineering establishes potential technical solutions for achieving the desired project outcome. The success of the subsequent stages of the project will depend not only on the feasibility of the project concept but also on the specific engineering solutions identified during this phase. Following the completion of the pre-engineering phase, the project undergoes a final investment decision to assess its continued feasibility and viability for implementation, subsequently entering the design phase where detailed engineering activities are conducted. (El-Reedy, 2011, pp. 16-20)

Design phase

The design phase focuses on developing the detailed specifications, layouts, and configurations of the project deliverables. It involves translating project requirements into concrete designs, considering feasibility, functionality, and other requirements. In the design phase the project organization defines the solutions that achieve the project objectives and goals while meeting the standards governing the sector. Design decisions made in this phase have a significant impact on the overall success of the project. (Beitz et al., 1996; Oberlender et al., 2022b) As highlighted by Beitz et al. (1996), the design phase aims to ensure that the product design is optimized regarding project requirements. This optimization process involves considering various factors such as materials, technologies, assembly methods, and other considerations. Furthermore, the design phase involves iterative refinement and evaluation of design options. Designers work closely with other project stakeholders, incorporating their feedback and ensuring that the designs align with the desired requirements and expectations. (Beitz et al., 1996)

In building projects, during the design phase architects, engineers, and designers collaborate to create detailed plans, models, and specifications to meet the requirements set for the building. The outputs of the design phase in building projects are, for example, construction drawings, technical specifications, and schedules, which serve as a foundation for the subsequent execution phase. These outputs provide guidance for the procurement of materials, equipment, and resources needed for the execution. They also provide essential instructions to the contractors on how to execute the necessary work. Before the execution phase in building projects, the contractor or contractors need to have been selected. (El-Reedy, 2011, pp. 20-26; Oberlender et al., 2022b)

Execution phase

The execution phase of a project represents the stage where the intended outcomes of the project are carried out, based on the plans and designs formulated in the preceding phases. Within the execution phase, the responsibilities and operating procedures, task content, and associated work details are clarified, along with specific resource requirements within the project team. Based on these clarifications, the necessary resources for execution are acquired, and work is carried out according to the project plans and designs. Execution phase requires the planned technical execution and procurement, and it should be considered different from the implementation of the whole project. (Artto et al., 2011, p. 30) The execution phase is important for the project's success, as it involves the actual implementation of the project plan, changes become challenging, and costs start to sink into the project.

In building projects, the execution phase starts with setting up the construction site based on the construction site plan, including mobilizing the necessary personnel, equipment, and materials on site to begin the work. After setting up the site, the actual physical construction work of the project can start, which includes such activities as ground works, foundation work, building erection, installation of various systems, and other construction-related activities. The construction phase involves managing relationships with different stakeholders, and addressing any issues or concerns that arise during the construction work. (Oberlender et al., 2022c) General management of execution is part of project management's work, but construction management is often responsible for managing construction activities. After the execution phase the project moves on to closing phase.

Closing phase

The closing phase is the final stage of the project, which involves different ending procedures. A project is typically considered complete when the delivered product has been handed over, put into operation, and acceptance has been obtained from the customer. Finalizing project documents, delivering them to the customer, and archiving them are essential tasks related to project closure. After handover, conducting a closure or feedback meeting and preparing a final project report are part of duties of project management in project closure. The project is evaluated together with the customer, and customer satisfaction feedback is collected to promote learning. The closing phase also provides an opportunity to review the project outcomes, assess the project suppliers' performance, and identify areas of improvement for future projects. However, despite the significance and opportunities provided by the project's formal conclusion and resolution of all outstanding matters, the closing phase often receives insufficient attention. (Artto et al., 2011, p. 39)

In building projects, the closing phase typically involves such tasks as commissioning and testing, final inspection and punch list, documentation and handover, project closeout, and demobilization. Commissioning and testing involve thorough examination of the completed project artifacts to verify their compliance with stipulated requirements, followed by their formal commissioning for the client's use. Final inspection and punch list involves carrying out a final inspection of the completed project and creating a punch list of any outstanding items or issues that need to be addressed prior to handover. Documentation and handover activities encompass the completion of all project-related documents, such as as-built drawings, operation and maintenance manuals, warranties, and certificates, as well as the formal transfer of the completed project to the client. Project closeout involves the settlement of all project accounts, including final payments to suppliers, as well as the termination of all contracts and agreements associated with the project. Demobilization encompasses the proper disposal of construction-generated waste materials, dismantling any temporary structures, and the withdrawal of personnel and equipment from the project site. It is also recommended to conduct post-project evaluations among project stakeholders to assess project success and identify valuable lessons learned for future endeavors. (Oberlender et al., 2022d).

While literature often regards monitoring and control as a distinct phase within the project (Artto et al., 2011; Campbell, 2014; Project Management Institute 2021), in this thesis monitoring and control is recognized as project management's activity throughout the entire life cycle of project. Monitoring and control involves monitoring the project's progress through various reporting mechanisms. Reporting focuses mainly on comparisons between planned and actual statuses, aiming to identify deviations from targets. Additionally, reporting should be proactive to reveal potential future deviations rather than those that have already occurred. This provides better opportunities to take corrective actions in a timely manner. Additionally, change management and systematic change control methods play a crucial role in monitoring and control activities. If the project does not progress according to the plans, the situation must be analyzed, and necessary changes should be made to the project plan. The monitoring and control activity is especially important in the execution phase, providing feedback to the design phase. (Artto et al., 2011, p. 39; Project Management Institute, 2021) Furthermore, the monitoring and control should be integrated into stakeholders' internal management procedures. This includes, for example, documenting changes made to the project plan, tracking progress against targets, and preparing regular progress reports. These measures contribute to effective monitoring and control practices in project management. (Oberlender et al., 2022d)

As illustrated by the cloud in figure 4 the project management's tasks are needed throughout the project. Comprising already mentioned project management activities during projects, figure 5 illustrates the project management knowledge areas acknowledged by the PMBOK (Project Management Institute, 2021).

Figure 5. *Different project management knowledge areas, based on (Project Management Institute, 2021).*

Figure 5 presents a visual representation of the knowledge areas within the domain of project management, depicted within the framework of the project management cloud. As can be seen from the figure, project management encompasses management of various activities and resources across the entire life cycle of a project. Each of these knowledge areas consists of various processes, tools, and techniques that project management can use to manage different aspects of a project more effectively. By applying these knowledge areas, project managers can enhance their ability to deliver projects successfully and meet project objectives and goals within the project constraints. (Project Management Institute, 2021)

3. ENVIRONMENTAL SUSTAINABILITY IN BUILDING PROJECTS

Next in the thesis the fundamental principles for environmentally sustainable buildings and building projects are introduced, followed by an introduction to the regulatory framework that establishes the requirements and guidelines for mitigating environmental impacts in building and construction sector. Once the foundations and regulatory aspects of environmentally sustainable building projects have been established, the thesis will proceed to present assessments for evaluating and enhancing building projects environmental sustainability. The assessments outlined in this chapter offer measures to address and manage the major factors of building projects' environmental impacts, thereby enhancing the pursuit for more environmentally sustainable building projects.

3.1 Foundations

An early definition for sustainable construction was presented in 1994 by Charles J. Kibert at the First International Conference on Sustainable Construction held in Tampa, Florida, US. Kibert (1994) proposed that sustainable construction means creation and management of a healthy built environment by controlling resource efficiency and environmental degradation. Moreover, in the same conference Wyatt (1994) stated sustainable construction to include “cradle to grave” appraisal, which includes managing the serviceability of a building during its lifetime and eventual deconstruction, which should be approached more as a disassembly than as a traditional demolition work.

As previously discussed in this thesis, the project management triangle serves as a representation of the traditional project management approach towards managing projects. The traditional project management approach aims to efficiently allocate and utilize resources dedicated to a project, with the objective of achieving the optimal combination of time, cost, and quality performances to maximize stakeholder benefits (Costantino et al., 2015). Nevertheless, as Armenia et al. (2019) highlights, this approach has faced criticism over time for its reductionist nature, as it inadequately addresses broader social and environmental concerns associated with sustainability challenges. Consequently, there is a disparity in the evaluation criteria between project success and project management success, hindering the effective integration of sustainability considerations in the project management process (Bannerman, 2008).

Armenia et al. (2019) emphasize that these challenges create trade-offs for project management, as the traditional approach may overlook essential sustainability factors. By focusing primarily on short-term project efficiency, the broader and long-term impacts of projects can be neglected. Thus, adopting a more comprehensive and integrative approach that incorporates sustainability considerations into project management practices is crucial for addressing sustainability challenges effectively. (Armenia et al., 2019)

However, when environmental and sustainability aspects are incorporated as project goals, the interconnections among these constraints become more complex due to the inclusion of additional considerations. In the context of environmentally sustainable building, the project goals expand to include objectives related to resource depletion, harmful emissions, and biodiversity preservation (Bourdeau, 1999). Figure 6 illustrates the expansion of the traditional project management triangle when these criteria are incorporated, depicting the increased complexity and interconnectedness of the project constraints.

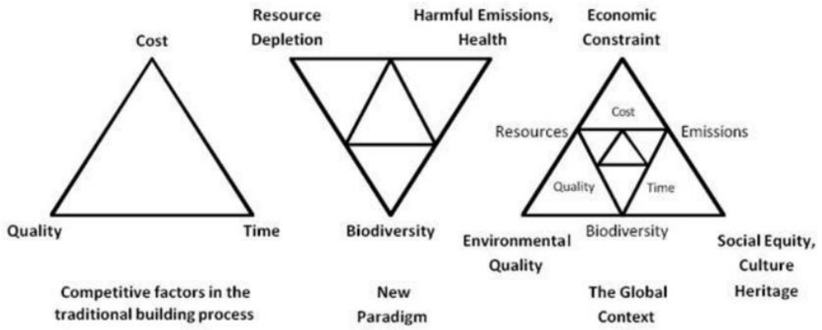

Figure 6. *Added project constraints through considering sustainability as project goal (Collins, 2011, p. 18).*

In figure 6 the leftmost triangle represents the traditional project management triangle, while the center triangle incorporates constraints pertaining to environmental sustainability, including goals related to resource depletion, harmful emissions, and biodiversity. Finally, the rightmost section of the figure portrays the project constraints when Environmental, Social, and Governance (ESG) criteria are considered as project goals. By introducing additional goals into the project, the project management's challenges are expected to increase due to the augmented and frequently conflicting goals (Project Management Institute, 2021).

In the context of the complex relation between construction practices and the environment, there has been a conscientious drive towards promoting sustainable design and operational methodologies. This endeavor aims to establish a framework that enhances the harmony between the natural ecosystem and the built environment. Consequently, environmentally sustainable buildings endeavors to discern and adopt an ecological paradigm that perceives these two domains as fundamentally interlinked entities (Adebayo, 2002).

Furthermore, as Huovila and Koskela (1998) states sustainable construction or also known as green building is seen as a building and construction sector's solution to achieve sustainable development. The U.S. Environmental Protection Agency (2016) has defined the green building as "The practice of creating structures and using processes that are environmentally responsible and resource-efficient throughout a building's life cycle from siting to design, construction, operation, maintenance, renovation, and deconstruction. This practice expands and complements the classical building design concerns of economy, utility, durability, and comfort. Green building is also known as a sustainable or high-performance building."

At the project level, the integration of sustainability principles should begin already during the project's initiation and endure throughout the entire life cycle of the project. Sustainable choices made during the early stages of the project hold greater significance compared to those made at later stages, as the feasibility of adopting sustainable solutions decreases while the project progresses. Design and construction decisions will influence the building's operational costs, and in many cases the revenue generated over the building's lifetime (Boswell & Walker, 2004). According to studies conducted by Shady (2018), and Dwaikat and Ali (2018), environmentally sustainable buildings may entail higher initial costs, but they exhibit lower operating costs and an enhanced overall value, thereby increasing the owner's profits when considering the building's entire life cycle. Thus, these considerations need to be made during the projects.

At the operational level, environmental sustainability encompasses the utilization of energy and other resources, as well as the management of waste generated from the processes. Environmental sustainability efforts primarily focus on minimizing waste generation, mitigating pollution, enhancing energy and material efficiency, reducing emissions, limiting the use of hazardous or toxic materials, and minimizing the occurrence of environmental incidents. (Gimenez et al., 2012)

3.2 Regulations

The significance of regulations in relation to environmental conditions may not be readily apparent when regulations effectively fulfill their intended purpose, thereby making it challenging to detect the relation between regulation and the state of the environment. Nonetheless, historical evidence suggests that environmental regulations have played a crucial role in resolving various environmental issues, such as water usage and pollution, ozone depletion, and land use planning (Kokko, 2017, p. 1). Environmental sustainability is governed by a diverse array of legislative measures and norms, with global environmental law representing the most comprehensive framework. In addition to global environmental law, environmental regulations are implemented at the European, national, local, and individual actor levels. In this chapter, the most significant environmental regulations impacting the building sector in Finland are introduced.

3.2.1 Global and European environmental law

The global environmental law describes the international regulatory level, which consists of national agreements between states whose goal is to protect the environment globally. The drivers for environmentally sustainable construction are set in motion by national-level strategies, which are aimed to respond on harmful environmental changes caused by human activities. The international agreements concerning Finland are for example, the UN framework agreement on climate change, i.e., climate agreement 1992 (SopS 61/1994) and the Convention on Biological Diversity, i.e., Biodiversity Convention 1992 (SopS 78/1994). International agreements can be supplemented with authorization provisions with the given protocols. For example, the climate agreement has been supplemented by the Kyoto Protocol in 1997 (SopS 12/2005 and SopS 13/2005). (Kokko, 2017, pp. 33-39) The UN framework agreement on climate change was supplemented by the Paris Agreement in 2016, which goal is aimed worldwide to pursue to limit the global warming to 1.5 ℃ compared to pre-industrial levels. Therefore, the goal is to reduce as quickly as possible greenhouse gas emissions, which are contributing to global warming. The Paris climate agreement does not impose quantitative emission reduction obligations, but with the help of the agreement the parties undertake to implement their national emission targets. (UNFCCC, 2015)

The aim of EU's environmental policy is to preserve, protect and improve the quality of the environment, protect people's health, consume natural resources in sustainable way and fight against climate change. Article 37 of the Official Journal of the European Union (2016/C 202/02) emphasizes that a high level of environmental protection and improvement of environmental quality must be included in Union policies in accordance with the principle of penetration and ensured in accordance with the principle of sustainable development. EU's environmental goals are carried out through legislative procedure and according to Article 192 of the Treaty on the Functioning of the EU (TFEU). However, the EU institution is not directly able to influence the legislation of the member states or act in their member states' treaties outside of their jurisdiction, it is still seen as having great impact on fight against climate change. (Kokko, 2017, pp. 39-47)

The environmental policy goals presented above are specified with the help of environmental programs, which guide the implementation of environmental and climate policy. The eighth environmental program entered into force in May 2022 and is valid until 2030. The purpose of environmental programs is to accelerate the European Green Development Program inclusively and fairly, so that the EU achieves its goal to be carbon neutral by 2050, which is set in the European Climate Act. The latest environment action program focuses on speeding up the transition to a climate-neutral and resource-efficient economy while recognizing that human wellbeing and prosperity depend on healthy ecosystems. (European Commission, n.d.)

The climate policy framework of the European Union centers on three fundamental components: the Emission Trading System (ETS), national burden sharing arrangements for sectors not covered by the ETS, and specific obligations related to the Land Use, Land Use Change, and Forestry (LULUCF) sectors (Ympäristöministeriö, n.d.-b). Among these, burden sharing and LULUCF mechanisms directly affect the building and construction sector, while the ETS indirectly impacts the sector by encompassing the production of various resources used in the sector. These policy instruments collectively aim to drive emissions reductions, foster sustainable land management practices, and promote environmentally sustainable practices across the EU to support the pursuit of climate change mitigation and sustainability objectives (Ympäristöministeriö, n.d.-b).

3.2.2 Finnish environmental law

National environmental rights have become a fundamental principle of sustainable development. National regulation describes the level of regulation that is based on the states' own legislation but is also guided by international level. (Kokko, 2017, p. 47) Finland's climate policy is shaped by obligations imposed by the EU's climate policy, the United Nations' climate agreement, the Kyoto Protocol, and the Paris climate agreement. With the help of climate policy, Finland's goal is to reduce greenhouse gas emissions, increase the share of renewable energy sources, improve energy efficiency, and promote adaptation to climate change. (Laine et al., 2020)

In Finland, the normative framework for the national legal system is anchored by the Finnish Constitution (731/1999), serving as its highest level. The fundamental environmental right is linked to section 20 of the Finnish Constitution, according to the section, responsibility for nature and its diversity, environment and cultural heritage belongs to everyone. Under the Constitution no one can be directly made responsible for the environment, but the responsibility is carried out by ordinary laws. Furthermore, the Finnish Constitution explicitly mandates the Government to safeguard the right of all citizens to a healthy environment and facilitate their participation in decision-making processes concerning their living environment. In line with this provision, public authorities are obligated to promote environmental protection and ensure opportunities for citizens to engage in environmental affairs and contribute to decision-making when developing legislation and administrative practices (Kokko, 2017, pp. 48-49).

In Finland, several legislations control the building and construction sector's environmental impacts. These include, for example, Environmental Protection Act (527/2014), Act on Environmental Impact Assessment Procedure (252/2017), Climate Act (423/2022), and Land use and Building Act (132/1999). (Ympäristöministeriö, n.d.-c) These legal instruments are central to regulating and governing environmental concerns in the building and construction sector, reflecting Finland's commitment to sustainable development and environmental protection within the context of national legal frameworks.

Environmental Protection Act (527/2014) sets the general framework for environmental protection in Finland. The act includes provisions related to construction activities, emissions control, waste management, and environmental impact assessments. Act on the Environmental Impact Assessment Procedure (252/2017) implements the EU's Directive on Environmental Impact Assessment. It requires building and construction projects exceeding certain thresholds to undergo Environmental Impact Assessment (EIA) procedure to evaluate and mitigate potential environmental impacts. The aim of the law is to promote the evaluation and consideration of environmental impacts in planning and decision-making. The procedure also increases access to information and participation opportunities for all project stakeholders. Climate Act (423/2022) sets national targets and measures to mitigate climate change and adapt to its effects. It addresses greenhouse gas emissions reduction strategies and energy efficiency requirements for various sectors, including the building sector. The Land use and Building Act (132/1999) is the main act concerning the building sector. General objective for the Land Use and Building Act (132/1999) is to provide a legal framework for sustainable, efficient, and balanced land use planning and construction practices in Finland. The current Land Use and Building Act is in effect until 31st of December 2024, the revised Act is entering into force on 1st of January 2025 (Ympäristöministeriö, n.d.-d).

In addition to the previously mentioned environmental legislations, the building and construction sector in Finland is governed by several other pertinent laws and regulations aimed at promoting environmental sustainability. Noteworthy among these are Water Act

(587/2011), Waste Act (646/2011), Energy Efficiency Act (1429/2014), and Chemicals Act (599/2013). These legislations address critical aspects such as water management, waste handling and disposal, building's energy performance, and the regulation of chemicals used to minimize their adverse impact on the environment. (Ympäristöministeriö, n.d.-c)

Furthermore, specific regulations pertaining to environmental damage, noise control, and air quality further contribute to the comprehensive legal framework governing the construction sector's environmental responsibilities (Ympäristöministeriö, n.d.-c). These regulations are designed to ensure that construction activities are conducted in a manner that minimizes negative environmental impacts, safeguards natural resources, and upholds high standards of environmental protection and sustainability throughout the construction lifecycle. By incorporating these legal instruments, Finland endeavors to foster sustainable development and maintain ecological integrity within building and construction sector.

Regional and local regulatory levels are described in provinces, municipalities, and regional administrative authorities of state. One key form of regulation at the regional level concerning building sector is zoning, Zoning procedure is guided through the Land Use and Building Act (132/1999) and the Land Use and Building Decree (895/1999) concerning approval of the plan map. Other regulation means that municipalities can issue to guide environmental protection and its use, within the framework of self-government, are normative decisions, norms. (Kokko, 2017, pp. 51-52) Such norms include, for example, building regulations for municipalities, which municipalities are required to have by Section 14 of the Land Use and Building Act (132/1999). Other similar municipal norms are the environmental protection regulations according to section 202 of the Environmental Protection Act (527/2014) and the waste management regulations according to section 91 of the Waste Act (646/2011).

3.2.3 The actors' self-regulation

The actors' regulatory level refers to the self-regulation generated by specific business sectors, professional groups, companies, or other community entities. This form of self-regulation complements other levels of regulation and occupies the lowest position within the norm hierarchy. It is important to note that self-regulation norms must not contradict higher regulatory levels, and some of these norms are more social in nature rather than being strictly legally binding. Additionally, it's good to notice that self-regulation as a term clearly describes how environmental legislation as a concept is no longer sufficient to cover diversified environmental regulation. (Kokko, 2017)

Self-regulation's goal may be to ensure the quality of the operations in certain industry sector or professional group. Often the aim is also to increase appreciation and trust among the public. Sometimes self-regulation is motivated by an effort to prevent the legislature from interfering in the sector. This can be done by showing that the usual legal regulations are unnecessary (Tala, 2005, p. 19) Moreover, research indicates that adopting responsible business practices has a positive impact on a company's operations. Responsible business entails not only compliance with national laws but also surpassing legal requirements (Liappis et al., 2019).

According to Tala (2005), self-regulation can be categorized into four distinct levels: firstly, rules formulated in a general format; secondly, mechanisms established to monitor or oversee compliance with these rules; thirdly, a system of sanctions for violations; and finally, a decision-making method for resolving disputes.

At the first level of self-regulation the actors themselves create the initiative and regulatory measures for regulation without external parties, which makes it the clearest self-regulation method of the four. In this case, the creation and maintenance of a self-regulatory system is voluntary, as well as compliance with regulatory rules. (Tala, 2005) An example of this kind of self-regulation is the company's internal operating guidelines for prevention of environmental damage (Kokko, 2017, p. 54).

The second level of self-regulation is, for example, to join in an industry specific certification system that is controlled by an external actor. By complying with the requirements of the certification system, the operator is given the right to use environmental certification, for example, in its marketing. (Kokko, 2017, p. 54) Certification systems offered by an external operator in the building and construction sector are for example BREEAM and LEED, which are both targeted as buildings' international environmental classification systems. BREEAM (Building Research Establishment Environmental Assessment Method) classification was created by BRE (Building Research Establishment) based on the European standards. The buildings to be certified are classified into different categories according to the specified criteria. BREEAM is the most widely used building environmental rating system in Europe. LEED (Leadership in Energy and Environmental Design) rating is based on American practices and was created by the U.S. Green Building Council. The system is globally the most used classification system regarding buildings' environmental sustainability. In the classification system, buildings can be evaluated differently in categories and classes. The advantages of certification systems are their uniform set of criteria and global comparability. (Green Building Council Finland, n.d.-a)

The third means of self-regulation can be based on the regulatory framework set by the state or the EU, where a voluntarily committed actor is able to implement the final regulation quite independently (Kokko, 2017, p. 54). One example from this kind of low level of self-regulation is EMAS (Eco-Management and Audit Scheme), which is a European management and audit system based on the Regulation (EC) No 1221/2009 of the European Parliament and is structured according to the international environmental standardization system, ISO 14001. Environmental systems are created as part of the operator's own environmental management and with the help of the system the operator can recognize its direct and indirect environmental effects. Through detecting the environmental effects, the organization can systematically work towards a more efficient and environmentally sustainable way of operating. To receive EMAS certificate and EMAS logo, to use in communication, the organization needs to commit to comply with environmental legislation, continuously improve the level of environmental protection, and publicly report on environmental issues. (Suomen ympäristökeskus, 2023)

Green Deal agreements are another example of this level of self-regulation. The Green Deal agreement describes a voluntary agreement between the state and the operator. The agreement aims to promote the circular economy and find solutions for overconsumption of natural resources, the reduction of biodiversity and climate challenges. From the point of view of the Finnish building and construction sector, the most significant Green Deal agreements are Green Deal for non-road mobile machinery sector (2019-2025), Green deal on sustainable demolition (2020-2025), and Emission-free construction sites - Green Deal for sustainable procurement - agreement (2020-2030). (Parviola, 2022)

The fourth element of self-regulation can be used in situations where participants are in dispute. self-regulation can be seen as a solution on the dispute, but it needs to be sure that self-regulation can’t contradict the upper-level regulation. The advantage of self-regulation is that it enables a faster response compared to legislation-based control. Self-regulation goal is often an effort to continuously improve operations or quality, for example anticipating the changing needs of key stakeholders. (Kokko, 2017)

3.3 Assessments

Environmental assessment methods hold a pivotal role in the building and construction sector's pursuit for environmental sustainability, as they are indispensable in mitigating and reducing the environmental impacts associated with the buildings. Prior to addressing these impacts, it is essential to identify and comprehend the potential environmental consequences of these projects. (Green Building Council Finland, n.d.-b) The use of environmental assessments can be supported by regulations, but actors can additionally use industry-validated voluntary assessments to perform their environmental sustainability.

Green Building Council Finland (n.d.-b) introduced buildings life cycle indicators in 2013, which focus on key aspects from an environmentally sustainable perspective, such as a building's energy performance and carbon emissions throughout its entire life cycle, encompassing both the design and use phases. The environmental impacts of a building are predominantly determined by project planning and design, underscoring the critical importance of addressing environmental concerns during these initial phases (Khaleel, 2021).

While the initial phases of a project undoubtedly hold great importance for mitigating buildings environmental impacts, it is crucial to acknowledge that the construction and use phases of a building contribute significantly to its environmental impacts. Thus, efforts to mitigate these impacts must extend beyond the planning and design phases. During construction activities, effective planning, thoughtful material selection, efficient production methods, optimized construction practices, waste management, and material reuse strategies can all contribute to mitigating the environmental impacts of the project. (Khaleel, 2021) Throughout the building's use phase, environmental stewardship responsibilities lie with its users. Users are accountable for utilizing, maintaining, and repairing the building and its systems in line with their intended design and functionality (Häkkinen et al., 2020, p. 164). This underscores the need for active involvement and commitment from users to ensure optimal and sustainable building performance over time.

According to research studies, energy performance assessments and life cycle assessments are recognized as the most significant measures for reducing the climatic impacts of building projects (Khaleel, 2021; Häkkinen et al., 2020; Ympäristöministeriö, n.d.-e; Green Building Council Finland, n.d.-b). These methods provide valuable insights and frameworks for assessing and addressing the environmental sustainability of building projects. Additionally, in this thesis project suppliers' environmental sustainability assessments are seen to support sustainable building project's success. In the context, supplier refers to a project stakeholder that is selected for the project to contribute to achievement of project deliverables. Next in the thesis these measures are clarified.

3.3.1 Building's energy performance

Energy performance assessments consider factors such as building envelope insulation, energy form used in building, heating and cooling systems, equipment efficiency, and machinery energy consumption. By analyzing these parameters, energy performance calculations help to identify opportunities for energy savings and optimize the building's energy performance. (Ympäristöministeriö, 2018) Governments and regulatory bodies in EU have set energy performance regulation and standards that certain building typologies must meet, and energy performance calculations play a role in ensuring compliance with these energy regulations and standards. Energy performance assessment schemes and methods are primarily established for two purposes: energy classification and energy performance diagnosis. (Wang et al., 2012)

Energy classification entails the adoption of standardized or authorized approaches to effectively communicate building’s comparative energy efficiency and carbon emissions to both building owners and other interested stakeholders. The aim is to promote ongoing efficiency improvements and conservation efforts. (Wang et al., 2012) The energy performance can be classified by energy certificate. The classification of energy efficiency is based on the building's E-figure, which is a calculation tool that provides a standardized metric for comparing the energy performance of different buildings. The E-figure is calculated by first determining the purchase energy consumption based on the building’s standardized use, weighing the calculated purchase energy consumption by with the coefficient of each energy form and adding up the total energy consumption, and finally by reporting the total result per net heated area of the building per year. The coefficients of energy forms in Finland are given in Government Decree (788/2017). This benchmarking allows owners and other interested parties to identify buildings’ energy performance and encourages the adoption of energy-efficient design strategies and technologies. (Green Building Council Finland, n.d.-b; Ympäristöministeriö, 2018)

Energy performance diagnosis focuses on identifying faults and diagnosing the underlying causes of suboptimal performance in buildings. This diagnostic process enables the provision of targeted energy-efficient measures to enhance the building’s overall energy performance. (Wang et al., 2012) Particularly, energy performance diagnosis can be valuable when dealing with buildings lacking comprehensive benchmarking data yet having the desire to enhance the building's energy performance. In such cases, the diagnostic methodology offers an effective tool to assess and address energy inefficiencies, enabling the implementation of appropriate measures to improve the building's energy performance.

Energy performance assessments can be used in the design phase of building projects to determine and optimize energy efficiency. By using modeling and simulation tools, designers can assess the energy performance of different design options and identify the most efficient strategies. These calculations consider factors such as building orientation, energy form selection, building envelope insulation, HVAC system efficiency, and waste heat recovery systems. Through analysis, designers can make informed decisions that enhance the energy performance of the building. (Wang et al., 2012) Moreover, energy performance calculations enable the prediction and forecasting of a building's energy consumption and associated costs. The forecasting can support building projects' decision-making in planning phase regarding buildings' energy performance.

Energy performance measurements are used to validate the actual energy consumption of buildings after the construction phase. These measurements, based on real energy consumption data, serve multiple purposes. Firstly, they can be utilized to establish real life energy efficiency goals and verify the achievement of these objectives. Secondly, energy performance measurements enable the monitoring, planning, management, and improvement of energy consumption, economic performance, and overall efficiency of properties. Furthermore, they provide a basis for allocating the costs associated with energy procurement among different users. (Green Building Council Finland, n.d.-b)

Moreover, the comparison between the designed energy performance and the measured energy performance allows for a comprehensive assessment of the accuracy of the initial calculations. This verification process plays a critical role in identifying any potential discrepancies and provides valuable insights for optimizing building performance. Operational adjustments, effective maintenance practices, and strategic retrofitting initiatives can be implemented based on these findings. (Green Building Council Finland, n.d.-b) By employing energy performance calculations and measurements, stakeholders in the building sector can effectively enhance energy efficiency, ensure the alignment of buildings with sustainability objectives, and ultimately contribute to the development of a more sustainable and environmentally sustainable built environment.

3.3.2 Life cycle assessment

The environmental impacts of buildings can be categorized into embodied and operational impacts. Embodied impacts pertain to the environmental consequences associated with building products, while operational impacts relate to the building's ongoing operation. Of these, the operational environmental impacts, especially energy consumption, have received significant attention, as they heavily influence the outcomes of a building's life cycle assessment. However, the focus from energy consumption during the operational phase is gradually shifting, as buildings become more energy-efficient, and the utilization of renewable energy sources increases. Consequently, this shift underscores the importance of critically evaluating other life cycle phases, such as the materials used in buildings and their manufacturing processes (Häkkinen et al., 2020, pp. 40-41).

Life Cycle Assessment (LCA) serves as a quantitative approach to comprehensively examine the environmental consequences of products and services throughout their entire life cycle. This assessment considers all stages, starting from raw material extraction, encompassing production, utilization, and finally, end-of-life disposal and recycling. As such, LCA is commonly referred to as a "cradle to grave" approach in evaluating environmental impacts. An important aspect of LCA involves identifying potential transfers of environmental impacts from one medium to another and/or from one life cycle stage to another. The application of LCA enables the recognition and inclusion of such trade-offs in the analysis, which would otherwise be overlooked if LCA was not conducted, as it may lie outside the typical scope or focus of the decision-making process. (Curran, 2015)

The LCA methodology is standardized and well-established, adhering to the ISO 14040 series of standards. The ISO 14040 framework provides a structured basis for conducting LCA analyses and ensures consistency and reliability in the assessment process. The ISO-standardized LCA methodology allows for a systematic evaluation of environmental impacts associated with products and services, facilitating more informed decision-making in sustainable development practices. LCA framework based on ISO 14040 is depicted in figure 7.

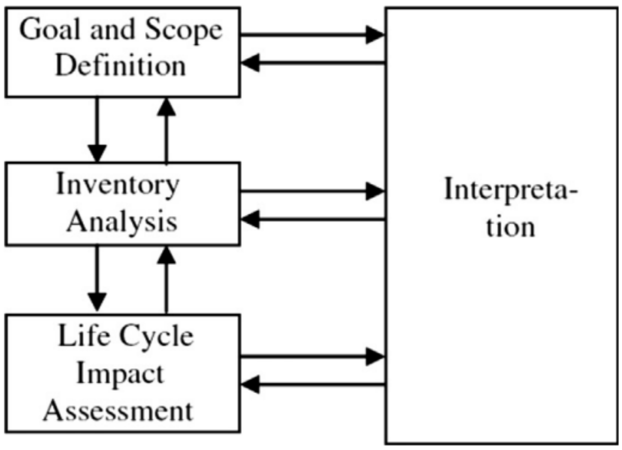

Figure 7. *LCA framework (SFS-EN ISO 14040).*

The LCA framework illustrated in figure 7 consists of four distinct phases: Goals and Scope definition, Life Cycle Inventory Analysis (LCI), Life Cycle Impact Assessment (LCIA), and Interpretation. The Goals and Scope definition phase encompasses establishing the purpose and boundaries of the LCA study, including the system boundaries and level of detail. These aspects are intrinsically linked to the primary objective of the LCA. The Life Cycle Inventory Analysis (LCI) involves the compilation and quantification of input and output data concerning the system under investigation. This phase entails collecting relevant data to meet the predetermined study goals and scope, enabling a comprehensive understanding of the life cycle of the product or service being assessed. Moving to the Life Cycle Impact Assessment (LCIA), the objective is to provide additional insights to comprehend and evaluate the environmental significance of the product system's LCI results. LCIA aids in assessing the potential environmental impacts associated with the life cycle stages of the product or service. The final phase, Life Cycle Interpretation, involves evaluating the outcomes of either the inventory analysis or the impact assessment, or both, concerning the established goals and scope. This phase aims to draw conclusions and make recommendations based on the LCA findings. (SFS-EN ISO 14040) By systematically following the LCA framework, researchers and practitioners can conduct comprehensive and robust life cycle assessments, contributing to informed decision-making in sustainable development endeavors.

The life cycle of a product or service can be highly intricate, encompassing various stages, starting from raw material extraction and processing to production, followed by distribution to the end-users, and finally culminating in recycling or disposal (Suomen ympäristökeskus, n.d.). To help the identification and assessment in the building and construction sector the building’s life cycle is divided into modules. Figure 8 provides a categorization of a building's life cycle into these modules based on SFS-EN 15978, outlining the different stages and components that are subject to environmental analysis and evaluation.

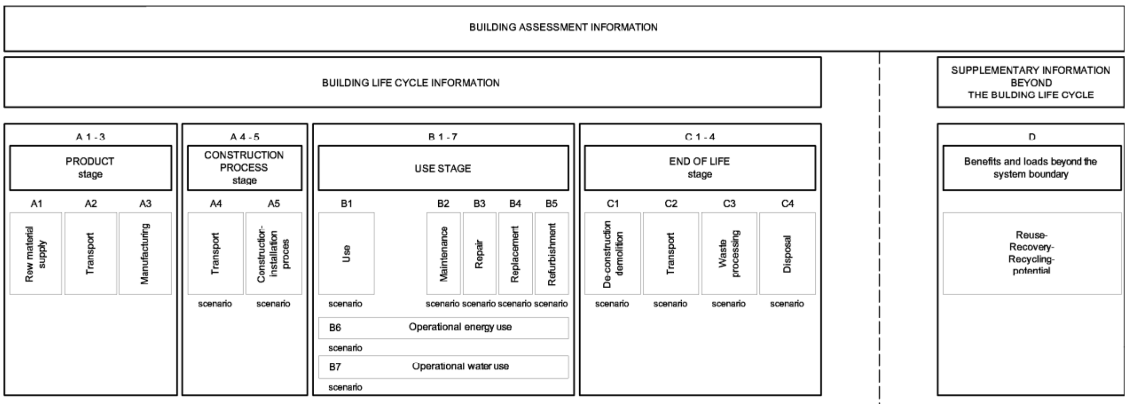

Figure 8. *Building's life cycle modules (SFS-EN 15978).*

In figure 8 is illustrated the division of a building's life cycle into four distinct modules, denoted as A to D. Each module is further subdivided into different subcategories, for example, module A encompasses the product and construction process stages, represented by numerical differentiations.

In building life cycle assessments, various environmental impacts are typically studied, including climatic effects, emissions to water and soil, changes in land use, eutrophication of water bodies, and natural resource usage. Additionally, the life cycle analysis method is employed in various footprint calculations, wherein each calculation focuses on assessing a specific environmental impact individually (Malinen, 2022). One of these is the carbon footprint assessment, which has garnered significant attention in recent years.

In carbon footprint analysis GHG- emissions that are produced by different activities during the products life cycle are measured. The term carbon footprint is used as the carbon dioxide CO_2 is the predominant GHG being emitted by human activities. Yet other GHG emissions, including methane CH_4 and nitrous oxide N_2O, also have significant contributions to global warming. Emissions from these other gases are normalized to the mass of CO_2 and carbon footprint results are reported as one unit, mass of CO_2 equivalent CO_2e (e.g., kg of CO_2e or metric tons of CO_2e). The carbon footprint analysis considers the origins, composition and amounts of the emitted greenhouse gases. The GHG sinks and removal rates should also be included in a carbon footprint analysis to be able to determine the net emission rates, which the footprint refers to. Carbon offsetting of compensations should not be considered in carbon footprint assessments. (Franchetti & Apul, 2012)

Life cycle assessment poses a significant challenge due to its intricate and complex value chain, wherein many of the stages are beyond the direct control of the company conducting the analysis. Acquiring and collating comprehensive information concerning the environmental effects at various stages of the product's life cycle may necessitate extensive research and data gathering efforts. Additionally, environmental impacts often have to be addressed indirectly through subcontractors and other external partners (Liappis et al., 2019, p. 117).

One method to help conducting the LCA is Environmental Product Declarations. An EPD (Environmental Product Declaration) is a voluntary and publicly available document used to communicate the results of a product’s Life Cycle Assessment (LCA) and its environmental impacts throughout its entire life cycle, from raw material sourcing and manufacturing to its end-of-life phase, involving at least modules A1-A3, C and D. EPDs can be created for a wide array of items utilized in the construction industry, including raw materials, components, products, product groups, combinations of products, building elements, and technical equipment. (Building Information Foundation RTS sr, 2021).

The primary goal of EPDs is to furnish stakeholders with accessible and standardized information about the environmental performance of the evaluated product, ultimately promoting informed decision-making and supporting sustainability in the construction sector. In the European Union, EPDs are developed following the guidelines set forth in the EN 15804 standard. The harmonization between EN 15804 and EN 15978 standards ensures the seamless integration of product-level data and assessments into broader building-level life cycle assessments. (Vuorinen, 2019)

However, research conducted by Lindqvist (2022) indicates that comparing the environmental impacts of building products using EPDs can present challenges. Despite the standardization efforts, differences in reporting methodologies and the consideration of various technical attributes contribute to the complexity of product comparison based solely on EPDs. Consequently, stakeholders should approach EPD-based comparisons cautiously, considering both environmental and technical aspects to make well-informed decisions promoting sustainable practices in the construction industry. (Lindqvist, 2022)

3.3.3 Suppliers’ environmental sustainability assessment

The client or developer plays a critical role in achieving sustainability in building projects. They hold the responsibility of demonstrating leadership to other project stakeholders and driving innovation through their supply chain to deliver more efficient, less polluting, and economically viable buildings (Häkkinen & Belloni, 2011). Sodagar et al. (2008) emphasize that assessing sustainable outcomes for projects is a shared responsibility among all stakeholders. Furthermore, Rohracher (2001) underscores that successful sustainable building projects require a close and coordinated interaction between project stakeholders. Additionally, Rekola et al. (2012) emphasizes that sustainable building projects necessitate a high level of compatibility among stakeholders, surpassing that of traditional building projects. Therefore, careful selection of project suppliers should be regarded as part of the project's strategic decision-making process to ensure the desired outcomes are achieved. Hence, in sustainable building projects, the selection of suppliers who are motivated and possess the necessary capabilities to work towards project’s environmental objectives and goals are important for sustainable project’s success. Additionally, identifying the appropriate project phases where the suppliers should be involved and defining their roles are essential parts for effective collaboration and successful project outcomes (Görög & Gèorèog, 2013). By engaging the right suppliers and establishing clear roles and responsibilities, sustainable building projects can benefit from increased collaboration, expertise, and commitment to achieving project’s environmental objectives and goals.

In the process of selecting suppliers for the project, environmental sustainability can serve as a one selection criterion. This supports the sustainability of the project and at the same time strengthens cooperation among environmentally sustainable actors and promotes sustainable development. Assessing external contributors from a sustainability perspective is also advantageous in terms of reporting, given that the EU's Corporate Sustainability Reporting Directive (2022/2464), effective from 2024, mandates large and listed companies (excluding listed micro-enterprises) to disclose their sustainability impacts across the entire value chain. Furthermore, beyond its benefits to the end customer, the sustainability assessment proves value to the contributors themselves, as it enables them to identify developmental objectives and address critical observations constructively. This, in turn, empowers companies to enhance their operations and advance toward a more sustainable trajectory. (Ahonen, 2023)

In accordance with (SFS-EN ISO 20400), mapping sustainability issues to evaluated stakeholders allows the client and project management to ascertain which external contributors (and their supply chains) are involved in addressing specific sustainability issues. Additionally, the standard recommends integrating sustainability considerations into existing governance arrangements rather than creating a separate governance program.

External contributor's selection often comprises prequalification and tendering processes. Prequalification focuses on overall capabilities of the contributor to deliver expected outcomes, including sustainability ones, while tendering usually focuses on the capacity and commitment of the contributor to deliver detailed and specific requirements, including those related to sustainability, for goods or services. (SFS-EN ISO 20400) Prequalification makes sure by predefined set of criteria that the external contributor can implement the project work and can therefore participate in tenders. Because of the nature of the project business, external contributors need to sell their capability of completing the expected outcome, instead of selling an already-completed product. Clients need to rely on the external contributor's capability of implementing their work. (Görög & Gèorèog, 2013) Thus, the client organizations should identify potential contributors who are capable and reliable to perform the work through prequalification.

Based on (SFS-EN ISO 20400), the requirements for prequalification should be well-defined and consider relevant sustainability issues, with a focus on assessing sustainability risks, including opportunities, associated with the contributor's tasks. During the prequalification phase, it is imperative to assess the technical, financial, and project managerial capabilities of the contributors. These capabilities can be evaluated through a range of methods, such as examining reference projects, reviewing statements, and conducting surveys. Furthermore, as the process advances, and potential contributors undergo further evaluations during the tendering process, additional measures, such as audits, site visits, and other means of gathering evidence of capability, can be employed to provide added assurance of contributor's suitability for the project. Furthermore, the client may choose to encourage contributors to sign a code of conduct or similar charter, and/or participate in a sustainability initiative. In making this decision, the implications for the supplier should be thoroughly considered to ensure the potential benefits and challenges are properly weighed. Evaluation between candidates can be done with the help of holistic assessments, rankings with weighted criteria, or by multicriteria decision making. (Görög & Gèorèog, 2013).

From the perspective of environmental sustainability, the technical and project management capabilities of the contributors take on particular significance. Technical capability in environmental sustainability refers to the proficiency and expertise in ensuring environmentally sustainable outcomes for the expected project results. Project management's capability in environmental sustainability indicates that the contributor organization possesses adequate professionalism in planning and controlling their work for the project in an environmentally sustainable manner. (Modified from Görög & Gèorèog, 2013). By carefully evaluating these capabilities, the client can ensure that the selected contributors are well-prepared to deliver sustainable results and effectively address the project's environmental objectives.

4. ENVIRONMENTALLY SUSTAINABLE PROJECT MANAGEMENT

As presented earlier in the thesis, the legislation is one cornerstone in change making and in adoption of more sustainable ways of acting in building and construction sector. Nevertheless, legislation can be lacking and might not concern all sectors equally, as is the case with the industrial building sector. For example, in Finland buildings categorized as an industrial or mining buildings are not facing as strict regulation regarding buildings' energy efficiency and climatic affects as for example residential buildings, which need to be designed as close to net zero energy and starting from 1st of January 2025 need to have a climate statement when applying for building permit (Eduskunta, 2023).

Even though the legislation concerning industrial buildings environmental sustainability can be seen to be getting stricter and used as a steering mechanism, the development can be slow and not strict enough and due to this, other measures to act more environmentally sustainable are needed. Häkkinen and Belloni (2011) states that the development of sustainable building processes is not hindered because of lack of existing information, technologies, or assessment methods but are facing the challenges of adopting new processes and working methods for implementation. Consequently, in this thesis, the adoption of environmental sustainability in industrial building projects is perceived to be contingent upon effective project management practices. This perspective is supported by the research conducted by Banihashemi et al. (2017), which reveals that project managements' knowledge, skills and abilities on project activities and tighter control over construction activities are one of the most influential critical success factors towards more sustainable building projects.

To utilize sustainability in a project level the project management should consider sustainability as another success criterion for the project alongside the traditional project goals (Ebbesen & Hope, 2013). Moreover, changes in clients' demands and systematic enforcement of environmental regulations play a pivotal role in transition towards a sustainable project management (Banihashemi et al., 2017; Martens & Carvalho, 2017). Additionally, Delnavaz (2012) reminds that it's essential to consider the managements process as well as the stakeholders' involvement all over the project management process to successfully deliver a sustainable project.

Research conducted by Martens and Carvalho (2017) indicates that environmental sustainability is widely acknowledged as a high interest among project management and that they acknowledge the importance and financial benefits that the environmentally solid practices bring along. More in detail, the study shows that project managers are concerned on project resource consumption, particularly water and energy. Additionally, according to the study done by Wu et al. (2019), the group of respondents who used green construction management produced significantly higher mean quality levels for the highway engineering projects than the projects that were managed in traditional measures.

There are different possibilities and ways for project management to implement more environmental sustainability procedures during the industrial building project's life cycle. Particularly the environmentally sustainable decisions made during the early phases of the project are important, since as seen in figure 1 the possibility for changes decreases and costs of changes increases while the project advances. From project management's point of view the project's big picture is important and in minimizing environmental impacts the most focus should be allocated to the elements that produce the most environmental impacts and which can be affected during the project's life cycle. Typically, in building projects the most climatic impacts are released by the operation of building and by building products (Häkkinen et al., 2020; Jäätvuori et al., 2021; Vehmaanperä, 2021). Additionally, construction activities have several harmful environmental impacts such as emissions, natural resource consumption, waste generation, hazardous contamination, and other environmental impacts associated with construction activities (del Rio Merino et al., 2010; Khaleel, 2021; Ympäristöministeriö, n.d.-a). Thus, these elements should be considered in environmentally sustainable projects.

Industrial building projects present unique challenges in terms of design and implementation due to various factors. The main challenges arise from heavy loads and wide spans caused by the large machinery and the space requirements for industrial processes (Gourlis & Kovacic, 2017). Due to this, the load-bearing structures need to be hefty to handle heavy loads and wide spans. These large and heavy structures result in significant emissions from building materials, as pointed out by Häkkinen et al. (2020, p. 24). Additionally, these buildings often have diverging interior climate requirements due to the nature of industrial processes, and they involve various interactions among different systems, such as structural components, HVAC-systems, and machinery floor layout and infrastructure. Moreover, industrial buildings tend to demand higher amounts of energy, and depending on the production process, they may generate higher internal heating loads compared to other building typologies. (Gourlis & Kovacic, 2017)

During the planning and design phases of building projects, stakeholders possess the most significant opportunity to influence the project's environmental sustainability, as many solutions can be compared and positively impacted before final decisions are made. San-José Lombera and Cuadrado Rojo (2010) suggest that the sustainability of industrial buildings should be approached similarly to residential and facility buildings. However, the location, size, and specific requirements of industrial buildings are primarily determined by process and machinery choices, as well as essential standards, making decisions related to these aspects challenging to affect. Moreover, individual feasibility studies for industrial buildings are typically not conducted separately, as they are perceived to primarily support the overall industrial process. Additionally, the industrial building sector is currently confronted with challenges in terms of environmental performance comparisons, primarily due to the limited availability of references in the industrial building sector. In contrast, other sectors, such as residential buildings, have well-established classifications for building energy performance (Kalliomäki, 2018).

Despite these challenges, the subsequent section of the thesis elucidates strategies for managing industrial building projects in a more environmentally sustainable manner, encompassing the entire project life cycle, with due consideration given to decisions pertaining to the building's operational and end-of-life stages. In pursuit of this objective, the environmental sustainability of industrial building projects is approached through the establishment of setting environmental objectives and goals, stakeholder involvement and understanding, and acknowledging appropriate steering mechanisms, as advocated by Delnavaz (2012). Additionally, in this thesis possible measures to mitigate industrial building projects environmental impacts are identified.

4.1 Objective and goal setting

As stated previously in the thesis the importance of understanding the objectives and goals of the project as early phase as possible is crucial and it is no different when implementing sustainability goals for industrial building projects. As Häkkinen and Belloni (2011) state, the lack of adequate knowledge for developing a project with clear objective and goals is a hindrance for the sustainability of the building project. It is recommended by Robichaud and Anantatmula (2011) to define the priorities for sustainable building during the project’s feasibility study to establish a framework for all future decision making and keeping the end in mind, since by basing the selections on other measures, forcing compliance with sustainability goals later will in most cases lead to cost inefficiency. Thus, early consideration of sustainability is vital for delivering environmentally sustainable results. Moreover, the project objectives and goals should be established clearly to all project stakeholders, so that all stakeholders can work towards them. Especially in industrial building projects, which are usually large, complex and involve various stakeholders, it is crucial for success that all stakeholders know what goals are pursued.

Kubba (2010) states that the progress of the green building process should be managed by measurable goals related to a specific requirement. Furthermore, Häkkinen and Belloni (2011) emphasize that environmental objectives and goals should be expressed clearly, and performance based, as well as monitored and maintained during the whole project. These goals should be measured by information provided by the design and construction teams and the project management should manage the selected solutions by this information (Kubba, 2010). For these purposes, for example, energy performance clarifications and LCA related goals can be established for buildings (Green Building Council Finland, n.d.-b).

However, industrial buildings present distinct challenges for benchmarking these measures due to their unique operational energy and water requirements and ventilation needs. Additionally, their processes' operations, and specific programmatic connections with other buildings make clear environmental objective and goal setting challenging and pursuit of robust efficiency measures more complex. Despite these challenges, it is possible to establish clear environmental sustainability goals for industrial buildings, for example, by utilizing certification systems. One such system is LEED (Leadership in Energy and Environmental Design), which offers four different levels of certifications based on a credit scaling system. These certification levels can be adopted as project-specific goals and have already been applied in the context of industrial buildings (U.S. Green Building Council, 2023). Additionally, United Nations Sustainable Development Goals (UN SDGs) can be used to set project objectives (Akomea-Frimpong et al., 2022).

An essential part for applying the principles of sustainable development is the rational use of natural resources (del Río Merino et al., 2010). Natural resource consumption on project level can be managed through waste handling, material selection, reuse, and recycling as well as with energy and water usage control and optimization (Delnavaz 2012). Construction activities also emit various pollutions including climatic emissions, parcels, noise, vibration, and vaporous discharge. (Pitt et al., 2009) To manage these negative environmental impacts clear project specific goals and methods should be established for mitigating these impacts. Project management plays a crucial role in setting these goals on project level (Delnavaz 2012).

4.2 Stakeholder involvement and understanding

The clients possess the most authority in a project's decision-making process, thus their decisions in determining which objectives and goals are involved in a project holds great importance (Häkkinen & Belloni, 2011). Clients' decisions are even more significant in sustainable building because the goals are long-term, and the benefits seem to be most of the time intangible and usually are not mainly driven by regulatory (Hwang & Tan, 2012). Within the industrial building projects, in which the client is typically a corporate entity, and the building serves as a facilitator of processes, the client's role as a catalyst for tackling buildings environmental impacts can be seen to become even more pronounced. As a result, the sustainable outcome of such projects is heavily influenced by the specific strategies and sustainability requirements established by the client organization, which, in conjunction with regulation, will set a clear path for the project's overall sustainability performance. The study conducted by Griffin et al. (2010) underscores the significance of persuading clients regarding the benefits derived from opting for environmentally sustainable structural materials and focuses on the building's energy efficiency. Therefore, the client's understanding of the value that can be added through the incorporation of sustainability principles is important (Delnavaz, 2012). Consequently, it can be held project management's responsibility to ensure that clients are adequately apprised of the potential benefits that can be garnered through the adoption of environmentally sustainable practices for the project.

While clients wield considerable influence in environmentally sustainable decision-making in industrial building projects, other stakeholders also have vital roles for achieving environmental sustainability. Williams and Dair (2007) conducted case studies revealing instances where certain stakeholders, who should have been involved, were not engaged despite advertising and consulting local planning authorities. Early involvement of these stakeholders could have potentially influenced the adoption of sustainability objectives. Moreover, end users should actively participate in demand specification, as their involvement acts as a driver of process innovation (Häkkinen & Belloni, 2011). Thus, considering stakeholder involvement becomes essential to enhance the environmental sustainability of a project, as each stakeholder involved in the building process contributes to the development of the building and construction sector (Delnavaz, 2012). Research conducted by Griffin et al. (2010) acknowledged that design stakeholders are particularly instrumental in advocating for more environmentally sustainable structural materials and systems, given their comprehensive understanding of available alternatives and potential trade-offs.

Project management's tasks involve identifying, analyzing, and proactively engaging with stakeholders from the initiation to the finish of the project, which helps to enable success and increase value of the project (Project Management Institute, 2021). Considering that building projects entail a wide range of specialists, project management assumes a critical role in coordinating their efforts and fostering equitable solutions to emerging challenges (Hills et al., 2008). Additionally, it is acknowledged that collaboration and communication among stakeholders present significant challenges in delivering successful green projects. Project management's responsibility is to conduct planning and strategy meetings to ensure that project objectives and goals are understood by all team members. (Robichaud & Anantatmula, 2011). Thus, project management assumes a distinctive position at the project level, playing a crucial role in overcoming these challenges, promoting environmental sustainability, and driving industry-wide change (Hills et al., 2008).

The mitigation of negative environmental impacts and associated risks necessitates proactive engagement with workers and subcontractors before the commencement of construction activities. Furthermore, the importance of addressing these concerns should be continually reinforced during weekly meetings as the project progresses (Delnavaz, 2012). For example, del Rio Merino et al. (2010) highlights the significance of implementing waste management strategies and involving all stakeholders in the construction process. Effective waste reduction measures are achieved through the allocation of responsibilities among construction managers, general contractors, and subcontractors to minimize waste production. (del Rio Merino et al., 2010)

The lack of training and education on personnel regarding sustainable building is one of the general barriers to sustainable construction (Matar, 2008). Robichaud and Anantatmula (2011) recommend a project management approach for green construction regarding training and education for on-site construction personnel. They suggest starting construction activities with a kick-off meeting to educate people about sustainable building, and project management should conduct a similar meeting with incoming stakeholders, prior to commencing incoming subcontractor to work. In addition, monthly on-site meetings that include education and training sessions on green buildings are vital for all site workforces. (Robichaud & Anantatmula, 2011). These meetings can be furthermore used with stakeholders to acknowledge challenges and risks related on achieving environmental sustainability of construction activities.

4.3 Steering mechanisms

Various steering mechanisms, such as regulations, incentives, and voluntary actions, are being employed within the building and construction sector to promote environmental sustainability. However, the effective utilization of these mechanisms may encounter impediments arising from inadequate access to suitable instruments and knowledge regarding their availability, potentially hindering progress towards sustainable construction practices (Häkkinen & Belloni, 2011). Additionally, the limited understanding of environmental performance-related information and technologies can also serve as an obstacle for sustainable building projects (Sodagar et al., 2008).

The role of the regulations can be positive for achieving additional and new requirements such as environmental sustainability objectives in building projects since achievement of these objectives needs changes and new considerations compared to conventional ways that are already established. Regulations can exert influence through either prescriptive or performance-based approaches. Prescriptive regulations are directly linked to specific technologies or prescribed means of compliance, while performance-based regulations focus on achieving specified results (Häkkinen & Belloni, 2011).

Scholarly literature, as indicated by Meacham et al. (2005), advocates for the implementation of performance-based regulations, as they offer greater support for innovation and flexibility in meeting goals. Conversely, normative regulations, which rely on achieving societal consensus, may appear effective in promoting sustainability objectives, but they can be comparatively slow in generating tangible outcomes. Additionally, within the context of the fragmented nature of the building sector and the multitude of stakeholders involved, circumstances may arise wherein hard laws are perceived as the only possible way to advance and achieve sustainability objectives (Häkkinen & Belloni, 2011).

Williams and Dair (2007) found this assertion through the findings derived from their case studies. The scope of their studies encompassed five distinct residential and mixed-use schemes conducted in England between 2001 and 2004. The interviews of their study involved participants from diverse backgrounds, including stakeholders engaged in land use planning and regulation, development, construction, and end-use aspects of the projects. The investigation's outcomes revealed a recurring pattern where the failure to achieve sustainability objectives within the examined case studies primarily resulted from stakeholders' lack of consideration for these objectives. Notably, sustainability objectives were only taken into account when explicitly mandated by regulatory requirements. (Williams & Dair, 2007)

Conversely, Häkkinen and Belloni (2011) state that rigid regulations could act as a hindrance for sustainable solutions. Williams and Dair (2007) similarly support this notion, as their case studies also revealed that regulations, in certain cases, hindered the implementation of sustainability objectives. These objectives could not be realized due to disallowance or restrictions imposed by regulatory authorities. Notably, project management is tasked with addressing regulatory approvals for clients during the planning and design phases (Jaworski & Samanta, 2006). This underscores the significance of navigating regulatory constraints as part of the project management process to facilitate the integration of sustainability objectives effectively.

The other kind of instruments of steering mechanism are economic incentives such as tax reductions and green finance, which can influence the clients' willingness to consider sustainability objectives. As both innovations and regulations are needed for a more sustainable future in the building and construction sector, incentives can stimulate innovations and create demands for alternatives before the clients distinguish the alternative's benefits with their experience. (Häkkinen & Belloni, 2011)

According to Pitt et al. (2009), a primary driver for achieving sustainable building practices lies in the presence of financial incentives. These incentives often revolve around attaining specific certification levels or aligning with the United Nations Sustainable Development Goals (UN SDGs), as highlighted by Akomea-Frimpong et al. (2022). Notably, clients' awareness of these financial incentives plays a crucial role during the initial stages when contemplating the integration of sustainability concepts into the project. Project managers can impact clients' interest of these incentives by providing timely and pertinent information, thereby enhancing their willingness to embrace environmentally sustainable goals (Delnavaz, 2012). Hence, project management's awareness and expertise concerning sustainability can significantly influence the outcome and success of sustainable building projects.

A noteworthy barrier to sustainable building practices can be attributed to the scarcity of information and expertise in the field. This concern is often associated with concerns over higher investment costs and an increased risk of unforeseen expenses throughout the construction process. The augmented risk of unforeseen costs is linked to various factors, including the use of unfamiliar techniques, a lack of prior experience, the need for additional testing and inspection during construction, limited support from manufacturers and suppliers, and a lack of performance information. (Häkkinen & Belloni, 2011)

According to Robichaud et al. (2011), the initial cost of sustainable building may indeed surpass that of conventional building methods. However, Häkkinen and Belloni (2011) counter this perspective, asserting that the construction of an energy-efficient building does not significantly increase investment costs. Furthermore, they contend that any higher initial investment can be effectively retrieved through cost savings achieved during the building's life cycle, particularly in terms of operational and maintenance expenses.

Within the context of industrial production buildings, the overarching objective typically pertains to long-term considerations, and investment decisions are frequently founded on rigorous financial evaluations (Hilden et al., 2021). In such assessments, paramount significance is placed on the potential cost savings realized throughout the entire life cycle of the project, thereby directly influencing the decision-making process. In this regard, careful economic scrutiny of each decision becomes imperative, with project management assuming the responsibility of providing the client with comprehensive cost estimates. (El-Reedy, 2011) This practice ensures that economic factors are considered, enabling informed and well-grounded investment choices for industrial production building projects.

4.4 Measures at project level

Clients, or their representatives such as project management, bear the responsibility of possessing adequate knowledge regarding pertinent methods and programs available for assessing the environmental performance of their projects. Understanding how to effectively employ these methods throughout various project phases is crucial. (Kubba, 2010) In the context of this thesis, specific methods selected to achieve better environmental sustainability for industrial building projects in planning and design phases include: the building's longevity and adaptability, energy performance calculations, Life Cycle Assessments (LCAs), Building Information Modeling (BIM), and the integration of sustainability principles in the planning and design processes. Moreover, during execution phase natural resource usage, waste handling, material selection, reuse and recycling and environmental impacts can be managed through Environmental Management system (EMS) (Delnavaz, 2012). These approaches collectively contribute to a comprehensive assessment of the project's environmental sustainability, empowering clients and project management to make informed decisions for achieving improved ecological outcomes.

The longevity and adaptability of a building represent crucial life cycle characteristics, ensuring its sustained functionality and relevance over time. Adaptability pertains to the building's capacity to accommodate changes during its intended lifespan. If a building cannot accommodate potential changes in usage requirements, it may become outdated and reach the end of its functional life before reaching its planned service life. Conversely, if major modifications are necessary for accommodating a change in building's use, substantial costs and environmental burdens may arise. The challenge lies in ensuring adaptability amidst the context of prolonged building lifespans. To effectively address future modification needs, it is advisable to anticipate and incorporate them during the planning and design phases, when feasible. While construction costs represent a fraction of overall expenses incurred during modifications, architectural strategies can significantly enhance a building's adaptability. Designing structurally versatile and open spaces can contribute to improving adaptability, while avoiding over-engineering is essential. Moreover, considering potential alternative uses during the design phase can minimize ecological implications associated with future changes. (Punkki, 2003)

In the case of industrial buildings, their ability to adapt swiftly is critical to maintaining competitiveness, given the diverse and rapid factors influencing their operation. The inability to adjust facilities and organization quickly can lead to a loss of competitiveness. Thus, when strategically planning and designing industrial buildings for long-term use, it becomes essential to account for the change drivers that have influenced industrial buildings in the past, present, and will continue to do so in the future (Wiendahl et al., 2015, p. 1). By considering these dynamic factors, project management can proactively recommend adaptable factory environments for the project client, enabling industrial buildings to remain competitive and responsive to changing market demands.

In the industrial building sector, the availability of benchmarking data may be limited. However, energy simulations can be effectively employed to measure and assess an individual building's energy performance throughout the design process. Additionally, conducting Life Cycle Assessments (LCAs) allows for the evaluation of the environmental impacts of various building components, providing insights into the environmental effects of products and systems utilized in the buildings. These methodologies enable design teams to explore alternative concepts that prioritize energy efficiency and the selection of more environmentally sustainable components. (Kubba, 2010) Additionally, as more and more energy performance and life cycle assessments are conducted, they support creation of benchmarking data in the industrial building sector.

Furthermore, incorporating designs that enhance energy efficiency is paramount to reducing energy wastage and emissions during the building's operational phase. This approach offers several advantages especially in industrial buildings, as heating loads can be repurposed for process needs, provide heating for nearby structures, or be stored for future utilization. By leveraging such synergistic effects and optimizing the flexibility of load-bearing structures, more environmentally sustainable outcomes can be achieved in industrial building projects. (Gourlis & Kovacic, 2017)

The design process of buildings necessitates thorough validation and design review to prevent clashes and conflicts between different systems, making Building Information Modeling (BIM) valuable tool in facilitating the design process (Gourlis & Kovacic, 2017). Furthermore, the notion of sustainable building design as an isolated task can hinder the successful attainment of sustainable building results (Rekola et al., 2012). Instead, it is essential to integrate sustainable design principles into the work of designers.

Hills et al. (2008) recognize an important role for project managers to influence the performance of the industry regarding material supply chain. Project managers can control the supply chain by negotiations concerning delivery times, checking factory quality and progress and the conformance with the specification upon delivery and site installation. Moreover, project management should ensure optimum deliveries by planning and scheduling. (Delnavaz 2012) Due to these roles, project management can have a direct impact on construction activities efficiency, which ultimately affects the project's environmental and financial performance.

Griffith (2002) states that the environmental impacts of construction activities are one of the key challenges in sustainable building projects. Reducing the inadequate effects of construction process on environment should be an agenda for sustainable building. Adopting environmentally responsible practices and procedures alongside environmentally classified products and minimizing external pollution and environmental damage facilitates sustainable construction practices. Considering these practices and procedures beforehand should be done in design phase but implementation of these plans is considered as a challenge of construction phase. The project management has a role in addressing construction activities environmental impacts, although construction manager can be mainly held responsible for utilizing them (Arditi & Ongkasuwan, 2009).

As project management is eventually the responsible stakeholder for execution of the project. They can provide goals and information for construction managers and contractors to change their habits and use the technologies that are helpful to reduce natural resource usage, waste generation and emissions during construction activities. (Delnavaz 2012) In a broader view, project management should ensure about environmental impacts on major environmental impacts by implementing Environmental Management System (EMS) as an efficient way to manage environmental performance of the construction activities (Griffith, 2002).

Reduction of waste and recycling during the construction can be supported by their financial benefits, which can support general contractors and trades to adopt waste management policies and practices on site (YIT, 2023). At the site the recycling containers should be clearly designated and indicating the lists of what is and is not recyclable on them as well as the recycling containers are monitored to prevent contamination (Delnavaz, 2012). Considering the extensive nature of industrial building project sites and the inherent time constraints, urgency often pervades the construction process (Riihimäki, 2023). Thus, in these projects it becomes even more important to establish clear and well-defined recycling and waste handling strategies to efficiently address waste-related concerns. Furthermore, the general contractor and construction management should ensure that pollution from construction activities are minimized and that natural resources are used in sustainable way during the execution.

Additionally, as closing phase has been identified by (Artto et al., 2011, p. 39) as important phase to analyze the performance and learn from the project. Therefore, especially in the industrial building projects, where the environmental performance of buildings is lacking the solid reference and benchmarking data, it can be seen as an efficient method to improve the environmental sustainability of the future projects by analyzing the implemented project’s environmental sustainability.

5. CASE STUDY

The case study is conducted to find out how environmental sustainability has been considered in a recently implemented industrial building project in Finland. The project under scrutiny was chosen from a pool of industrial building projects where AFRY (previously Pöyry) had been actively engaged in providing project management and other services. The selection was guided by the objective of identifying potential areas for enhancing environmental sustainability practices within such projects. The chosen subject project was chosen due to its successful implementation, geographical location in Finland, and its representation of the typical consideration of environmental sustainability among the options.

To ensure a comprehensive analysis, diverse private project resources were utilized, encompassing project meeting memos, various reports, and other relevant documents. The presence of a document control system facilitated efficient access to these resources. By drawing upon these resources, the current state of environmental sustainability among an industrial building project and project management was successfully obtained.

5.1 General information

The project selected is a food industrial plant, which was built in Southern Finland. The project's conceptual design was done during 2017-2018 by others. After the conceptual design, the project's feasibility study was conducted by AFRY during the year 2018. AFRY continued with the project's pre-engineering study in 2019, which continued until Q2 2020. The final investment decision was made by the client after the pre-engineering and AFRY continued with the basic engineering which was done during the years 2020-2021. After basic engineering AFRY was selected as the main partner for the project and provided the project with detail engineering and project and construction management services. The construction activities started during the Q1 of 2021 and the plant was finished in Q1 2023. AFRY also provided a permit study for the project. The client and AFRY had conducted a similar project before together in another country, which was used as a reference for the project. (AFRY, n.d.)

The city where the site is located is developing the area of the plant into industry and commerce use. The component master plan of the area came into force in 2017 and the plant area is designated for industry and commerce use (T-21). The project consisted of a total of 14 buildings facilitating various industrial activities. The plant is located in a leasehold site from the city. (AFRY, n.d.) Environmental conditions of the site and its near areas were studied in the planning phase and these findings are summarized next in the thesis.

In close proximity to the site, the nearest residential areas are located at a distance of 0.5 kilometers to the north. In the area there are scattered individual houses, with the closest locating approximately 200 meters to the south of the site. Schools and kindergartens are situated more than one kilometer away from the site. The plant area is situated alongside a brook, which serves as the conduit for stormwater drainage from the industrial site to the municipal stormwater network, eventually discharging into the brook. (AFRY, n.d.)

The plant plot is located near the border of groundwater area, which is part of the groundwater area of the city. The plot border is located near to the groundwater formation border, but the site is not located on the actual groundwater area. The groundwater area was classified as an important area and the quality of the water was good during the permit study. However, some elevated concentrations of pesticides had been detected from the groundwater. There were no water intake plants in the groundwater area, but there were several water intake plants in the groundwater area of the city. (AFRY, n.d.)

The closest protected area is located 1.3 kilometers southeast of the plant. This area is classified as a Natura 2000-network protection area. Additionally, there are two smaller privately protected areas encompassing hardwood forest and black alder woodland, situated approximately 2.9 kilometers to the east of the site. Ecologically valuable regions for bird nesting had been identified 650 meters south of the site. Furthermore, according to information provided by the city authorities, the recreational forest area adjacent to the southern part of the site has been recognized as an integral habitat for Siberian flying squirrels (Pteromys volans). (AFRY, n.d.) The flying squirrel is categorized as a protected species under the Nature Conservation Act (1096/1996).

The natural soil of the area is comprised of bedrock, medium fine sand, and peat. However, the natural soil at the plot had been replaced with fill soil. The site area was not marked in the national database of possibly and knowingly contaminated areas. Based on the historical aerial photographs the plot area was found to have previously been forest and cultivated land. There was no reason to suspect that the onsite area would be contaminated from the previous operations on the plot. (AFRY, n.d.)

5.2 Environmental decisions and considerations

Based on the available private project research resources for the case study, the environmental sustainability of the buildings had not been considered as a project goal, and it was not considered as such during the planning and design phases of the project. The focus of project meetings revolved around standard project goals, such as managing schedule, cost, scope, and quality of different stakeholders' work and for the whole project. The industrial process' and mandatory systems' functional requirements, regulations, and reference project mainly directed the planning, design, and execution of the project's industrial buildings. However, certain voluntary environmental considerations were done during the project.

Environmental assessments were discussed with the city's environmental authority. The Environmental Protection Act 527/2014 and Environmental Protection Decree 713/2014 were identified as the main regulations concerning the project's environmental protection and permitting. Since the production plant was not listed as requiring an Environmental Impact Assessment (EIA) assessment, no EIA was conducted. However, an environmental permit, including noise and odor modeling, building permit, and chemical permit were needed for the project. Specific appendices related to environmental topics, such as water and environmental authority permits for wastewater discharge, construction waste handling reports, and neighbor hearings were mandated for the building permit. Additionally, in the plan map was stated that the designing and construction shall consider biodiversity values of the area and determine the possibilities of renewable energy production and their impact on the scenery. The project design was required to comply with local laws and regulations and use international ISO standards where applicable. However, it was not indicated where ISO standards were seen as applicable, and for example ISO 14001 – Environmental management standard was not required to be used. Best Available Technology (BAT) requirements primarily governed process design, not building design. (AFRY, n.d.) More focus could have been given to environmental aspects; however, it would have directly affected the other project goals and would have required knowledge and motivation to surpass the regulatory minimum requirements.

Renewable energy production was mainly discussed concerning the process energy needs, while the implementation of solar panels into the buildings for electricity production was dismissed due to fire protection reasons and late emergence (AFRY, n.d.). The project management could have supported the use of renewable energy in buildings and affected the client's willingness to do so. However, waste energy and heating loads from the process and buildings' ventilation were selected to be utilized in process and heating of the buildings (AFRY, n.d.).

Flying squirrel surveys had been conducted in the site area, and based on the environmental permit study, the facility's operation and implementation were not believed to have any discernible impact on the habitat or persistence of the flying squirrels in the area. Additionally, it was noted that the operation of the facility is not anticipated to have any discernible impact on the nature conservation areas or their conservation values, as the facility is situated at a considerable distance from the nearest nature conservation sites. (AFRY, n.d.)

The city had ordered soil investigations in the area in 1995 and in 2002, and the initial building description was based on the soil investigation conducted in 2002. Based on that report the groundwater was not seen to have effect for the project and the buildings were expected to be based on pile foundations, with the average length of piles anticipated to be 14 m, while the ground floors and lighter external structures could be based on soil exchange. Through the final soil investigations was found that the groundwater was very close to the surface and underground structures needed to be avoided whenever possible. Final soil investigations also affected the floor and pile structures, which needed to be more robust than anticipated. (AFRY, n.d.) The final soil investigations were done at a rather late phase, and earlier investigation results could have helped the design team to make more informed decisions. The investigations were ordered by the project management.

Mainly all building system selections were based on functional analyses and previously used methods in the reference project, and environmental impacts were not used in determining structural or other building system selections. However, structural adaptability was supported by defining modules for the buildings. Additionally, one notable recommendation relating to environmental sustainability was made by geotechnical engineer during design phase, while it was noticed that bedrock was closer at the south side of the site and by mirroring the layout for heaviest structures, depending on the original site layout, should be considered in implementation phase. However, this recommendation was made mainly due to the costs relating to lighter foundation solution. (AFRY, n.d.) The recommendation could have been implemented if the recommendation would have been made in earlier phase. Conducting LCA could have helped to notice this already in planning phase and the solution would have been most probably obtained.

Furthermore, while the project cost budget started to reach its limits and some cost reductions were needed. The cost reductions were obtained from structural selections, in which some structures were changed from cast-in-place to prefabricated, some were optimized, and some structures were found unnecessary and were left built. (AFRY, n.d.) If the design of structures had involved LCA, some of these solutions could have been obtained earlier and re-engineering expenses could have been avoided.

All suppliers conducting construction activities were mandated to use CE marked products and to have SFS-EN ISO 9001 quality certification system implemented in their work procedures. Environmental management system or use of Environmental Product Declaration (EPD) materials or products were not required. However, in the supplier selections, certified environmental management system, as for example SFS-EN ISO 14001, and the supplier’s track record of demonstrating good performance in terms of sustainability and exhibiting positive development in environmental sustainability were considered beneficial. (AFRY, n.d.) Requiring suppliers to use environmental management system as is the case with quality management system, would further help to access environmentally sustainable practices in the project and support sustainable development in the sector.

Suppliers participating in the project’s execution were contractually obligated to furnish a comprehensive list of hazardous materials and handle those according to relevant regulations. As part of their Health, Safety, and Environment (HSE) plan, the suppliers were further required to develop environmental protection procedures. It was held as the supplier’s responsibility to identify, assess, and address the environmental risks associated with their work. Additionally, they were directed to use the principles of Best Available Techniques (BAT) where applicable and implement best practices to mitigate and minimize environmental impacts. (AFRY, n.d.) However, the use of BAT was not monitored, which would support the utilization of BAT in the project.

Furthermore, the examination of environmental impacts from project activities was mandated to be conducted in an integrated manner. This encompassed the simultaneous assessment of discharges and emissions released into the air, water, or soil, along with other factors such as resource consumption, waste minimization, energy efficiency, noise and vibration levels, and accident prevention. (AFRY, n.d.)

In fulfilling their obligations, suppliers conducting execution activities were expected to provide a detailed account of all potential emission sources, describing them in a comprehensive manner. These emissions were to be maintained at the lowest feasible levels. The provided information included the quantity of emissions emitted during different phases of the project, such as site installation, commissioning, and maintenance, as well as during any abnormal operations. The composition and frequency of emissions, along with the characteristics of the emission sources, were to be specified by the supplier. (AFRY, n.d.)

Safety and environmental goals for the project's execution were established to ensure a comprehensive approach to risk management and environmental protection. These goals encompassed several key aspects, including no accidents, no ignitions of hot works, no deviations of environment, no deviations of quality and no disturbances to the neighbors. Furthermore, operational guidelines were formulated to address environmental emissions resulting from construction activities. These guidelines encompassed deviation notification and damage management protocols, conducting equipment commissioning inspections at the construction site, and implementing proactive maintenance measures. (AFRY, n.d.) Project specific environmental goals could be also given to design teams to mitigate project's environmental impacts, as their solutions affect buildings' execution and end of life environmental impacts, the project management would be the responsible stakeholder for requiring use of LCA and energy performance assessments and setting goals for these assessments.

The management of stormwater was given special attention, with consideration given to the storage and handling of chemicals within the project facility premises. To mitigate the risk of chemical spills and firefighting water runoff, stormwater was collected and directed into stormwater tanks located within the plant area. Additionally, areas with higher environmental risks were paved with impermeable asphalt, ensuring that water runoff was channeled into the stormwater tanks and prevented from infiltrating the surrounding environment. (AFRY, n.d.)

6. DISCUSSIONS

The research on environmentally sustainable project management within the industrial building sector was undertaken utilizing theoretical and empirical approaches. Theoretical research comprised of literature review, while empirical study utilized a case study analysis. The literature review was aimed at elucidating the relationship between project management practices and the attainment of environmental sustainability in industrial building projects. Concurrently, the case study focused on a recent industrial building project in Finland, serving as a concrete illustration of how environmental sustainability considerations were integrated into the project management processes during the project.

As was found in the literature review, attaining environmental sustainability in industrial building projects can be facilitated through the application of measures that have already proven effective in other building typologies (San-José Lombera & Cuadrado Rojo, 2010). Nonetheless, it is important to acknowledge that industrial buildings present distinct challenges concerning adoption of environmental sustainability, mainly attributed to the specific requirements associated with facilitating industrial activities within the buildings (Gourlis & Kovacic, 2017; U.S. Green Building Council, 2023). Despite these challenges, based on the research it is feasible to achieve environmental sustainability in the industrial building sector. To achieve this, project management can positively influence the industrial building projects' environmental sustainability by various measures. The project management can influence the industrial building project's environmental sustainability by increasing clients' awareness of the benefits that environmental sustainability can have for the project, setting clear objectives and goals related to environmental sustainability, employing steering mechanisms and methods for managing the project's environmental impacts, and by recognizing the potential impact that project stakeholders, particularly internal stakeholders, can have on the project's environmental sustainability. (Delnavaz, 2012)

The case study revealed that in a recently implemented industrial building project environmental sustainability was mainly driven by legislation, which was similar to findings from the literature review. The project management's decisions regarding industrial buildings were mainly defined by process, functional and regulatory requirements, as well as based on solutions obtained from a previously conducted similar project. However, it was found that environmentally sustainable project management practices were used in selecting suppliers for execution phase and in managing construction activities.

The project management and design stakeholders also had a role in energy efficiency through designs that used waste heat recovery systems. Additionally, the project management tried to involve renewable energy production methods into the project through adding solar panels on buildings, but this was dismissed due to the challenges regarding fire safety and lack of interest among the client, which was probably affected by the recommendation's late emergence. (AFRY, n.d.)

Through the findings from literature review and case study, the client's role towards environmental sustainability holds significant value in building projects (AFRY, n.d.; Häkkinen & Belloni, 2011). However, several project stakeholders were identified to have an effect on more environmentally sustainable building projects (AFRY, n.d.; Delnavaz, 2012; Griffin et al., 2010; Sodagar et al., 2008). Additionally, it was found through both research approaches that regulation is a key component towards addressing building projects environmental impacts (AFRY, n.d.; Williams & Dair, 2007; Häkkinen & Belloni, 2011). Despite the notable influence of clients and regulations, the research findings show that project management has several measures to affect industrial building projects' environmental sustainability (AFRY, n.d.; Delnavaz, 2012). However, the case study exposed a gap between the existence of these measures and their actual implementation. Thus, environmentally sustainable project management can be seen to have a positive effect on industrial building projects' environmental sustainability in the future when these measures are implemented. Especially, the industrial building projects' planning, and design phases possess great potential for project management to positively affect the industrial buildings' operational and product-related environmental impacts.

To support and facilitate environmentally sustainable project management in industrial building projects, a project management checklist has been formulated based on the research findings. The checklist is presented in appendix A. Project management of industrial building project can use the checklist as a practical guiding tool to improve projects' environmental sustainability. By proactively adopting and adhering to this checklist, project management can foster greater environmental consciousness, drive sustainable practices, and effectively contribute to the overall advancement of environmental sustainability of industrial building projects.

Even though the literature review and case study were conducted successfully the research obtains limitations. The limitations are due to the considerably few literature reviews done on industrial building sector and research involving environmentally sustainable project management in building and construction sector. The case study's limitation is due to its consideration of only one project, although it was selected to represent the average consideration of environmental sustainability of available projects. Additionally, the reader needs to take into account that the checklist is not piloted in an actual project and is based on the research findings of the thesis. Moreover, as the thesis focuses on project's environmental sustainability, which has effect on other project goals, the interlinkages between project's environmental and other goals need to be kept in mind when adopting environmental objectives and goals for projects.

7. CONCLUSIONS

The objective of this thesis was to identify how industrial building projects can be managed in a more environmentally sustainable way. The research objective was obtained through literature review and case study. As a result of the research, a project management checklist was formulated. The checklist helps the project management to identify how industrial building project's environmental sustainability can be taken better into account throughout project's life cycle. Based on the research, project management of future industrial building projects can influence the project's environmental sustainability by increasing clients' awareness of the benefits that environmental sustainability can have for the project, setting and supporting objectives and goals related to environmental sustainability, employing steering mechanisms and methods for managing the project's environmental impacts, and by recognizing the potential impact that project stakeholders, particularly internal stakeholders, can have on the project's environmental sustainability. Especially, the industrial building projects' planning, and design phases show great potential to positively affect the buildings operational and product-related environmental impacts.

Through the research the main challenges affecting industrial buildings environmental sustainability were identified. To tackle these challenges, future research is needed on industrial buildings' environmentally sustainable planning and design, encompassing integration of environmental sustainability in project management and design processes. Especially in the industrial building sector more research and piloting are needed on utilization of energy performance simulations and life cycle assessments on building products and systems. Additionally, further research is needed to identify the efficiency of different steering mechanisms towards environmental sustainability in industrial building projects.

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APPENDIX A: PROJECT MANAGEMENT'S CHECKLIST

Project management's measure	Observations
Provide the client with information about benefits that environmental sustainability can have for the project's industrial buildings	These benefits can include among others: -Building use phase's cost savings, added value, increased adaptability and longevity, financial benefits, appreciation among public, and decrease of project's environmental impacts
Set and support achievement of environmental sustainability related project objectives and goals of industrial buildings	Some of these objectives and goals need approval from the client as they possess the most power in decision making process. -Certification systems, UN SDGs, and project specific goals
Involve environmental sustainability assessment in supplier selections	By this way sustainable development can be supported and risks related to suppliers' capability of conducting their work can be decreased.
Involve and understand project stakeholders	All project stakeholders can have a role for more environmentally sustainable project and usually stakeholders have specific knowledge about environmental sustainability regarding their role on the project.

Be aware of steering mechanisms, methods, and technologies regarding industrial buildings environmental sustainability	These factors can have an effect on other aspects of a project, for example in costs, quality, risks and effectiveness of the project. -Financial and regulatory steering mechanisms -EMS, LCAs, energy simulations
Educate and supervise stakeholders about environmental sustainability	Education and supervision can work as an effective steering mechanism. -Involve education and supervision of environmental impacts in meetings
Involve project's building's environmental sustainability assessments in project closure	The project's closure provides an opportunity to learn from the project's environmental challenges and considerations.