Whole Life Carbon Reduction

Investors' Approach in Renovation Projects

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TU Delft Delft University of Technology

DGBC Dutch Green Building Council

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"Sustainability is no longer about doing less harm. It’s about doing more good."

-Jochen Zeitz

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by

Rinu Mariam Panicker
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In collaboration with ***Dutch Green Building Council (DGBC)***

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Colophon

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I hope you have a nice read!

-Rinu Mariam Panicker

Executive Summary

The real estate sector significantly contributes to carbon emissions in the Netherlands. Considering the extensive number of existing buildings, renovation presents a substantial opportunity to meet carbon reduction goals. Real estate institutional investors, who own and manage a considerable portion of this ageing building stock, play a crucial role in this endeavour. Currently, renovation processes primarily focus on reducing operational carbon, often neglecting embodied carbon considerations. This study aims to develop a phased approach for integrating whole-life carbon (WLC) considerations, emphasizing embodied carbon, into the current energetic renovation processes of real estate institutional investors in the Netherlands. To guide this research, the following question has been formulated: *How can real estate institutional investors incorporate whole-life carbon reduction into their renovation processes in the Netherlands?*

Overview of the Research Methodology
The research started with a literature review to identify key aspects like roles, barriers, and motivators. This foundation informed semi-structured interviews with industry experts to gather insights into current practices and challenges in the Dutch context. The interview data was analyzed to identify themes and patterns, leading to the development of a process that integrates embodied carbon considerations into existing energetic renovation workflows. This process was validated through an expert panel discussion, refining it based on industry feedback. The iterative methodology ensured the process was both theoretically grounded and practically applicable to embodied carbon integration in current energetic renovation approaches.

Final Strategies for WLC Integration
The research developed a comprehensive dual-level approach for integrating embodied carbon considerations into the current energetic renovation processes for real estate institutional investors. At the strategic level, the framework establishes the foundational aspects through carbon pricing, approach-based targets, coalition building, valuator collaboration, asset manager training, and material passport development. At the project level, the embodied carbon reduction measures are integrated into five key stages of the existing renovation workflow: initial assessment, renovation planning, plan presentation, implementation and monitoring, and post-project evaluation. Each stage incorporates targeted strategies that address specific barriers while maintaining operational efficiency. This structured approach enables investors to systematically implement WLC carbon reduction measures while working within current constraints and stakeholder requirements. It acknowledges current industry limitations while providing a practical pathway for incorporating embodied carbon considerations into the current energetic renovation processes through clear pathways and incentivization strategies across the value chain.

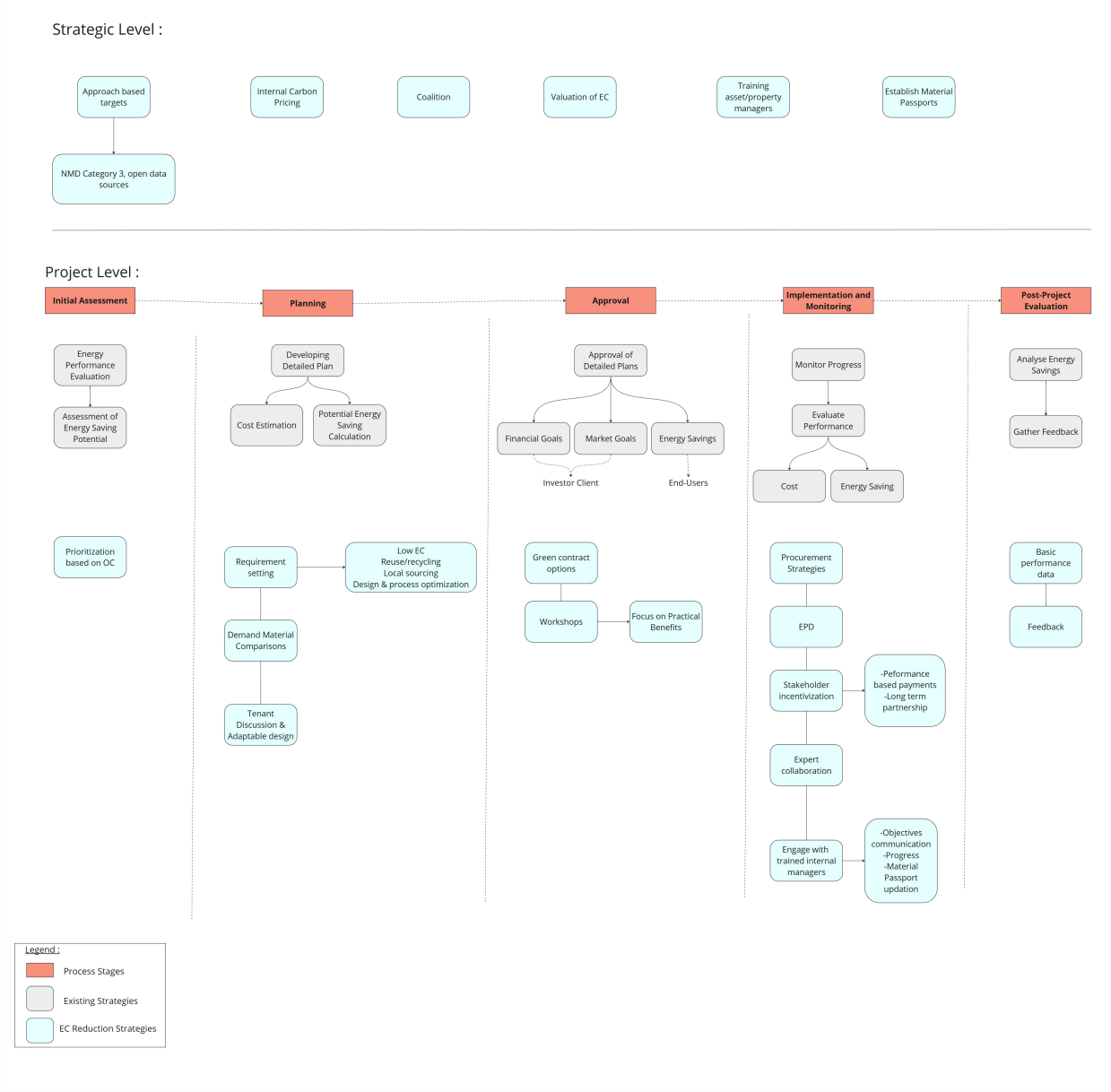

Figure 1: Final Strategies for WLC Integration

Recommendations for Investors

The recommendations for investors include implementing the proposed process in phases, starting with pilot projects to refine the approach. Investors should conduct an initial assessment of embodied carbon considerations for prioritized renovation assets, utilizing available data sources like the National Millieu Database and the Inventory of Carbon and Energy Database. They should also assess current whole-life carbon awareness within their organization and invest in targeted training for relevant stakeholders. Establishing a cross-functional team dedicated to whole-life carbon management is essential for overseeing the implementation of the process. Developing a clear roadmap for comprehensive carbon assessments, engaging with industry peers for best practices, exploring green financing options, and establishing a robust monitoring and reporting system for carbon impacts are also critical steps in reducing carbon emissions effectively.

Recommendations for DGBC

The DGBC is encouraged to develop standardized metrics and benchmarks for whole-life carbon in renovation projects to ensure consistent assessment across the industry. Developing carbon pricing frameworks will be impactful. DGBC should expand the scope of this research by focusing on understanding the roles and challenges faced by other supply chain actors, such as consultants and con-

tractors, to enhance collaborative sustainability efforts. Expanding existing certification schemes, like BREEAM NL, to include whole-life carbon considerations is vital. DGBC should facilitate knowledge sharing through workshops and publications and collaborate with international organizations to align assessment methodologies. Additionally, developing specialized training programs for real estate professionals and advocating for financial incentives and subsidies will further support whole-life carbon reduction initiatives.

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Chapter 1

Introduction

This chapter establishes the foundation of the research by examining carbon emissions in the real estate sector, focusing on whole-life carbon considerations in building renovation within the Dutch context. It presents the problem statement regarding embodied carbon integration in institutional investors' renovation processes and outlines the collaboration with the Dutch Green Building Council (DGBC). The chapter then defines the research objectives for developing a systematic approach to whole-life carbon integration, establishes the scope focusing on Dutch real estate institutional investors, and presents the main and sub-research questions that guide this study.

1.1 Background and Significance

Climate change represents one of the most significant challenges to humanity with its far-reaching impact on ecosystems, economies, and societies worldwide. To mitigate the severe effects of climate change, the Intergovernmental Panel on Climate Change(IPCC) emphasizes the urgent need to limit global warming to well below 2°C, with efforts to aim further to limit the temperature to 1.5°C above pre-industrial levels as stated in the Paris agreement (Shukla et al., 2019).

The EU has set a climate ambition of becoming carbon neutral by 2050, and all the member states have established their national policies to accomplish this goal while also contributing to global climate action (Commission, 2020). In the Netherlands, the government has set targets to reduce their greenhouse gas emissions to 49% relative to the 1990 levels by 2030 and an even more noteworthy 95% reduction by 2050 as outlined in the climate agreement(Klimaatakkoord) (GovernmentoftheNetherlands, 2024). Among the different sectors in the Netherlands, the construction sector contributes to 38% of the nation's carbon emissions, with 27% from operational energy use in buildings and 11% from embodied carbon in construction materials and processes, making it a major contributor to greenhouse gas emissions (Dutch Green Building Council, 2021). Considering the significant number of existing building stock, there is a great opportunity to reduce greenhouse gas emissions by renovating these buildings. This is particularly important as many of these buildings were constructed before many sustainability standards and energy efficiency practices were established (Konstantinou & Knaack, 2011). Renovation/refurbishment refers to the process of altering and enhancing an existing building to elevate it to an acceptable standard of condition (T. T. P. Bui, MacGregor, Domingo & Wilkinson, 2022).

Real estate institutional investors play a crucial role in this context, as they own and manage a significant portion of these older buildings (Christensen, Robinson & Simons, 2018). These institutional investors, including pension funds, insurance companies, real estate investment trusts, etc are the largest block of real estate owners and are projected to be doubled by 2050 (Christensen, Robinson &

Simons, 2022). They are recognized as key influencers in the chain of carbon emission reduction as their investment decisions significantly influence capital mobilization, building design, construction, asset management, disposal, and the reduction of real estate-related carbon emissions (World Business Council for Sustainable Development, 2021). They also possess the capacity to strongly incentivize market actors towards achieving carbon reduction goals (Garnett et al., 2023). Being one of the major stakeholders in the construction sector, they face mounting pressure to align their portfolios with sustainability goals while maintaining financial returns (Biasin, Delle Foglie & Giacomini, 2024). This pressure stems from various sources, including regulatory bodies, market demands, growing awareness of climate-related risks etc. (United Nations Environment Programme Finance Initiative, 2023).

1.2 Problem Statement

Real estate institutional investors have two major opportunities to tackle the greenhouse gas emissions in their portfolio: reducing operational carbon and minimizing embodied carbon. Currently, the focus has predominantly been on energetic renovations to reduce operational carbon, which refers to emissions from a building's day-to-day operations (Christensen et al., 2018). However, this approach often neglects the severe impact of embodied carbon – the emissions associated with materials and construction processes throughout a building's lifecycle (Eversmann, 2022). Neglecting embodied carbon can lead to a scenario where the carbon emissions related to renovation materials and processes will potentially nullify or even surpass the operational carbon savings (Röck et al., 2020). Therefore, it is crucial to adopt an integrated approach that considers whole-life carbon (WLC) which encompasses both the operational and the embodied carbon emissions to reach the carbon ambition goals (IIGCC, 2023).

Many leading real estate institutional investors in the Netherlands have demonstrated their commitment to reducing carbon emissions by signing initiatives like the Paris-proof commitment with DGBC, UNPRI, etc. These commitments make them responsible for reducing the overall emissions within their portfolio and not just operational carbon.

While there is a growing awareness among these investors regarding the importance of incorporating embodied carbon in their approaches, they face significant challenges in this endeavour. Some of these investors; who belong to the front-runner groups in such initiatives have portrayed their willingness by including agendas to reduce their material-related carbon emissions in their future investments in their published reports. However, despite the awareness and desire, these investors face significant challenges in considering WLC in their renovation strategies. The issue for these investors is not a lack of desire or understanding of the urgency, but rather the barriers they face and the absence of practical guidance for effectively integrating WLC considerations into their renovation strategies. Consequently, the challenge lies in overcoming these barriers and developing structured processes that will empower these investors to translate their aspirations into actionable strategies.

From an academic perspective, while the reduction of embodied carbon in new construction has received significant attention, there remains a critical knowledge gap in understanding the integration of WLC in renovation processes, particularly from the viewpoint of real estate institutional investors. Current academic literature largely focuses on investors' financial considerations and operational carbon reduction, with limited research addressing WLC integration. Furthermore, there is a notable absence of comprehensive frameworks or systematic approaches for integrating WLC considerations into existing renovation workflows from an investor's perspective. This gap is especially significant given the substantial role of renovation in achieving carbon reduction targets for the building sector, and the unique challenges it presents compared to new construction.

1.3 Collaboration with DGBC

This thesis is conducted in collaboration with the Dutch Green Building Council (DGBC) a leading non-profit organization at the forefront in promoting sustainable practices in the Netherlands. As an established member of the World Green Building Council, they develop programs on four main themes: carbon reduction, circularity, health, and climate adaptation. They develop and manage the BREEAM-NL certification, facilitate knowledge sharing and collaboration among over 400 partners within the construction sector, and also advocate for policy initiatives to achieve and promote sustainability goals in the Netherlands (Dutch Green Building Council, 2024).

DGBC has also formed a working group comprising leading real estate institutional investors—who are partners in their mission—at the forefront of carbon reduction efforts in the Netherlands. This group exemplifies the gap mentioned in the problem statement; actively seeking ways to translate their aspirations into actions. This thesis is designed to support proactive investors—who recognize the significance and urgency of considering WLC in their renovation strategies.

1.4 Research Objective

This research aims to provide real estate institutional investors in the Netherlands with practical guidance for integrating WLC considerations into their renovation strategies. It will analyze the current role of these investors in advancing WLC reduction while identifying the barriers and drivers influencing their adoption of this approach. By examining these factors, the research intends to empower investors to overcome challenges and seize opportunities, facilitating their ability to integrate WLC into their renovation projects. Furthermore, the research will focus on how to effectively incorporate WLC considerations into their existing renovation processes taking into account the relative unfamiliarity of the approach and the urgent need to address climate change mitigation.

1.5 Research Scope

This study focuses on real estate institutional investors in the Netherlands who manage diverse property portfolios, such as commercial, office, residential buildings, etc. It specifically targets investors aware of the significance of WLC and its incorporation in renovation processes. The scope is limited to existing building renovations and does not cover new construction.

1.6 Research Question

The following research questions were developed to formulate an answer for the problem described in the above section. The main research question will help investigate the current situation and provide a solution for the main topic/problem. The sub-questions will help in formulating an answer to the main research question systematically.

1.6.1 Main Research Question

The main research question acts as the guiding framework for this study, enabling an in-depth examination of how investors can effectively contribute to achieving carbon reduction targets, especially regarding WLC emissions in renovation projects.

How can the real estate institutional investors incorporate whole-life carbon reduction into their renovation processes in the Netherlands?

1.6.2 Sub-Research Questions

The sub-research questions will collectively contribute to addressing the main research question and are outlined below.

- *What roles do institutional investors play in integrating whole-life carbon reduction into their renovation projects ?*
- *What barriers and motivators do institutional investors face in incorporating whole-life carbon reduction into their renovation efforts?*
- *What strategies can be employed to integrate whole-life carbon considerations into their renovation processes while addressing the identified barriers and motivators?*
- *How practical and feasible are the proposed strategies for integrating embodied carbon into the current energetic renovation processes?*

Chapter 2

Research Approach

This chapter begins with the research question framework section, detailing the rationale behind each question, the methods utilized to address them, and the anticipated outcomes. The discussion extends to the validation method and ethics, ensuring the research is conducted with rigour and integrity. Finally, the chapter presents a research flow diagram, illustrating the progression of the research process.

2.1 Research Question Framework

This study employs a qualitative approach due to the exploratory nature of the main question and the need to develop a deep understanding of institutional investors' roles and challenges in incorporating WLC reduction in renovation approaches. The research methods include a comprehensive literature review and semi-structured interviews with real estate institutional investors in the Netherlands who are also in the working group with the DGBC.

2.1.1 Main Research Question

How can real estate institutional investors incorporate whole-life carbon reduction into their renovation processes in the Netherlands?

Reasoning

This question addresses the essential need for a practical approach to integrating WLC considerations into the renovation processes of institutional investors. It aims to align their sustainable practices with carbon reduction ambitions, thereby bridging the gap between investor's aspirations for effective implementation of carbon reduction strategies in real estate renovation projects.

Methods

The main research question is answered through a combination of literature review, expert interviews and expert panel discussion, as detailed in the sub-research questions.

Result

The expected outcome is a comprehensive set of strategies for institutional investors to incorporate WLC reduction into their renovation processes.

2.1.2 Sub-Question 1

What roles do institutional investors play in integrating WLC reduction into their renovation projects?

Reasoning

Understanding the current roles and responsibilities of institutional investors is crucial for identifying how and to what extent WLC considerations can be integrated by them.

Methods

This question will be addressed through a literature review and semi-structured interviews with real estate institutional investors in the Netherlands who are also in the working group with DGBC.

Result

A detailed overview of the roles institutional investors currently play and potential areas for expanded involvement in WLC reduction efforts.

2.1.3 Sub-Question 2

What barriers and motivators do institutional investors face in incorporating WLC reduction into their renovation efforts?

Reasoning

Identifying barriers and motivators is essential for developing effective strategies to encourage the adoption of WLC reduction practices.

Methods

This question will be explored through a literature review and in-depth interviews with institutional investors and industry professionals.

Result

A comprehensive list of barriers and motivators, providing insight into the challenges and opportunities for integrating WLC reduction in renovation projects.

2.1.4 Sub-Question 3

What strategies can be employed to integrate WLC considerations into their renovation processes while addressing the identified barriers and motivators?

Reasoning

Developing practical strategies is crucial for translating research findings into actionable steps for institutional investors.

Methods

Practical strategies for integrating embodied carbon into the current approaches of institutional investors will be developed, ensuring that existing processes remain undisturbed. The identified barriers from both the literature review and interviews will be considered in the relevant stages of the proposed process. Additionally, strategies for overcoming these barriers—drawn from insights gained through the literature review and interview findings—will be suggested.

2.1.5 Sub-Question 4

How practical and feasible are the proposed strategies for integrating embodied carbon into the current energetic renovation processes?

Reasoning

Given the inherent complexity of incorporating embodied carbon considerations into the renovation processes of institutional investors and the relatively unexplored nature of this research topic, it is

essential to ensure the practicality and feasibility of the conclusions drawn through validation.

Methods

To validate the research findings, an expert panel discussion will be held with representatives from the working group at the DGBC including the real estate institutional investors who participated in the semi-structured interviews, professionals from DGBC, as well as external investors not involved in earlier discussions. Incorporating insights from both previously engaged investors and new participants enriches the validity of the developed strategies, while professionals from DGBC provide essential expertise on sustainability practices and policies relevant to the real estate sector, ensuring alignment with these standards. A detailed overview of the validation method can be found in the section 5.2.

2.2 Ethical Considerations

The integrity of this research was upheld through a strong commitment to ethical considerations, focusing on the protection of personal data and participant confidentiality. Transparency was ensured by clearly communicating the research objectives, data collection methods, and participants' rights. Consent forms were created and signed by all participants, confirming their voluntary involvement and understanding of the study's purpose. Collaborating with the DGBC and institutional investors, careful planning was undertaken to adhere to ethical protocols, including identifying sensitive information and securely storing all data. All associated risks and mitigation measures were documented in the Data Management Plan and Human Research Ethics Form, which received approval from the relevant ethical review board.

2.3 Research Flow

This research flow diagram illustrates the step-by-step used to investigate the integration of WLC considerations into real estate institutional investors' renovation processes.

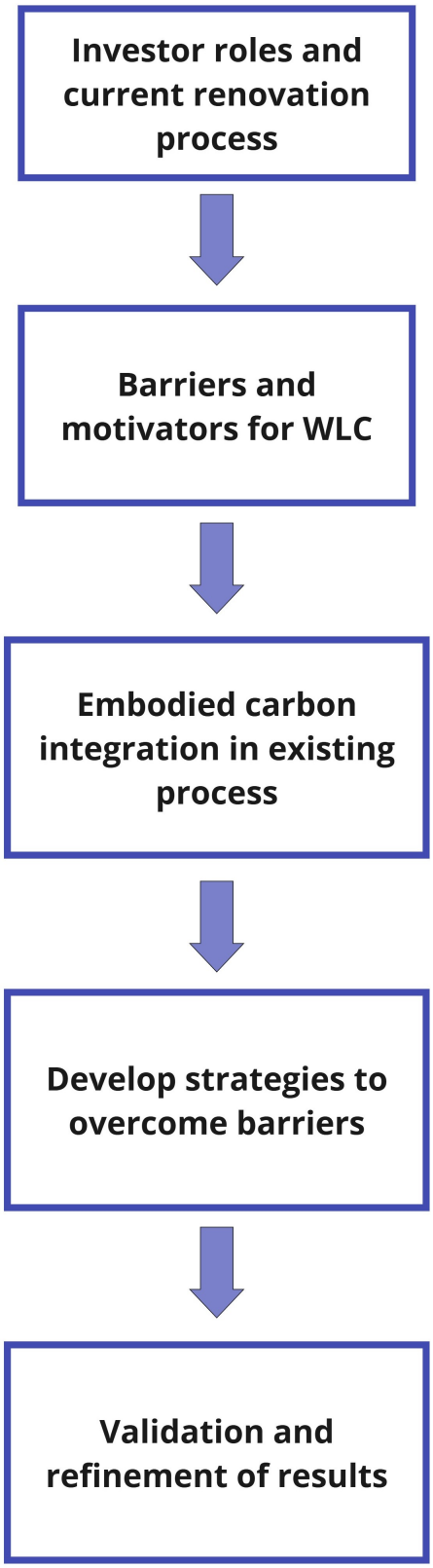

Figure 2.1: Research Flow

Chapter 3

Literature Review

The literature review chapter provides the foundation for understanding the integration of WLC reduction in building renovation projects. Beginning with the fundamentals of building renovation processes, the chapter explores the WLC concept and its application in renovation projects. It then examines the role of real estate institutional investors in carbon reduction initiatives, focusing on their unique position as entities that operate across multiple roles in the building system value chain. The chapter analyzes relevant policies and regulations within the Dutch context and concludes by looking into both the motivators driving institutional investors towards sustainable practices and the barriers they face in implementing sustainable real estate strategies.

3.1 Renovation of Buildings

Renovation/refurbishment refers to altering and enhancing an existing building to elevate it to an acceptable standard of condition. This complex and multifaceted process involves various stages that extend beyond mere physical improvements (T. T. P. Bui et al., 2022). While different literature papers may present varying numbers of phases, there is general agreement on the fundamental stages of renovation projects.

Staffansson Pauli et al. (2020), outline a detailed ten-step process for renovation, beginning with the identification of technical or functional obsolescence and ending with the user phase and maintenance. This comprehensive approach encompasses crucial stages such as inventory/documentation, pre-investigation and design of alternative solutions, cost calculations, design decisions, construction consent, and the actual renovation works.

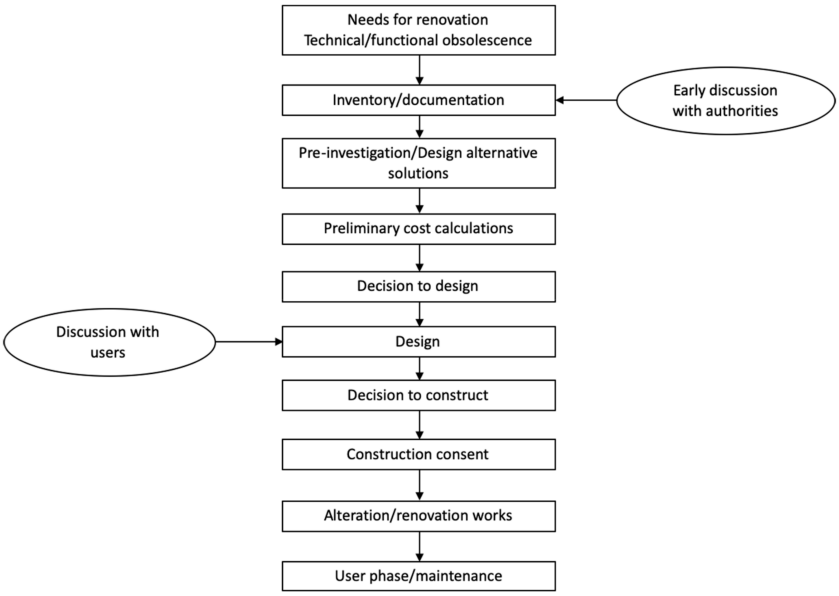

Figure 3.1: Steps in renovation (Staffansson Pauli et al., 2020).

Prieto et al. (2023), present a more condensed view of the renovation process, aligning it with the general construction project framework. This framework typically includes four main phases: (1) pre-project, which establishes project requirements; (2) pre-construction, involving the development of design solutions; (3) construction, where solutions are implemented; and (4) post-construction, focusing on project monitoring and upkeep. Even though the stages align with that of a general construction project, renovations introduce additional complexities due to existing structures, with the pre-project phase involving building analysis and diagnostics to delineate the scope of intervention. Furthermore, the presence of current occupants during construction significantly influences aspects such as scheduling (Ferreira, Pinheiro & de Brito, 2013; Konstantinou & Knaack, 2011; Ma, Cooper, Daly & Ledo, 2012). The figure below illustrates a detailed description of the renovation process stages with the core tasks, outcomes and the leading stakeholders involved in each stage.

Phase	1	2	3	4	5
Name	Pre-project	Concept design	Final design	Execution and handover	Post-construction
Description	Defines the need for the project, the problems, the ambition. Sets up the design team	Identification and comparison of strategy, interventions, design principles	Tender, specification of products, engineering of components	Manufacturing, assembly off-site and on site, hand-over	Post-occupancy evaluation / optimization loops
Core tasks included	Setting objective and criteria Diagnosis of existing condition Definition of client requirementsCost initial estimateSelection design team	Identification of renovation measures Decision on industrialized components design concept Assessment and optimization Preparation of permit applications	Detailed design for industrialized renovation Survey of existing building Engineering of the components Tender and products specification	Manufacturing Transport Mounting Site ConstructionConstruction quality control Hand-over	Building operation optimization Monitoring Post occupancy
Phase outcome	Project Brief approved by the client, and confirmed feasibility	Renovation strategy approved by the client	All design information required to manufacture and construct the project completed	Manufacturing, construction, commissioning completed and hand-over	Building used, operated, and maintained efficiently.
Leading stakeholder	Client team	Design team Specialist consultants Client team	Design/construction team Specialist subcontractors	Construction team Specialist subcontractors	Client Facility management Specialist consultants

Figure 3.2: process description of renovation Prieto et al. (2023)

T. T. Bui, MacGregor, Domingo and Wilkinson (2023), describe a renovation decision-making process involving nine stages: (1) evaluating the condition of the building, (2) setting goals, (3) devising renovation strategies, (4) generating alternative renovation plans, (5) estimating and evaluating performance, (6) selecting optimal renovation alternatives, (7) designing the project in detail, (8) carrying out construction, and (9) managing operation. Carbon reduction decisions for renovation primarily occur during the initial phases of this process.

This overview of the renovation process highlights the complexity involved and emphasizes the importance of tailored approaches. The decision-making stages reveal the critical points where strategic

planning and stakeholder coordination are essential to ensure successful outcomes. As the construction industry evolves, renovation projects are increasingly expected to address not only immediate functional needs but also long-term sustainability goals. This shift in focus underscores the growing importance of integrating environmental considerations, such as energy efficiency and carbon reduction, into renovation processes from the early planning stages through to post-construction management.

3.2 Whole Life Carbon and Renovation

This section explores the concept of whole life carbon and its application in building renovation. Whole life carbon is a critical aspect of sustainability because it provides a comprehensive view of a building's carbon footprint, from construction through its operational life to demolition. The following subsections define the whole life carbon concept and then delve into its relevance and application in building renovation processes.

3.2.1 Whole Life Carbon Concept

Whole-Life Carbon (WLC) refers to the total carbon emissions produced by a building throughout its entire existence. This concept encompasses both operational and embodied carbon emissions, and in some cases, it can include emissions linked to circular economy practices. Operational carbon emissions denote the net emissions from the energy consumed to operate a building, including various services such as lighting, heating, cooling, ventilation, and water. Embodied carbon emissions encompass all non-operational aspects of a building's lifespan. This includes emissions associated with the extraction, manufacturing, and assembly of building materials and components as well as processes like maintenance, repair, replacement, demolition, and disposal. Additionally, embodied carbon emissions cover emissions from transportation activities related to building production, such as the transportation of construction materials to a building site (Christie, 2021; Network et al., 2021).

As mentioned by Royal Institution of Chartered Surveyors (2017), the EN 15978 standard (the European standard) provides a comprehensive framework for assessing WLC in the built environment. It refers to WLC as the sum of operational and embodied carbon. It divides the life cycle of a building into distinct stages:

1. *Product stage (A1-A3):* This stage covers all processes from raw material extraction to the finished product at the factory gate.
2. *Construction process stage (A4-A5):* This stage covers transportation to the site and all on-site processes until the building is ready for use.
3. *Use stage (B1-B7):* This stage covers the period from the handover of the building to when it is deconstructed/demolished.
4. *End of life stage (C1-C4):* This stage covers the processes from the end of the building's use to the final disposal or recycling of materials.
5. *Benefits and loads beyond the system boundary (D):* This module includes potential benefits or impacts from reuse, recovery, or recycling that occur outside the system boundary, such as using recycled materials in other products.

In the Netherlands, the Environmental Performance of Buildings (MPG) is used to measure the environmental impact of building materials and processes throughout a building's life cycle. In the Dutch assessment method for the MPG, Module D, which includes reuse, recycling potential, and energy recovery, is considered alongside Modules A to C. This differs from the World Green Building Council (WGBC) method, which treats Module D separately. Additionally, the Dutch method does not include

operational water consumption within the WLC scope (Dutch Green Building Council, 2021).

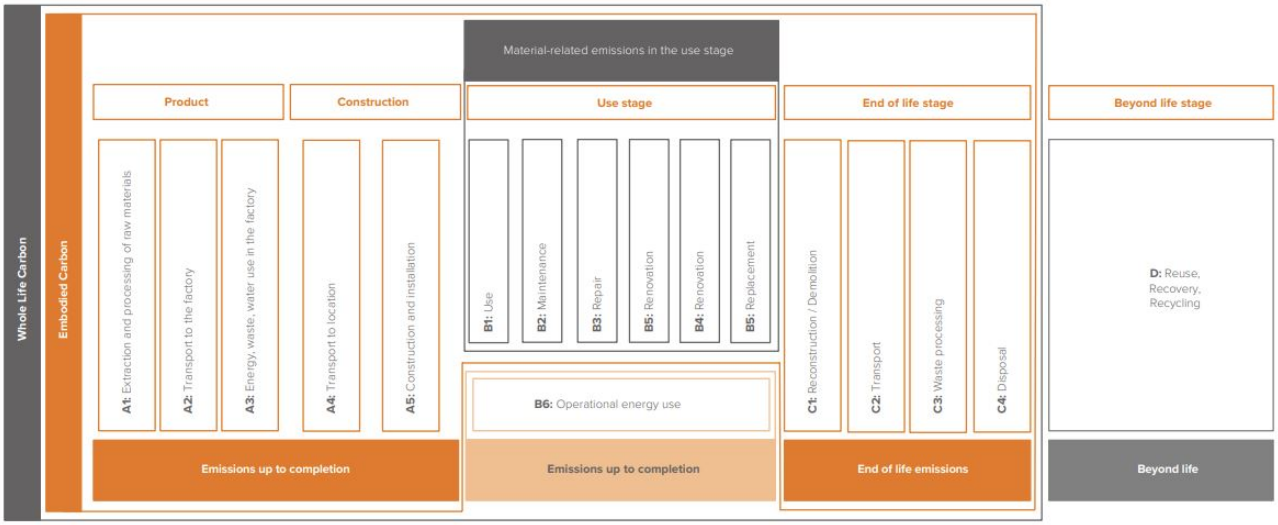

Figure 3.3: WLC concept following EN 15978 standard (Dutch Green Building Council, 2021).

3.2.2 WLC In Building Renovation

In building renovations, two primary opportunities for mitigating carbon emissions are operational and embodied carbon. Enhancing building energy efficiency emerges as a prevalent strategy for curbing operational emissions, commonly accomplished through upgrades in energy-efficient systems, adoption of passive design principles, and integration of renewable energy technologies. However, augmenting energy performance often entails the introduction of additional materials and processes, thereby amplifying the embodied carbon footprint of the entire structure. Therefore it is also important to consider embodied carbon reduction strategies alongside the reduction of operational carbon. The different embodied carbon reduction strategies that can be utilized are the following:

- Low carbon materials:

  Biobased materials such as timber, bamboo, and hempcrete are effective in reducing embodied carbon due to their ability to sequester carbon during growth. These materials serve as sustainable alternatives to traditional high-carbon materials like concrete and steel, significantly lowering the carbon footprint of construction projects (Fonteijn, Trip, Verstand, Liu & Ballinas, 2023).

- Material Reuse and recycling:

  The recycling of construction materials presents the greatest potential for reducing embodied emissions, achieving up to a 53% reduction. In comparison, reusing construction materials offers a smaller but significant reduction potential, contributing around 6.2% to embodied emission savings (Asdrubali, Baldinelli, D'Alessandro & Scrucca, 2015).

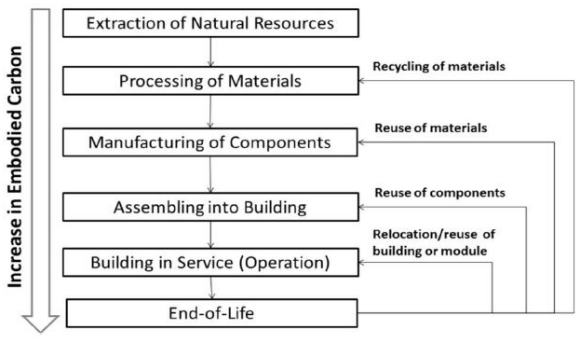

Figure 3.4: Embodied carbon relative to the material life cycle stages (Akbarnezhad & Xiao, 2017).

- Material minimization:

  Material minimization can be the best way to reduce embodied carbon in buildings (Akbarnezhad & Xiao, 2017). This can be achieved by strategies such as design optimization (Yeo & Gabbai, 2011).

- Local sourcing of materials and components:

  As per Rodriguez Serrano and Porras Álvarez (2016), transportation activities contribute approximately 16.5% to the total embodied carbon emissions associated with building construction. This can be prevented by locally sourcing materials (Pomponi & Moncaster, 2016).

- Optimizing construction processes:

  Optimizing construction processes to minimize equipment downtime, selecting the most efficient machinery for specific tasks, enhancing machinery utilization, and decreasing on-site mobility in both directions. Furthermore, construction optimization can be improved by utilizing advanced equipment and shortening project timelines. Using prefabricated components and off-site production methods is also an effective approach to further mitigate embodied carbon emissions (Akbarnezhad & Xiao, 2017; Pomponi & Moncaster, 2016).

Both embodied and operational carbon are crucial to consider during building renovations, as they significantly contribute to the overall carbon footprint of the building (T. T. P. Bui et al., 2022). Therefore it is very important to consider the WLC approach in renovation projects (T. T. P. Bui et al., 2022).

Traditionally, in life cycle assessments following standards like EN 15978, renovation is often categorized under stage B5 within the Use stage (B1-B7). However, this classification doesn't fully capture the comprehensive nature of WLC in renovation projects. WLC assessment in renovation projects encompasses a comprehensive evaluation of carbon emissions throughout a building's entire lifecycle, integrating both operational and embodied carbon considerations. Operational carbon refers to emissions associated with energy consumption during the building's post-renovation operation, including heating, cooling, and lighting. Embodied carbon, equally crucial, comprises initial carbon from new materials and components, emissions from construction processes and on-site activities, recurring carbon from maintenance and replacements, and end-of-life emissions from eventual demolition and disposal. It also considers the remaining embodied carbon in retained building elements and the end-of-life emissions of removed components (Royal Institution of Chartered Surveyors, 2017; Vilches et al., 2017).

The schematic representation as per (Vilches et al., 2017) illustrates which stages/aspects should be considered while doing an LCA for WLC consideration in renovation projects:

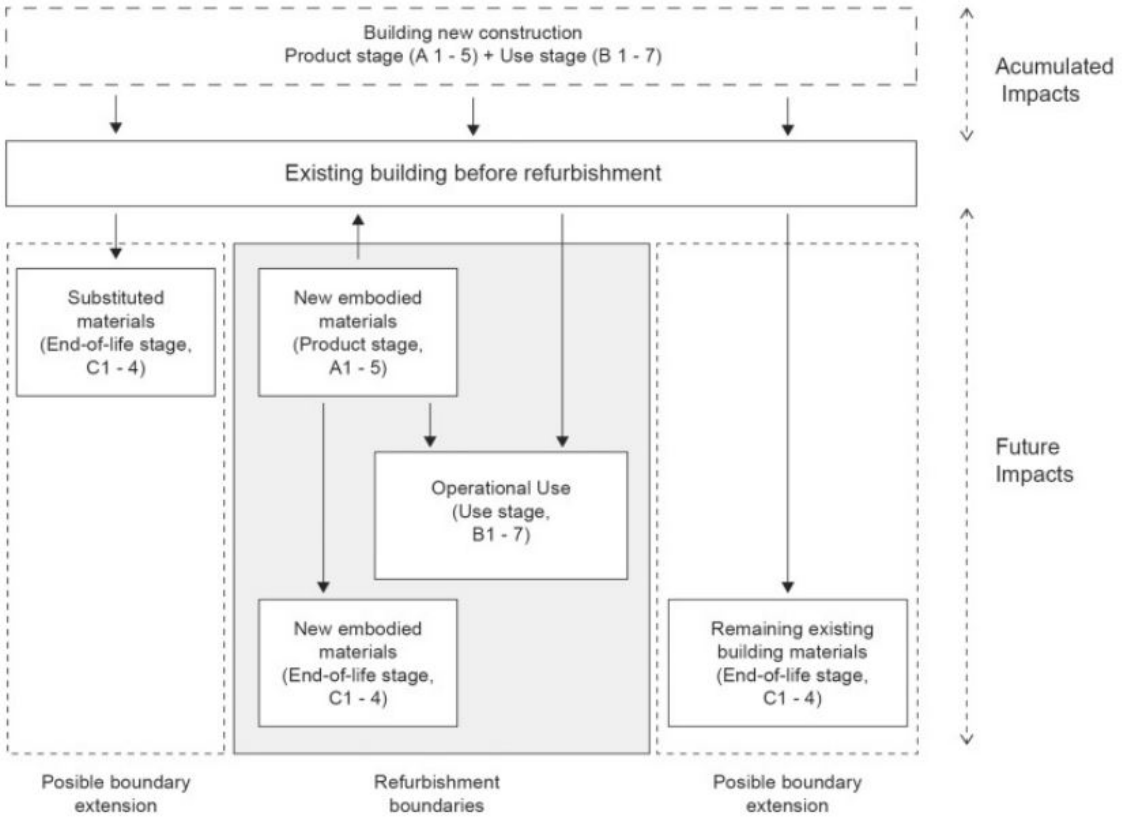

Figure 3.5: Building refurbishment boundaries (Vilches et al., 2017).

3.3 Investors and Carbon Reduction in Renovation

This section examines real estate institutional investors and their pivotal role in driving carbon reduction through renovation projects. As significant stakeholders in the construction sector, these investors operate across multiple functions - from providing capital and developing properties to managing assets. The following subsections first explore the nature and characteristics of real estate institutional investors which is then followed by an analysis of their unique position to influence carbon reduction initiatives throughout the building lifecycle, from investment decisions to property management practices, highlighting their potential to accelerate the transition towards sustainable real estate practices.

3.3.1 Real Estate Institutional Investors

Real estate institutional investors are entities that invest large sums of money in real estate assets on behalf of organizations or groups of individuals. These entities typically include pension funds, insurance funds, etc. Their investment strategies often involve acquiring and managing various types of real estate properties such as office buildings, residential buildings, etc. They seek to generate returns through rental income, property appreciation, and sometimes through development projects or value-added strategies. These investors often have significant resources and expertise in analyzing and managing real estate investments, allowing them to diversify their portfolios (Davis & Steil, 2004; Van Loon & Aalbers, 2017). Real estate institutional investors play several roles. Fund management involves overseeing investment vehicles dedicated to real estate, from raising capital to making strategic investment decisions. Property management ensures the day-to-day operations of individual properties, optimizing tenant relations and property performance. Asset management focuses on maximizing the value of each asset through strategic oversight and value enhancement initiatives and is usually outsourced to external parties. Portfolio management involves the holistic management of the entire investment portfolio, including asset allocation, risk assessment, and performance monitor-

ing. Asset management and portfolio management strategies are often delegated to external parties. Together, these roles work in concert to drive investment success, balancing risk and reward while striving to achieve the investor's financial objectives (Van Loon & Aalbers, 2017).

3.3.2 Role of Real Estate Institutional Investors

Institutional investors are the largest block of real estate owners and are projected to be doubled by 2050 (Christensen et al., 2022). Investors have a significant impact on capital mobilization, building design, construction, management, and operation, asset disposal, and the acceleration of real estate-related carbon emission reductions. Investor action has the potential to strongly incentivise market actors to cut emissions and steer activities within the built environment. Amidst various stakeholders to reduce WLC and renovation processes, investors emerge as a particularly potent force, capable of aligning activities towards achieving carbon ambitions by 2050. Being a powerful stakeholder and combining with the potential aspects such as WLC reduction in the renovation process, institutional investors can stir the process of attaining the carbon ambitions set by the government and other regulatory agencies (Garnett et al., 2023). In recent years, while an increasing number of real estate entities have demonstrated interest in sustainable development, a significant disparity persists between stated intentions and actual initiatives implemented by companies. Many lack the requisite strategy, organizational culture, and tools necessary to translate sustainability commitments into tangible actions (Ionașcu, Mironiuc, Anghel & Huian, 2020).

Real estate institutional investors occupy a strategic position in the building system value chain which makes them unique and the most suitable market parties. Their significance stems from their ability to influence both the influencer value chain (stakeholders who shape how buildings are designed, constructed and operated) and the building value chain (private sector actors required to physically construct and operate building assets) through their investment decisions and sustainability criteria. While they operate primarily through investment decisions rather than direct operational involvement, their influence extends across multiple segments of the system. Their position is particularly crucial as they face both physical climate risks and transition risks to their portfolios, making carbon reduction a strategic priority for protecting asset value. Through their procurement policies and investment criteria, they can shape building design, construction standards, and renovation practices. Furthermore, their substantial financial resources enable them to fund significant carbon reduction initiatives that other stakeholders might find challenging to implement. Their position enables them to influence decisions that determine which projects receive funding, what materials are selected, and what energy efficiency standards must be met - factors that significantly impact a building's life-cycle carbon emissions. This strategic position as capital providers, combined with their market influence and financial capacity, makes them essential catalysts in promoting carbon reduction efforts across the building life-cycle (World Business Council for Sustainable Development, 2021).

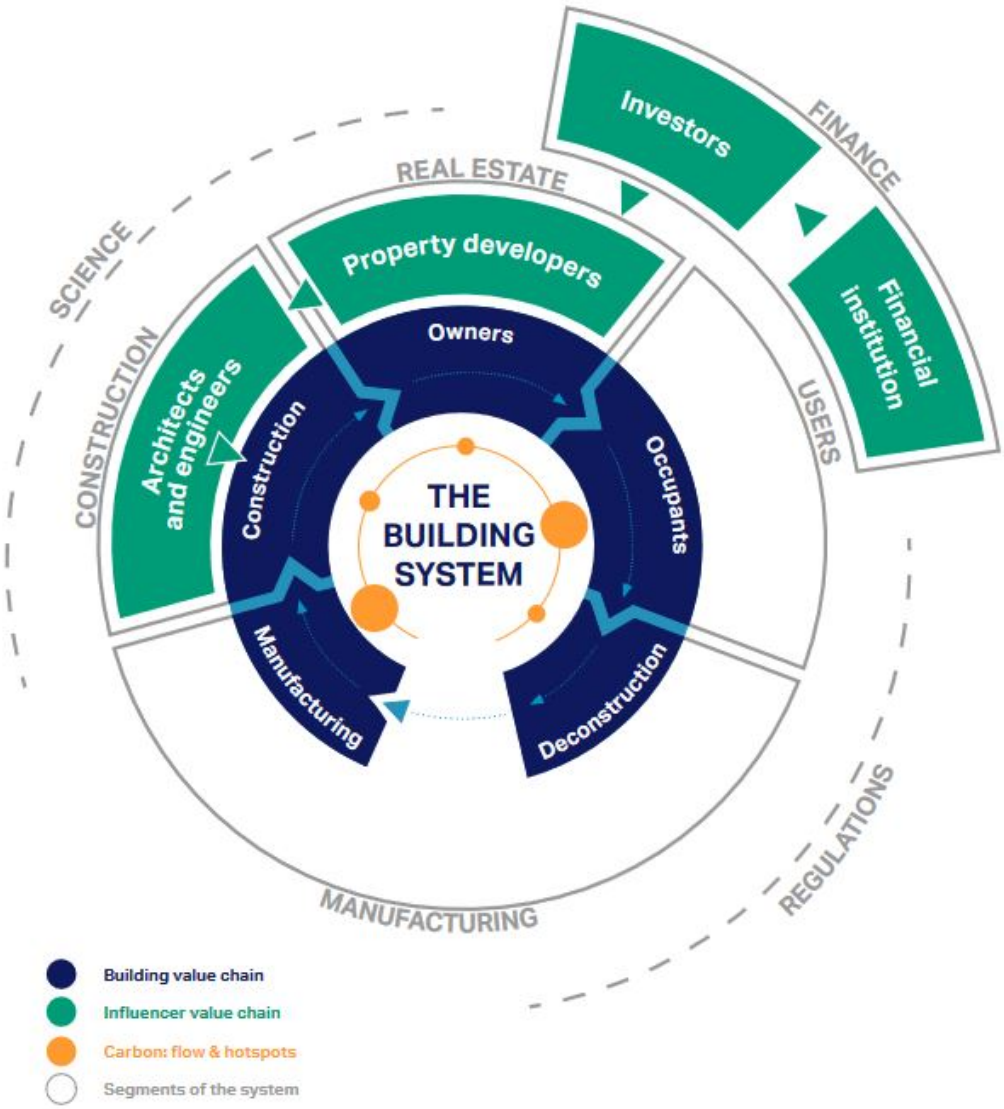

Figure 3.6: Value chain and carbon reduction influence (World Business Council for Sustainable Development, 2021).

Figure 3.7: Real Estate Institutional Investor Influence(Own Figure)

3.4 Policies and Regulations for the Dutch Context

To effectively integrate WLC into renovation projects, it is essential to consider the policies and regulations that govern the built environment in the Netherlands. These shape the strategies of real estate institutional investors and provide the framework within which they operate. This section will explore the key policies and regulations relevant to the Dutch context, highlighting how they influence the decisions and actions of institutional investors in their efforts to meet sustainability and carbon reduction targets. The various policies, regulations and initiatives that are relevant in the Dutch context are as follows:

UN Level

1. Paris Proof Agreement: The Paris Agreement, adopted by many countries in 2015 during the COP 21 in Paris, is a legally binding treaty that aims to limit global temperature rise to well below 2 degrees Celsius, with efforts to restrict the increase to 1.5 degrees Celsius above pre-industrial levels (UNFCC, 2024).

EU Level

1. EU Green Deal: It is a comprehensive policy initiative that is aimed at making the EU climate-neutral by 2050. It contains various policies such as the EU Renovation wave, circular action plan, sustainable finance, etc that are also aimed at decreasing carbon emissions and directing investments towards such carbon-reducing activities (Commission, 2024b). The various policies that fall under this and are relevant for this research are the following:

    - EU Renovation wave: This strategy aims to double annual energy renovation rates in the next ten years. It focuses on tackling energy poverty and worst-performing buildings (Commission, 2020).
    - Construction Products Regulation(CPR): The CPR establishes uniform guidelines for building product marketing within the European Union. It makes sure that consumers, public officials, and experts have access to trustworthy information so they can evaluate the features and performances of goods made by various manufacturers which involves environmental and sustainability criteria (Commission, 2024b).
    - Energy Performance Buildings Directive(EPBD): This initiative aims to improve the energy performance of buildings by setting minimum target requirements thereby promoting carbon reduction (European Commission, 2024a).
    - The EU Emission Trading System (ETS): It is a market-based mechanism for setting limits on greenhouse gas emissions. It is targeted toward the market parties such as the material suppliers and encourages these organizations to reduce emissions by requiring them to acquire allowances for carbon emissions. This fosters the utilization of cleaner technology and practices, which aids the EU's climate goals and transition to a low-carbon economy (European Commission, 2024b). The contractors, investors, etc are indirectly affected by this mechanism.
    - EU Taxonomy: It is a common classification system that enables firms to identify which activities are considered sustainable (European Commission, 2024c).
    - Corporate Sustainability Reporting Directive(CSRD): Businesses must report on how their operations affect society and the environment under the Corporate Sustainability Reporting Directive (CSRD). It makes the incorporation of ESG into their activities compulsory which is also directed to reduce carbon emissions (Commission, 2024a).
    - Sustainability Finance Disclosure Regulation (SFDR): Financial market participants, especially institutional real estate investors, are required by the SFDR to explain how they consider sustainability risks when making investment decisions. The legislation is being implemented gradually, and in the upcoming years, more standards will become mandatory (European Commission, 2024d).

Dutch Level

1. The Dutch Climate Agreement: As per the agreement, the government of the Netherlands has targeted to reduce greenhouse gas emissions by 49% in 2030 and 95% in 2050 compared to the 1990 levels (GovernmentoftheNetherlands, 2024).
2. Environmental Performance Of Buildings: The Environmental Performance of Buildings (MPG)

is a standardized calculation method that assesses the environmental impact of construction materials. It helps stakeholders evaluate and reduce the ecological footprint of buildings (Rijksdienst voor Ondernemend Nederland, 2024).

3. Nearly Energy-Neutral Buildings (BENG): These standards require new buildings in the Netherlands to be highly energy-efficient. These regulations ensure that new constructions minimize energy consumption while generating renewable energy on-site, supporting national climate objectives (Rijksdienst voor Ondernemend Nederland, 2024).

Initiatives

1. DGBC Paris Proof Commitment: The DGBC Paris Proof agreement aims to align the Dutch construction sector with the Paris Agreement's climate objectives. By providing a set of guidelines and tools for achieving carbon neutrality, it encourages stakeholders across the built environment to implement sustainable practices that support national and global emissions reduction targets (Council, 2024).
2. Actual Energy Intensity Indicator (WEii): It quantifies the actual energy consumption of buildings and provides insights into energy performance, helping identify inefficiencies and guiding targeted improvements in energy management (TVVL & Dutch Green Building Council, 2024).
3. BREEAM Certifications- It is one among the recognized certifications that help various stakeholder groups to their commitment to sustainability initiatives such as carbon reduction. The Dutch adaptation to BREEAM is BREEAM NL and the DGBC is the authority in issuing and managing the certification to the parties within the sector (BRE Group, 2024).
4. Global Real Estate Sustainability Benchmark (GRESB): GRESB assesses the Environmental, Social, and Governance (ESG) performance of real estate assets. By providing standardized data, it enables investors to evaluate sustainability practices and make informed investment decisions (GRESB, 2024).
5. CRREM Methodology: CRREM offers science-based pathways for the real estate sector to achieve decarbonization aligned with the Paris Climate Goals. It helps stakeholders understand and plan for the transition to low-carbon operations (Carbon Risk Real Estate Monitor, 2020).

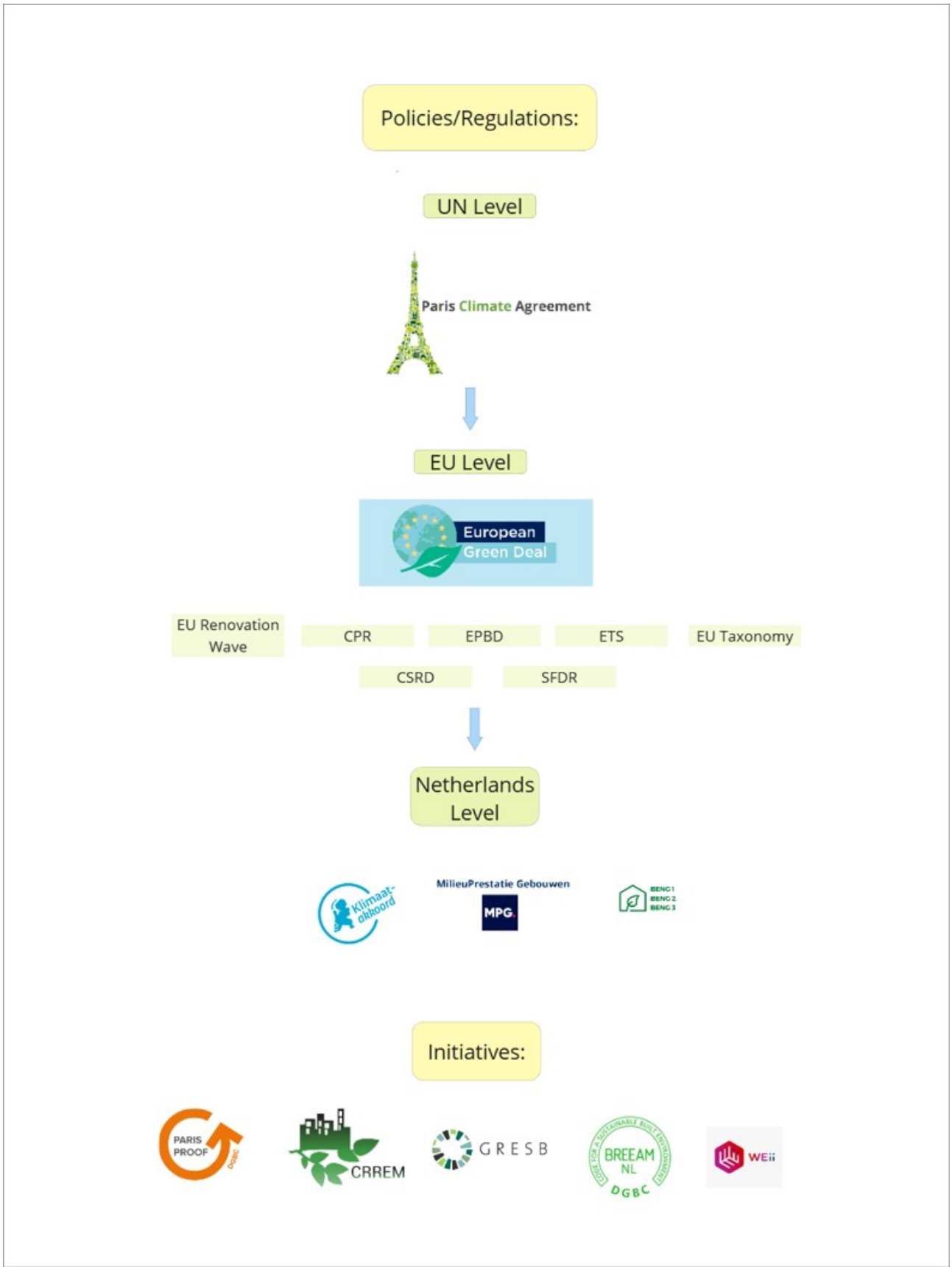

Figure 3.8: Policies and regulations (Own Figure)

3.5 Motivators of Institutional Investors

In an era where environmental responsibility is paramount, the integration of sustainable practices into investment considerations has become not just a choice but a necessity for real estate institutional investors. As sustainability becomes increasingly important in investment decision-making, aligning renovation practices with carbon reduction not only meets stakeholder expectations but also positions investors favourably in a competitive market. Ultimately, these motivators as explained below drive the integration of sustainable practices into the renovation processes:

1. **Financial Performance**

   Institutional investors are increasingly motivated by the potential for improved financial performance through carbon reduction in renovation projects. This includes enhanced financial outcomes through reduced operational costs and potential increased asset value (Lopez-de Silanes, McCahery & Pudschedl, 2022). The incorporation of carbon considerations also serves as a protection against future value depreciation of non-sustainable assets, which is becoming increasingly important in a market that values sustainability (Christensen et al., 2022). Furthermore, investors are attracted by the access to green financing options and preferential lending rates for sustainable renovations, which can make these projects more financially viable (Debrah, Chan & Darko, 2022). The economic drivers, including anticipated financial returns, payback periods, and asset finance ability, play a crucial role in decision-making processes for sustainable initiatives (Brooks & McArthur, 2019).

2. **Regulatory Compliance and Risk Mitigation**

   The evolving regulatory landscape is a significant driver for institutional investors to incorporate carbon reduction in renovation projects. Adherence to evolving building energy codes and environmental regulations, such as the EU Energy Performance Buildings Directive (EPBD), is becoming increasingly important. Investors are also anticipating future mandatory reporting requirements for embodied carbon emissions, which is prompting proactive measures in renovation strategies. By incorporating carbon reduction considerations, investors aim to reduce exposure to potential fines and penalties related to carbon emissions (Sayce, Ellison & Parnell, 2007). This approach aligns with the broader trend of legislation and regulation driving sustainable property investment, as well as risk mitigation strategies in the face of changing lease patterns and market demands.

3. **Long-term Asset Management**

   Long-term asset management considerations are driving institutional investors to incorporate WLC reduction in renovation projects. This approach helps in future-proofing assets against changing market demands and regulations, ensuring their long-term viability and value (Christensen et al., 2022). The extension of building lifecycles through sustainable renovations is seen as a strategic asset management activity aimed at enhancing sustainability and value creation. By creating more resilient and adaptable building portfolios, investors are better positioned to mitigate risks associated with climate change impacts and changing market preferences (Debrah et al., 2022). Moreover incorporating carbon considerations in renovation projects can enhance an investor's competitive position in the market, potentially leading to improved tenant attraction and retention, and higher asset values, thus contributing to long-term asset performance and resilience (Christensen et al., 2022).

4. **Corporate Strategy and Reputation**

   Alignment with corporate sustainability commitments and ESG targets is a significant motivator for institutional investors to incorporate WLC reduction in renovation projects (Brooks

& McArthur, 2019). This approach enhances the company's reputation among stakeholders, including investors and tenants, demonstrating a commitment to addressing climate change within the real estate sector. Institutional investors are increasingly aware of the environmental impact of their portfolios and the need to contribute to climate change mitigation. Reducing the carbon footprint of their properties, including embodied carbon in materials and construction processes, aligns with global sustainability goals. Many institutional investors are motivated by corporate social responsibility and commitments to carbon neutrality, which drives them to pursue carbon reduction in renovation projects as a way to fulfil these pledges and contribute to a low-carbon economy (Hafner, Jones, Anger-Kraavi & Pohl, 2020). The emphasis on corporate social responsibility and responsible investment principles drives investors to pursue sustainable practices in their property portfolios, including WLC reduction in renovation projects.

5. **Industry Trends and Peer Pressure**

   Alignment with best practices in the real estate sector and competitive pressure to match or exceed peers' sustainability efforts are driving institutional investors to incorporate carbon reduction in renovation projects. The real estate industry is increasingly recognizing the importance of sustainability, and investors are motivated to stay competitive in this changing landscape (Christensen et al., 2022). This peer pressure and the desire to be seen as industry leaders in sustainability are pushing investors to adopt more comprehensive approaches to carbon reduction, including WLC considerations in their renovation strategies.

3.6 Barriers faced by Institutional Investors

Incorporating WLC reduction into renovation projects presents a range of barriers for real estate institutional investors. These barriers can hinder the effective implementation of these practices, creating a significant challenge in the context of the growing emphasis on sustainability in the real estate sector. Understanding these obstacles that the investors must navigate to align their renovation strategies with broader environmental goals is crucial. The barriers are as mentioned below:

1. **Economic and Financial Challenges**

   Real estate institutional investors face significant economic hurdles when incorporating WLC reduction in renovation projects. High upfront costs coupled with uncertain long-term returns create a challenging investment landscape. Additionally, the lack of a clear business case or commercial viability presents a significant barrier. Investors often struggle to justify WLC reduction initiatives from a financial perspective, as the long-term benefits may not be immediately apparent or easily quantifiable (Pan & Pan, 2021). Limited access to capital and green financing options further exacerbate these difficulties (Mustaffa, Ahmad & Bahrudin, 2021). The perception of high risk with low returns often deters investors (Mustaffa et al., 2021), while split incentives between building owners and tenants complicate the financial justification for improvements (Falkenbach, Lindholm & Schleich, 2010). Additional financial barriers include constraints related to capital expenditure, liquidity concerns, elevated transaction costs, and extended project lifecycles (Debrah et al., 2022). Discrepancies in VAT rates between new builds and renovations also contribute to the economic challenges (Davies & Osmani, 2011). These factors collectively create a complex financial environment that can discourage investors from prioritizing WLC reduction in their renovation strategies.

2. **Regulatory and Policy Issues**

   The regulatory landscape presents significant challenges for investors seeking to incorporate WLC considerations. A lack of clear and consistent climate policy frameworks creates uncertainty and hesitation among investors (Hafner et al., 2020). The absence of comprehensive

regulatory frameworks specifically tailored to renovation projects further complicates decision-making processes. Ambiguity in building regulations and compliance standards adds another layer of complexity (Davies & Osmani, 2011). Unpredictable shifts in policies and governmental limitations in capacity contribute to a volatile regulatory environment (Debrah et al., 2022). Moreover, the absence of clear regulatory requirements or standards for embodied carbon reporting and reduction leaves investors without clear guidance (IIGCC, 2023). This regulatory uncertainty makes it difficult for investors to confidently integrate WLC reduction strategies into their renovation projects, as they struggle to navigate an ever-changing policy landscape.

3. **Technical and Knowledge Barriers**

   Investors face numerous technical and knowledge-related obstacles in implementing WLC reduction strategies. A shortage of skilled advisors and experts in the field hinders effective implementation (Pan & Pan, 2021). The lack of standardized methodologies for measuring and assessing WLC impacts, particularly for embodied carbon, creates inconsistencies and uncertainties. They also face challenges due to a lack of quality and comparable data on both embodied and operational emissions, along with difficulties in accessing tenant energy data and a limited measurement of embodied carbon emissions in development projects. These data limitations make it challenging for investors to set meaningful targets, track progress, and accurately compare the carbon reduction potential across various renovations (IIGCC, 2023). Insufficient information and methods for evaluating existing buildings complicate the assessment of renovation potential (T. T. P. Bui et al., 2022). Knowledge gaps and inadequate expertise in the sector further impede progress (Hafner et al., 2020). The complexities arising from the diverse nature of existing building stock and a shortage of skilled personnel that can effectively implement these strategies add another layer of technical challenge (Davies & Osmani, 2011). These technical and knowledge barriers collectively make it difficult for investors to accurately assess, plan, and execute WLC reduction strategies in their renovation projects.

4. **Market and Demand-Related Barriers**

   Market dynamics and demand-related factors pose significant challenges for investors considering WLC reduction in renovations. Limited public awareness and insufficient market demand for sustainable buildings reduce the perceived value of such investments (Keeping & Levy, 2000). This is also due to the varying levels of awareness regarding carbon reduction initiatives among stakeholders (Davies & Osmani, 2011). Cultural barriers within the real estate and construction industries also pose significant challenges. These can include resistance to change, traditional practices that prioritize short-term gains over long-term sustainability, and a lack of understanding or appreciation for WLC concepts among key stakeholders. Industry resistance to WLC reduction practices further complicates implementation efforts (Pan & Pan, 2021). The absence of available green insurance products leaves investors exposed to additional risks (Debrah et al., 2022). These market-related barriers create a challenging environment where the benefits of WLC reduction may not be fully recognized or rewarded by the market, potentially discouraging investors from prioritizing these considerations in their renovation strategies.

5. **Process and Decision-Making Challenges**

   The decision-making process for incorporating WLC reduction in renovations is fraught with challenges. Lack of clarity in project planning and goal-setting often leads to suboptimal outcomes. Inadequate consideration of WLC reduction in early design decisions can result in missed opportunities for significant improvements. Inconsistency in accounting and calculating carbon emissions creates difficulties in accurately assessing the impact of renovation strategies (T. T. P. Bui et al., 2022). There are challenges related to hard and soft lock-ins. These lock-ins,

which can be technological, institutional, or behavioral, impede the transition to more sustainable alternatives despite the potential benefits. This becomes particularly evident in renovation projects, where existing systems and practices can be difficult to change (Granoff, Hogarth & Miller, 2016). Furthermore, the short-term investment horizons typical in the real estate sector often conflict with the long-term perspective required for effective WLC reduction (IIGCC, 2023). Geographical barriers can complicate on-site zero-carbon implementation, as local conditions may limit the feasibility of certain strategies (Pan & Pan, 2021). This requires investors to develop tailored approaches for each renovation project, potentially increasing complexity in the decision-making process. These process-related barriers can lead to ineffective decision-making and implementation of WLC reduction strategies in renovation projects.

6. **Risk-Related Barriers**

   Risk considerations present significant obstacles for investors in WLC reduction projects. Various financing risks spanning market, credit, liquidity, sector, policy, financial, and environmental domains create a complex risk landscape. Risks associated with contract structures and heightened lending risk attributed to low collateral asset valuation can deter investment. Performance risks inherent in energy efficiency projects add another layer of uncertainty (Debrah et al., 2022). These multifaceted risks can make WLC reduction projects appear less attractive to risk-averse investors, potentially limiting the scale and scope of such initiatives in the real estate sector.

The literature review has established the theoretical foundation by examining key concepts, including renovation stages, WLC principles, investor roles, Dutch policy frameworks, and the motivators and barriers that influence sustainable practices. While this broad exploration provides valuable insights, there remains a critical need to understand the practical implementation of WLC considerations in renovation projects within the Dutch context. The subsequent chapter narrows this focus through empirical research, using semi-structured interviews with Dutch real estate institutional investors to explore how they integrate carbon reduction strategies into their renovation processes, the barriers, opportunities and practical challenges they encounter while trying to incorporate WLC in their renovation approaches etc.

Chapter 4

Interview Analysis

This chapter presents an analysis of interviews conducted with Dutch real estate institutional investors, examining how WLC considerations are currently integrated into renovation practices. The findings build upon the theoretical framework established in the literature review, providing insights into practical implementation challenges and opportunities within the Dutch real estate sector.

The chapter begins with an overview of interview participants and methodology. It then explores current investment practices and energetic renovation processes, before delving into investors' understanding of WLC concepts and their practical application. The chapter further investigates the barriers these investors encounter, their motivations for implementing WLC strategies, and emerging opportunities in the sector.

4.1 Participant Overview and Interview Methodology

For this study, a group of nine real estate institutional investors in the Netherlands were interviewed. The investors interviewed are well-known within the real estate sector and are front-runners in carbon reduction and sustainability initiatives within the country. As identified by (Warren-Myers, Hurlimann & Bush, 2021), the frontrunners play a crucial role in shaping practices and setting standards within the industry thereby encouraging others in the sector to adopt such carbon reduction practices. These organizations were selected based on their track record of executing ambitious sustainability goals, active engagement in industry initiatives such as the DGBC's Paris Proof commitment, and inclusion in sustainability rankings and industry acknowledgements. All the participating real estate institutional investors are also part of the DGBC working group collaborating on the circular energetic renovation initiative.

For the interviews, one representative from each of the real estate institutional investor firms was selected. The selected representatives were the ones who were closely associated with integrating or dealing with such carbon reduction and sustainability practices within their respective firms. The positions of these interviewees included sustainability advisor, ESG manager, head of sustainability, project manager sustainability, sustainability manager, and director ESG. These professionals were interviewed since they are involved in developing, implementing, and monitoring carbon reduction initiatives within their firm as well as having a comprehensive overview of their firm's sustainability practices. They also possess a significant position within their firms to instigate changes in their processes regarding sustainability. Additionally, they also interact with other organizations and initiatives such as DGBC which are dedicated to sustainability and carbon reduction in the real estate sector alongside many other sectors. These interactions help them familiarize with the industry-wide practices, challenges, and emerging trends in carbon reduction within the Dutch real estate sector.

Assigned Code	Interview position	Firm
I1	Director of ESG	Firm 1
I2	ESG Manager	Firm 2
I3	ESG Manager	Firm 3
I4	Head of sustainability	Firm 4
I5	Sustainability Manager	Firm 5
I6	Director of ESG	Firm 6
I7	ESG Manager	Firm 7
I8	Sustainability Advisor	Firm 8
I9	Sustainability Head	Firm 9

Table 4.1: Participant overview

Initially, a thorough literature review was conducted, establishing a foundational understanding of WLC reduction in renovation projects within the real estate sector. The literature review provided valuable insights into key aspects, including the broader barriers, motivators, and roles of real estate institutional investors. It also explored relevant policies, regulations, and other critical elements that frame the context of this research. Building on insights gathered from the literature review, the interview questions were designed to delve deeper into specific aspects relevant to the field.

Regarding the interview format, semi-structured interviews were conducted with these professionals and the interviews were designed to explore key aspects of WLC reduction in renovation projects within the Dutch real estate sector. The questions aimed to understand the current carbon reduction practices within the interviewees' firms, specifically focusing on renovation projects. The interviews also delved into the roles typically played by the investors in carbon reduction initiatives. Additionally, the discussions sought to identify the motivators driving carbon reduction efforts and the barriers hindering their implementation. While the main themes remained consistent throughout the interviews, the semi-structured format allowed for flexibility, enabling interviewees to provide detailed insights and examples based on their unique experiences and organizational contexts. This approach ensured a comprehensive exploration of the current state, challenges, and motivators of the real estate institutional investors in achieving WLC reduction within the Dutch real estate sector.

4.2 Current carbon consideration in investment approaches

This section examines how real estate institutional investors currently approach carbon considerations in their renovation projects, with a particular focus on their existing practices and energetic renovation processes. Through analysis of interview findings, it explores the practical implementation of carbon reduction strategies within the Dutch real estate sector. The discussion first investigates current practices in renovation projects, followed by a detailed examination of the energetic renovation process, revealing how investors evaluate and implement carbon reduction measures in their portfolios. This analysis provides insights into the present state of carbon consideration in their approaches, establishing a foundation for understanding both the progress made and areas requiring further development.

4.2.1 Current practices in renovation projects

This section details the current practices in renovation projects followed by real estate institutional investors, including their current focus, preferences, ambitions, and approach to carbon reduction. The analysis reveals how investors prioritize operational carbon reduction while embodied carbon considerations remain in the early stages of implementation.

In renovation projects, the primary focus remains on reducing operational carbon. This is evident from statements like the one from investor I4, *"Our focus is mainly still on operational carbon, and*

we have not started reducing embodied carbon yet within our portfolio". Some investors prioritize renovations based on factors such as the building's energy performance, potential for becoming Paris Proof, and associated costs. For instance, one investor (I6) noted, *"We mainly prioritize the worst-performing buildings in energy performance and look for opportunities to make the most impact at the lowest costs"*. Another investor (I2) mentioned, *"We combine the renovation of the worst-performing assets with already planned investments"* while another investor (I1) stated, *"Return on investment is our main priority, and then Paris Proof investment is a part of the target"*. Investor preferences during renovations are also influenced by factors such as subsidy opportunities and certification goals. One investor (I4) explained,*"We are often influenced by available subsidies, evaluating where we have the greatest opportunity for attaining those. This may lead us to adopt certain strategies, such as implementing a particular heat pump."* . The same investor (I4) also emphasized their focus on improving energy labels and achieving better BREEAM certifications, noting, *"We look at how to improve the energy label and also how we can gain certain BREEAM credits"*. In contrast, some investors prefer to rely on actual energy measurements over energy labels,*"We want to focus on lowering energy labels, but they don't always reflect actual energy usage. That's why we're choosing to look at the real energy usage instead of just the labels"* (I7).

Additionally, some investors are setting ambitious timelines for achieving carbon ambitions. For example, one investor (I2) shared, *"Rather than targeting 2050, we aim to ensure our funds are Paris Proof by 2040. This ambitious timeline is earlier than the typical goals, but we believe it is achievable. Importantly, this commitment does not necessitate substantial investments to enhance the sustainability of our assets"*.

Carbon considerations also affect whether to renovate or sell the assets and other commercial reasons. One investor (I7) explained, *"Our decision-making is top-down. If a building has very high energy usage, low performance, or high vacancy rates, we consider Paris Proof investments. However, we do not make selling decisions based solely on high Paris Proof investment costs"*.

Investors typically follow CRREM pathways, Paris Proof roadmaps, and targets set by the DGBC to guide their operational carbon reduction efforts.

However, during the interviews, some investors mentioned that they were aware of the importance of considering embodied carbon. This can be substantiated by what investor (I3) stated, *"It's crucial to consider embodied carbon in renovations, as it becomes more significant when operational carbon decreases. Some measures may emit so much carbon in production that they might not save any carbon at all. We need to decide whether to act now or wait for better alternatives while recognizing that achieving sustainability has a carbon cost"*.

Despite an awareness of the importance of addressing embodied carbon, only a few investors have started to consider how to incorporate it into their investment approaches. As one interviewee (I8) remarked, *"We do consider reducing the operational carbon for our assets, but for the embodied carbon part, for new buildings, we do follow the targets and guidelines provided, such as MKI and MPG, but that's not the case for renovations"*. Regarding the embodied carbon consideration within their approach, an investor (I5) explained, *"The current objective regarding embodied carbon is to gather data to assess our status. Once we have a clearer understanding, we plan to develop a roadmap with target values to achieve over the years. This goal is more of a flexible target rather than a strict requirement, whereas reducing energy consumption is a clear obligation"*.

The section effectively demonstrates that real estate institutional investors' current practices predominantly focus on operational carbon reduction, driven by tangible factors such as energy performance, costs, and certification schemes like BREEAM. While there is emerging awareness about embodied carbon's importance, as evidenced by investor statements acknowledging its growing significance when operational carbon decreases, practical implementation remains limited. Most investors are

still in the data collection phase regarding embodied carbon, with their decisions primarily influenced by established frameworks like CRREM pathways and Paris Proof roadmaps, along with available subsidies and certification requirements. This situation reflects a broader market environment where operational carbon dominates decision-making, while embodied carbon considerations await the development of standardized methods, regulatory requirements, and market incentives that would drive more comprehensive carbon reduction strategies in renovation projects.

4.2.2 Energetic renovation process

Institutional investors currently prioritize energetic renovations, making it essential to understand their processes to effectively integrate embodied carbon strategies into existing practices. These investors typically follow a structured five-stage approach, engaging multiple stakeholders and addressing key decision points at each phase.

It generally begins by assessing the assets/buildings within their portfolios for energy performance. Assessing the buildings is done via different dashboards and monitoring systems. One investor mentioned that they use the Power BI dashboard for assessing the energy performance of the buildings (I8). The worst-performing buildings are then prioritized for renovation. Sometimes they combine it with the already planned renovations. It is for different reasons that they prioritize such assets. Investor I1 mentioned that they use scaler software to translate the energy reduction report for the individual buildings into the roadmap. Some investors have a different process of understanding the current rules and regulations and their effect in the next few years and then as per the CRREM methodology, prioritize the stranded assets to prevent the risk in the future by also considering the opportunities for quick wins (I6). Whereas some firms have prioritized using trias energetica within their considerations. Sometimes energy labels and climate risks, energy performance are all a part of their decision processes while deciding the renovation.

After the analysis of their assets, most of the investor firms sit together with the developers/construction firms and sometimes also along with architects to discuss the plans to see if it is feasible commercially and sustainably (I6). After finalizing the plans, these plans are then presented to their investors and in the case of residential funds to the tenants to get their approval for proceeding with the renovation. After getting the approval, they set the requirements in the tender processes with the desired values. For the implementation process, the property or asset manager is the one within the firm who monitors the renovation process or has direct contact with the contractors. The property managers can either be from within the firm or third parties and are more responsible for the daily maintenance and have direct contact with the tenants as well. These investors heavily depend on a lot of third parties for different reasons such as data, calculation, design choices, etc. Some investors such as Investor(I4), mentioned that they also interact with maintenance firms and innovation companies to make decisions regarding sustainable renovations. Non-governmental organizations (NGOs) like DGBC are also among the organizations they interact with (I8). Some investors also have external auditors whom they discuss with and then from that these investors decide which plans to take forward in their financial models. Most of the investors do not have direct contact with the manufacturers, however, one investor(I7) has mentioned that they do interact with vendors.

The analysis reveals a structured approach to energetic renovation among institutional investors, beginning with portfolio assessment using tools like Power BI and methodology like the CRREM analysis to identify and prioritize underperforming assets. Their decision-making process incorporates multiple factors, including energy labels, climate risks, and opportunities for quick wins, often aligned with planned renovations. The renovation process involves collaboration with various stakeholders, such as contractors, architects, investors, tenants etc. A notable aspect is the investors' significant reliance on external parties for various aspects of the renovation process, from data collection and calculations to design choices and implementation highlighting the collaborative nature of energetic renovations in the real estate sector.

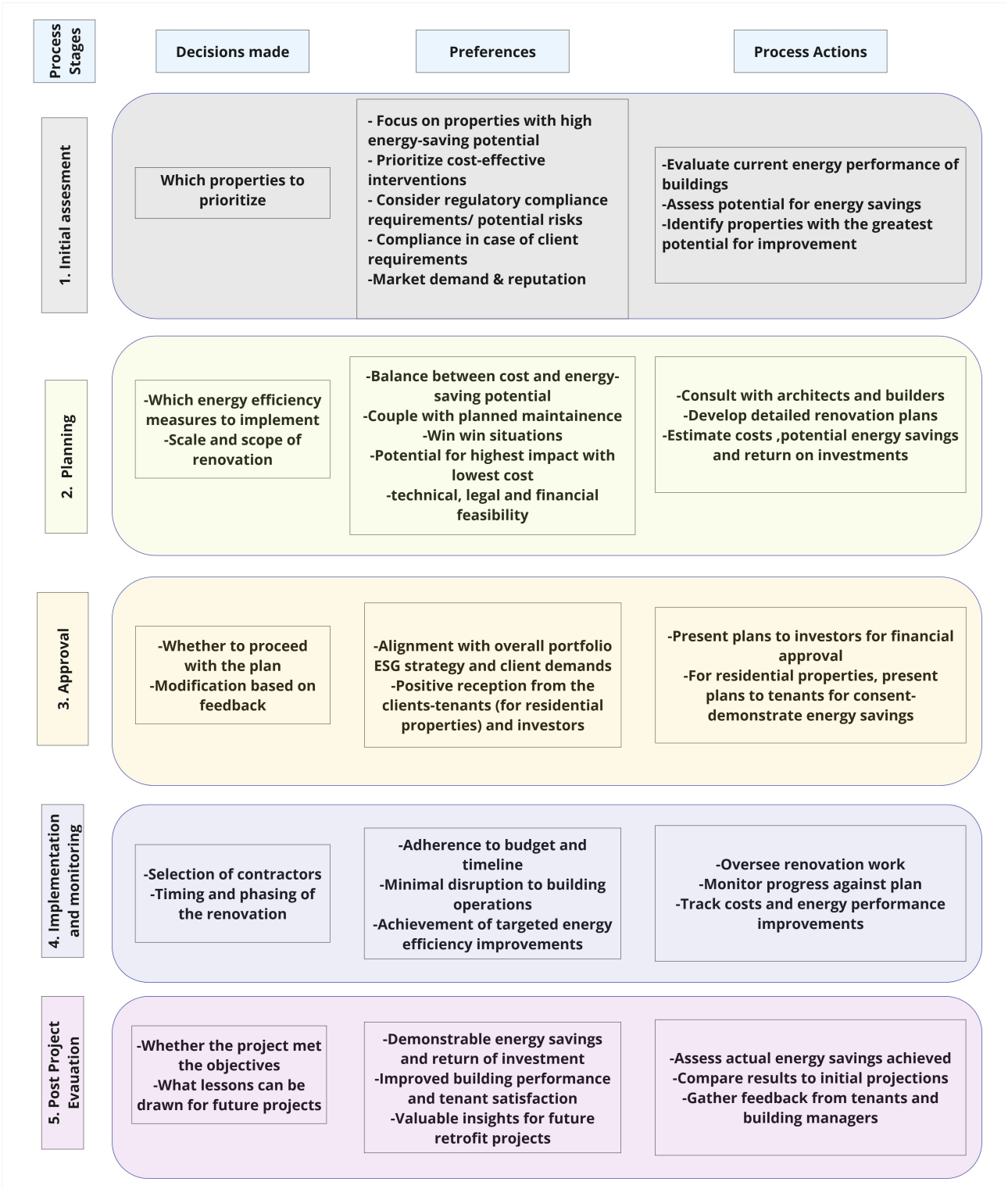

Figure 4.1: Energetic renovation process (Own figure)

4.3 WLC considerations

This section explores real estate institutional investors' understanding of WLC in renovation projects and identifies key stakeholders influencing its reduction.

4.3.1 Understanding of WLC among Investors

As mentioned in the previous sections, most of the real estate institutional investors have currently only been considering the operational carbon in their approaches. Even though they are aware of

the importance of considering embodied carbon in their renovation projects, they are in the stage of evaluating their current assets to make plans or set targets for reduction.

It was essential to understand whether the investors knew what the term WLC meant and since these investors are in the working group with the Dutch Green Building Council, most were well aware of the topic. However, the definitions and understanding of the investors varied. Many investors defined it as the combination of operational and embodied carbon. While mentioning this, they underscored that they were aware of the importance of focusing on both concepts simultaneously rather than only focusing on operational carbon which was the current status. Investor (I1) mentioned that *"It is the combination of embodied carbon and operational carbon"*.

Some investors understand or define WLC from the life cycle analysis perspective wherein they describe it as the carbon emissions occurring from production to the end-of-life stage. Investor (I3) mentions that, *"Consider all stages of your activities, starting from production till the end of life stages. We're prioritizing global warming potentials now because it's new and needs more attention, but all stages are important"*.

Some investors mentioned it in terms of OpEx and CapEx carbon. Investor (I7) mentions that,*"WLC- the amount of carbon which is used to build or create something, and the amount of carbon to maintain and operate it in a certain way. Whereas operating is the use of energy for heating, lighting, cooling, etc and maintenance is repairing, and renovating using new materials which are also embodied carbon. Some refer to it as CapEx carbon capitalize, OpEx carbon, and operational expenditure carbon. These two form the WLC"*.

Even though all of them are aware of the topic, some investors highlight the difficulty of talking about WLC due to the diverse interpretations of the different stakeholders on the topic. This is visible in the statement of the interviewee (I8), *"It's a bit difficult to discuss WLC because different parties interpret it in different ways"*. This highlights the need for a common language throughout the sector regarding the WLC perspective.

4.3.2 Key Influencers on WLC Reduction

To effectively implement WLC reduction strategies in renovation projects, it's important to identify the key influencing stakeholders. While investors play a significant role, they often rely on other stakeholders for successful carbon reduction efforts To investigate this, the investor perceptions of who has the largest impact on lowering WLC were looked into. This facilitates determining the awareness of the investors regarding their influential position in incorporating WLC in renovation projects.

Most of the investors perceive themselves as the most important stakeholder within the supply chain who can make a significant impact on WLC reduction in renovation projects. This can be evident from what investor I9 has mentioned, *"I would say that we are the most important one since we are positioned in the centre of the value chain and we are responsible for setting targets and facilitating targets for WLC and energy efficiency making us the key facilitator for large scale change"*.

Apart from realizing their key position within the supply chain for driving the WLC reduction, they also pinpoint the key roles of other stakeholders such as owners, occupants, contractors, architects, etc. Investor 18 mentions, *"Architects and contractors are responsible for the design and implementation and they have an important role in the process"*. This point is added on by investor I2,*"Builders have the responsibility to have the knowledge and know how to implement it without making it harder on any other parties"*. Contractors are mainly responsible for the implementation of the project and architects are responsible for the design and selection of the materials. Investors are dependent on these third parties for data, material selection, design finalization, implementation, etc which are critical factors in determining the WLC of a particular asset.

Investors also highlight the key role of tenants and owners and how their demands will drive the changes. Investor I6 says that *"If the tenants demand a requirement, the investors will do that to keep them"*. The external pressure from these stakeholders is a driver for the investors to consider the reduction of WLC within their assets/portfolio.

Throughout the whole process, the investors play several crucial roles such as setting the targets/KPIs, pushing the other parties within the supply chain into WLC implementation, and monitoring the projects. However, they are also dependent on other stakeholders mainly contractors and builders for aspects that are crucial in performing their roles efficiently and also for the successful implementation of the carbon reduction strategies/plans. Investors rely extensively on contractors and architects for data, carbon estimates, design options, materials, and implementation. They also rely on their knowledge, expertise, and capability to manage these elements efficiently, ensuring the project fulfils its objectives while maintaining high standards of sustainability and effectiveness. Therefore, for the successful realisation of the WLC in renovation projects, a collaborative effort among the different stakeholders is important.

4.4 Barriers for WLC Reduction in Renovation Projects

To incorporate WLC within their renovation projects, real estate institutional investors face a lot of barriers in the current context. It is essential to identify these barriers and mitigate them to help them incorporate WLC in their renovation projects.

The table below provides an overview of the barriers prioritized according to the frequency with which they were mentioned by the interviewees:

No.	Barrier Description	Frequency Indicator	Priority Level
1	High cost	×××××××	High
2	Insufficient data/calculation methods	××××××	High
3	Lack of knowledge and required skillset	×××××	Medium
4	Lack of stimulants for others in the supply chain	×××××	Medium
5	Lack of standards throughout the sector	×××××	Medium
6	Low or no Return on investment(ROI)	×××××	Medium
7	Material shortage	×××	Medium
8	Benefits not visible in valuation	×××	Medium
9	Technical issues	×××	Medium
10	Organisational lock in	××	Low
11	Market is not ready	××	Low
12	Hesitation by supply chain actors to use new materials	××	Low
13	Construction company not scaling up enough	××	Low
14	Difficulty in getting the tenants to agree	×	Low
15	Split incentives	×	Low
16	Lack of scenario analysis	×	Low
17	Complex due to the involvement of many stakeholders	×	Low
18	Lack of transparency between stakeholders	×	Low

Table 4.2: Barriers and priority

To analyse the interview data further, a thematic analysis was performed. This included categorising the identified barriers into broader categories and then them as internal/external barriers. The table

gives an overview of the barriers and their categorization:

Categories	Barriers	Type
Market and Supply Chain	Market not ready	External Barriers
	Lack of stimulants for others in the supply chain	External Barriers
	Lack of data/calculation methods	External Barriers
	Lack of standards	External Barriers
	Material Shortage	External Barriers
	Hesitation by supply chain actors to use new materials	External Barriers
	Construction company not scaling up enough	External Barriers
	Lack of transparency between stakeholders	External Barriers
Knowledge and Capacity Deficit	Lack of knowledge/required skillset	External Barriers
Economic Barriers	High cost	Internal Barriers
	Low/No ROI	Internal Barriers
	Benefits not visible in valuation	Internal Barriers
	Split Incentives	Internal Barriers
Stakeholder Engagement Issues	Difficulty in convincing the tenants to agree	Internal Barriers
Operational Constraints	Technical issues	External Barriers
	Organisational lock-ins	Internal Barriers
	Lack of scenario analysis	Internal Barriers
	Complex due to many stakeholders being involved	External Barriers

Table 4.3: Barriers and their categories

1. **Market and Supply Chain Barriers**
   To ensure a smooth transition toward integrating WLC reduction strategies in renovation projects, it is essential to create an environment that supports this process. The market and supply chain barriers are a huge hindrance to the investors in the process.

   - **Market not being ready yet**
     The concept of embodied carbon is relatively new as compared to operational carbon and has not been widely used within renovation practices yet. The market unreadiness is a significant barrier. Even though the investors are the ones initiating the process, the process can only be implemented successfully and effectively with the help of various parties within the supply chain. Investor, I1 mentioned, *"They don't even know about operational carbon, let alone embodied carbon. They can't even estimate the carbon savings from insulation in a roof renovation, as they only handle the replacement and installation. The market isn't ready for this level of detail yet."* This refers to the installation parties in this context, however, this applies to many parties in the supply chain. Another investor, I8

mentions that" *"The market is improving and larger contractors and architects are seeking insights into carbon data. However, it's not fully ready yet because many manufacturers still lack the necessary data"*. This indicates that although the sector is making progress, the majority of the market has not yet reached the required level of readiness.

- **Lack of data/calculation methods**
  Investors need proper data and calculation methods to make plans and set requirements for reducing WLC in renovation projects. However, the lack of reliable data and calculation methods makes it difficult for them to analyse the carbon emissions within their assets to take the next steps. Most investors rely on third parties such as contractors for the data and calculation and think it's their responsibility to do it well. Investor I3, while asked about data and calculation, mentioned that,*"As investors, we already contribute significantly more than before, but ultimately, it is the contractor's responsibility to handle their tasks"*. Having this not only helps them in setting targets but also helps them in communicating their targets or expectations to others in the supply chain. Investor I2 mentioned,*"It helps in communicating clearly and setting precise targets, making engagement with stakeholders easier. Being specific about goals, like reducing carbon to 50 kilograms per square meter instead of 60, clarifies expectations and simplifies the process for everyone"*. These barriers also have a high priority level as compared to the other barriers as it is one among the most mentioned barrier by the investors.

- **Lack of stimulants for others in the supply chain**
  For WLC to be efficiently incorporated, all the stakeholders within the supply chain must collaborate with a shared sustainability mindset. However, that is not always the case. Investor I8 mentioned,*"While many parties have committed to the Paris Proof Agreement, not everyone sees the urgency. In this situation, some companies may lag, but these are the very ones we need to engage in the entire carbon reduction process and are crucial for making it happen"*.

- **Lack of standards**
  Regarding WLC in renovation projects, several standards are lacking. One among them is the lack of a common language. Investor I8 mentions,*"WLC is interpreted differently by different parties"*. This can make communication within the supply chain a bit difficult. The lack of standardization affects their internal decision-making processes as well. Investor I4 mentions, *"The lack of a commonly accepted framework, methodology or standard makes it difficult to integrate WLC into formal decision-making consistently"*. This leads to fragmentation and inconsistency in reporting and executing strategies, which may undermine the overall effectiveness of the efforts.

- **Material shortage**
  Investor I6 mentioned that *"Material scarcity is a significant challenge, especially when seeking products with lower embodied carbon, such as second-hand furniture or bio-based materials—there simply isn't enough supply to meet demand"*.This deficiency in the supply also leads to the higher cost of such materials. To add on to this investor I5 mentions that,*" While circular solutions are being developed, they're still quite new and not yet prevalent in the market. Even for installations like heat pumps, the options with low embodied carbon and such solutions aren't widely available yet"*. This also demonstrates the disparity between operational and embodied carbon. While attempts to minimize operational carbon such as through efficient heat pumps are being made, the embodied carbon associated with these solutions is often overlooked, potentially adding to the overall carbon footprint.

- **Hesitation by supply chain actors to use new materials**

Investor I9 mentioned that, *"The perception that wood-based construction are less safe in case of fire. This might not necessarily be true. Similarly, there is hesitation around recycled materials concerning safety and performance. It takes time for these beliefs and values to change and get ingrained in everyone's thoughts."* This lock-in might impede the ability of the actors within the supply chain to think creatively in using low embodied carbon materials thereby slowing down the progress of the incorporation of WLC in renovation projects.

- **Construction company not scaling up enough**
  Investor I3 mentioned,*"As investors, we're pushing for innovations more than expected, but construction companies aren't scaling up quickly enough. They need to accelerate the adoption and market introduction of new technologies"*. This underlies the need for them to bring innovations to the top. The investors mostly rely on constructors for data, carbon calculations, material selection, etc. The slow scaling up of these companies makes it difficult for investors to achieve their goals effectively.

- **Lack of transparency between stakeholders**
  This barrier is mainly important in terms of data sharing wherein there needs to be transparency between the different supply chain actors to facilitate the process smoother.

2. **Economic Barriers**
   Economic barriers are particularly significant for real estate institutional investors, as they face the challenge of aligning financial goals with sustainability objectives. These investors are typically focused on maximizing returns, which can lead to a reluctance to invest in initiatives that prioritize long-term sustainability over immediate profits. Consequently, they must navigate a complex landscape where balancing economic interests with the imperative for environmental responsibility is essential.

   - **High cost**
     Investor I5 mentions that *"These materials are of high costs but have the performance same as of regular materials"*. This in a way gives no incentive to the investors to consider using such materials. Even though the investors are sustainability-minded, the cost is a very important consideration when it comes to their decision-making choices. This barrier was found to be the most prominent among the barriers mentioned by the investors for incorporating WLC in their renovation projects. Therefore it is necessary to account for or consider ways of working around this barrier to facilitate the consideration of WLC in a better manner.

   - **Low /no ROI**
     Investor I6 mentioned that *"To my knowledge, current regulations do not require this, so it's an optional step that can only be taken if you have the funds or believe it will be profitable. Real estate investors are not charity organizations"*.Having a high cost and low / no considerable ROI(Return on investment) makes it difficult for the investors to actively in invest such initiatives. This is also evident from what investor I6 mentioned, *"It's really hard to integrate it into our normal business practice because at the end of the line, there's there's no ROI"*. This was also one of the most commonly mentioned economic barriers and lies high in the priority list of barriers to be worked upon.

   - **Benefits not visible in the valuation**
     Investor I7 mentions that *"If you have a full wooden building, then the value increases because it's so iconic at the moment. But otherwise, if you include something in our renovation, it doesn't add any value"*. This is also due to the reason that there are no benefits related to lowering the embodied carbon visible in the valuation. This makes the

investors subject to a lack of motivation to reduce embodied carbon in their renovation projects.

- **Split incentives**
  The initial costs are covered by the investors whereas the benefits going to another party such as tenants make the investors hesitant in the process. This is substantiated by the investor I4 who mentioned that, *"In our case, for instance, pursuing the highest insulation standards leads to energy reductions and savings that primarily benefit our tenants, rather than us as investors. This misalignment between who makes the investment and who reaps the benefits highlights a commercial and ROI challenge. It is not clear about this matter in the case of embodied carbon reductions yet."*

3. **Knowledge and Capability Deficit**

   - **Lack of knowledge or required skillset**
     To ensure that the process is implemented effectively, there needs to be the right skillset with sufficient knowledge to work on such new materials and WLC reduction strategies within the sector. The investors can set targets related to it, however, if it needs to take place efficiently there needs to be people who can or know how to do it well. This is not the current situation regarding WLC in renovation projects. Investor I5 mentioned that *"Advisors and contractors are more familiar with conventional materials than with complex, less-known bio-based options. There is a knowledge gap on this matter"*. This will hinder the adoption of such materials in the processes.

4. **Operational Constraints**

   - **Technical issues**
     Investor I5 mentioned that *"These materials take more space as compared to regular materials"*. Considering the relatively newer usage of such materials in renovation projects, there are several technical issues that they might face in the process which also makes it difficult to solve considering the lesser people who know how to work on it.

   - **Organisational lock-ins**
     Investor I7 mentioned, *"The majority of the real estate sector is traditional, slow-moving, and not used to major changes."*This reflects on the soft lock-ins that they have within their organisations to adapt to new changes quickly. However, few progressive front-runners are emerging such as the interviewees likely due to their involvement with DGBC and prior awareness of the topic's importance. These investors are already beginning to shift their thinking.

   - **Lack of scenario analysis**
     Investor I8 reflects on the need for a scenario analysis which would facilitate quicker decision-making regarding the material choices, design choices etc that could make their decision-making process smoother.

   - **Complex due to many stakeholders involved**
     The WLC presents a complex landscape involving numerous stakeholders with varying viewpoints. As noted by investor I7, *"It is difficult to make a decision regarding this matter considering the wide range of stakeholders within the sector who are not aligned on this goal"*.

5. **Stakeholder Engagement Issues**

   - **Difficulty in convincing the tenants to agree**
     Investor I2 mentioned, *"Getting residential tenants to agree on a renovation plan is a sig-*

*nificant barrier, requiring extensive lobbying and effort".*For the renovation of residential projects, there is a requirement that 70% of the tenants agree to proceed with the renovation. This reluctance may be due to concerns about the disruptions and inconveniences caused by renovations, from a failure to see clear benefits in upgrading their homes etc.

Stakeholder Barrier Mapping

The barriers identified were mapped to relevant stakeholders, revealing critical insights about implementation challenges and their distribution across the renovation value chain. The stakeholder mapping demonstrates that real estate institutional investors while occupying a central position, face barriers that largely lie beyond their direct control despite significantly impacting their decision-making capacity.

- High-priority barriers faced by investors, such as high costs, along with medium-priority barriers like low or no ROI and the failure to account for benefits in valuation processes, as well as low-priority barriers like the lack of scenario analysis, directly influence their decision-making but depend on external stakeholders for resolution. The resolution of these barriers requires coordinated action from multiple stakeholders, including governmental bodies, banks, and market parties.
- The supplier level presents another critical barrier cluster, where material shortages, lack of standardization etc create upstream challenges that cascade through the entire supply chain. These supplier-level constraints directly influence the high-priority barriers faced by investors, such as high costs and low ROI, demonstrating how supply chain limitations translate into economic barriers to investment decisions.
- A particularly significant observation is the presence of complex barriers in the implementation cluster directed to architects and builders such as contractors. The combination of technical issues, insufficient calculation methods, and lack of upscaling creates a challenging environment where practical implementation is hindered by both technical and operational constraints. This cluster of barriers at the implementation level significantly impacts investors' ability to execute carbon reduction strategies effectively, as they are dependent on these for technical knowledge and implementation.

The interconnected nature of these barriers across the supply chain demonstrates that while investors face direct decision-making impacts, the resolution of implementation challenges requires coordinated development of technical capabilities, standardization of practices, and evolution of supply chain capacity. Despite these dependencies, investors hold a pivotal position that enables them to influence the actions of other stakeholders within the supply chain to a considerable extent, fostering collaboration and driving progress toward addressing these challenges.

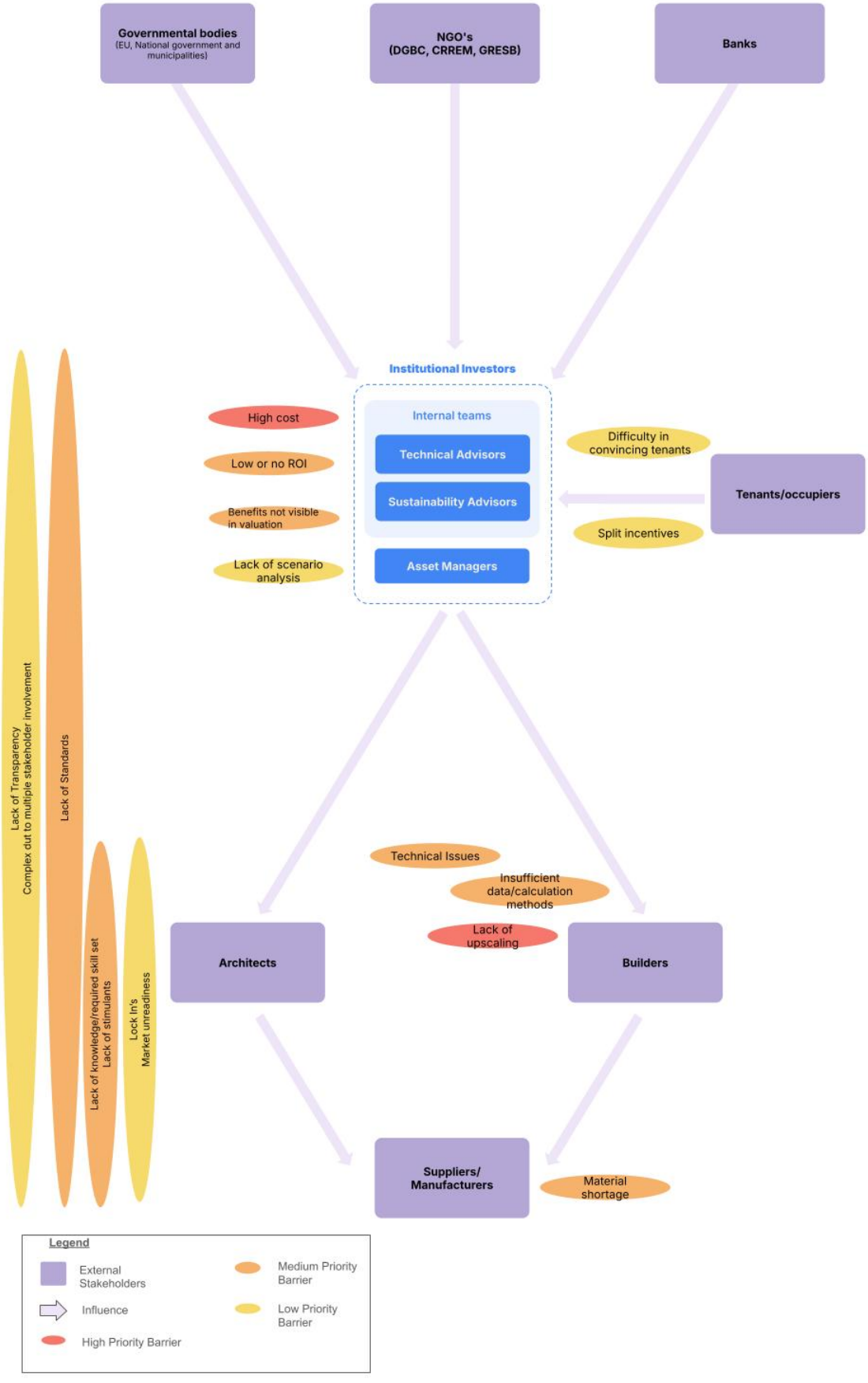

Figure 4.2: Barrier mapping (Own figure)

4.5 Motivators for WLC in Renovation Projects

Understanding what drives real estate institutional investors to incorporate WLC considerations in their renovation projects is essential for promoting wider adoption of carbon reduction strategies. This section examines the key motivators that influence investors' decisions to implement WLC approaches, ranging from internal environmental awareness to external regulatory pressures. Based on interview findings, these motivators have been categorized and prioritized according to their frequency of mention and impact on decision-making processes. The table below presents these motivators, followed by detailed explanations for each motivator.

No.	Motivator	Frequency Indicator	Priority Level	Category
1	Environmental awareness	××××××	High	Internal
2	Investors are asking for it	××××	Medium	External
3	Commitments such as DGBC's paris proof commitments	×××	Medium	Internal
4	CSRD	×	Low	External
5	To secure pension funds	×	Low	Internal

Table 4.4: Motivators and priority

1. **Environmental awareness**
   The investors are well aware of the adversity of the impacts that the embodied carbon could have on the environment. Investor I1 mentioned, *"It's important to be aware of the WLC impact, including both embodied and operational carbon. For instance, we might decide against a renovation if the embodied carbon is significantly higher than the reduction in operational carbon"*. Investor I3 also pinpointed that apart from being aware of the environmental issues, they also do feel a sense of responsibility considering the pivotal position they have in driving such initiatives.

2. **Investors are asking for it**
   Their investors, including pension funds, insurers, and other entities, are also their clients from whom they collect funds for their activities. This makes it crucial for them to meet these investors' requirements. Additionally, as these investors have committed to climate agreements such as the Paris Proof commitments, they have started asking more regarding such initiatives.

3. **Commitments such as DGBC's Paris Proof commitments**
   All the investors that were interviewed have signed DGBC's Paris Proof commitment and are therefore mandated to fulfil their commitment to keeping the temperature below the required levels. To do this, they also realize that it is important to focus not just on reducing the operational carbon but also on reducing the WLC in renovation projects.

4. **Corporate Sustainability Reporting Directive(CSRD)**
   This step is currently only applicable for newly built and not for renovation. However, the anticipation of the expansion of the scope of CSRD has made these investors start thinking of ways to reduce embodied carbon in their renovation projects too. Investor I5 mentioned,*" While the CSRD only requires us to report rather than make progress, it still helps by ensuring we gather the necessary data on the topic"*

5. **To secure pension funds**
   Investor I8 mentioned,*"To secure my pension funds, it is necessary to ensure financial stability in the long term"*. This is also to protect the fund's ability to keep up with future potential obligations and withstand the risks that may occur.

Stakeholder motivator mapping

The motivators for WLC integration were mapped across the stakeholder network, revealing critical insights about influence patterns and driving forces.

The analysis reveals a distinct hierarchy of motivators.

- Environmental awareness emerges as the sole high-priority motivator, reflecting a fundamental internal driver for change. This positioning suggests that organizational consciousness serves as the primary catalyst for carbon reduction initiatives.
- Medium-priority motivators cluster around organizational commitments and higher authority pressure, demonstrating the significant role of accountability in driving change. These motivators, including Paris Proof commitments and pressure from higher authorities, create a framework of formal obligations that reinforce internal environmental awareness.
- Low-priority motivators, such as CSRD requirements and pension fund security, represent emerging drivers that could gain significance as market maturity increases. The presence of these regulatory and financial motivators suggests an evolving landscape where formal requirements increasingly complement internal environmental consciousness.

It reveals a fundamental transformation in investors' organizational mindset, shifting from an exclusive focus on financial outcomes to embracing broader sustainability objectives.

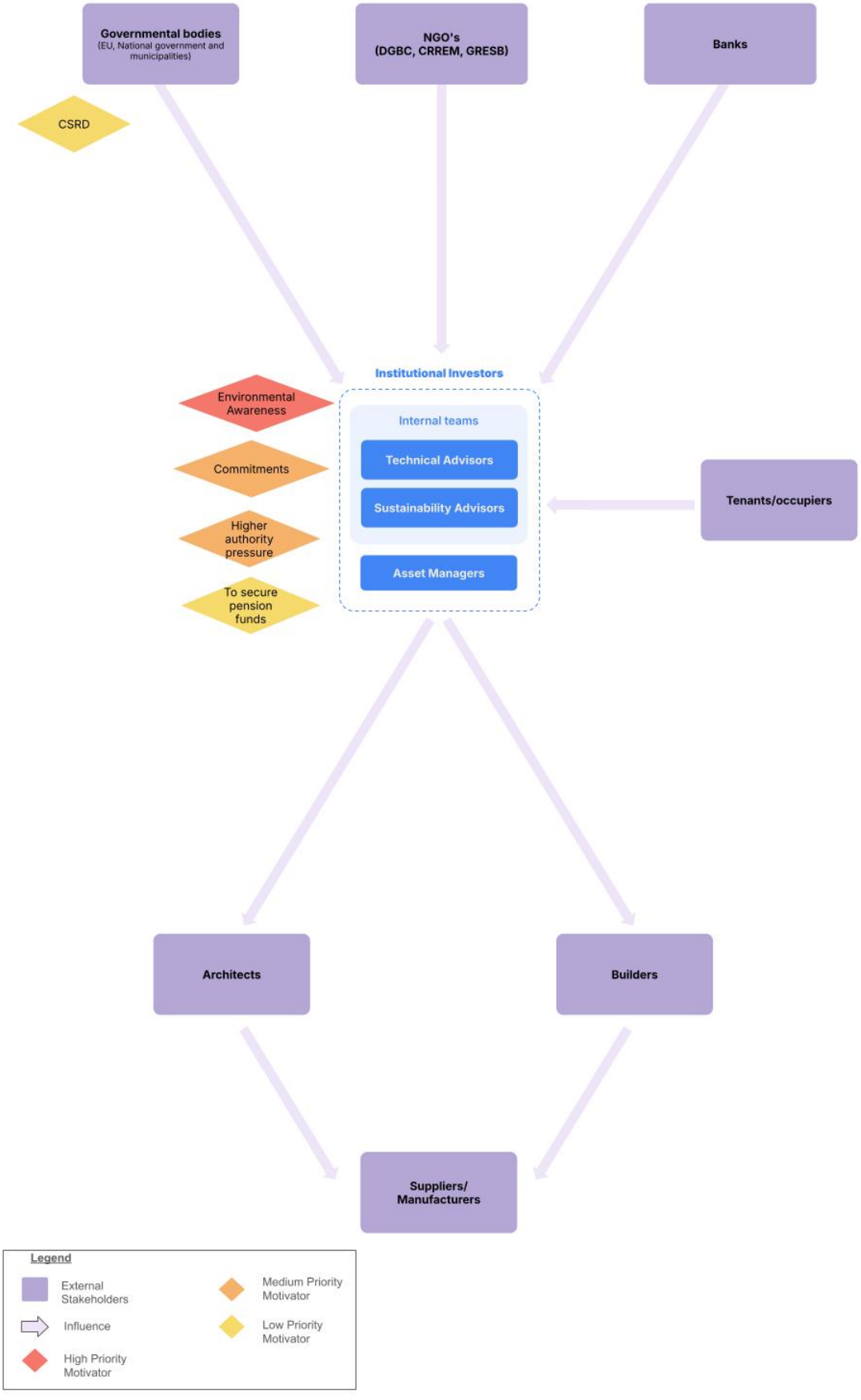

Figure 4.3: Motivator mapping (Own figure)

4.6 Opportunities for WLC in Renovation Projects

Real estate institutional investors identified several opportunities for integrating WLC considerations into renovation projects. Opportunities identify the potential avenues or advantages that can be leveraged to facilitate the integration of WLC reduction practices. Based on interview findings, these opportunities have been prioritized according to their frequency of mention and potential impact. The table below presents these opportunities, followed by detailed explanations for each motivator.

No.	Opportunities	Frequency Indicator	Priority Level
1	Carbon pricing/carbon credits/CBAM	××××××	High
2	Policy	×××	Medium
3	Embodied carbon accounted for in valuation	×××	Medium
4	Collaboration and upscaling	×××	Medium
5	EU Taxonomy	××	Medium
6	CRREM Methodology	××	Medium
7	Subsidies	××	Medium
8	Increase in the price of normal materials or decrease in the prices of biobased materials	××	Medium
9	Knowledge	××	Medium
10	New climate ambitions/part of investment plans	××	Medium
11	Increase in tenant attraction	×	Low
12	Public data or dashboards	×	Low
13	More pressure from the higher authorities	×	Low
14	Innovation	×	Low
15	Awareness of the future issues such as carbon debt, high mortgage etc.	×	Low
16	VAT Breaks on materials	×	Low
17	Ease of acess to products/service	×	Low

Table 4.5: Opportunities and priority

- **Carbon pricing/ CBAM**
  The greatest opportunity as mentioned by the investors was carbon pricing/CBAM. Setting a price on carbon will in a way help the investors deal with the high cost of the materials, low or no ROI, incentivize all the parties within the supply chain to adopt low carbon materials and strategies and also help to change the organisational lock-ins within themselves and others within the supply chain. This will also help bring the prices of such low-carbon materials on par with that of regular materials. Investor I9 mentioned,*"Higher carbon intensity means higher taxes for imported materials from outside the EU. This will incentivize the serious consideration of WLC in commercial models, as failing to address carbon intensity can lead to higher costs and increased commercial problems due to climate transition exposure"*..Apart from CBAM, the companies can also set an internal carbon price rather than waiting for such regulations to come in place from the government/regulatory bodies.

- **Policy initiatives**
  Mandating the requirements pushes the investors and others within the supply chain to act accordingly leaving them with no options to make any further excuses thereby incentivizing them to find a way out of the barriers impeding the process. This was evident from policy initiatives such as enforcing strict energy label requirements for office buildings.

- **Embodied carbon in valuation**
  Embodied carbon should be accounted for in the valuation in the case of renovation projects.

Investors mention that currently there are no incentives to consider a low-carbon material in renovation projects due to the lack of benefits. Investor I3 mentions, *" The benefits associated with using low carbon materials, particularly in areas like comfort, cost of living, and reduced risks, are included in our ESG policy, but since they don't visibly reflect in valuation it is a bit difficult"*. If benefits for including such materials are included in the valuation, it will incentivise the investors and other parties in the supply chain.

- **Collaboration and upscaling was mentioned as another opportunity**
  Investors mentioned that if they collaborate with other investors in the sector and everyone starts asking for WLC requirements in their renovation projects collectively, the others within the supply chain will be pressured to consider those and upscale accordingly. This might help in gaining momentum for the process within the sector.
- **EU Taxonomy**
  EU Taxonomy being a relevant driver could expand their focus points including stricter regulations on WLC in renovation projects and this will trigger the investors as well as others in the supply chain to change their ways of thinking and working and will find a way since it is mandatory.
- **CRREM Methodology**
  Currently, the methodology is widely implemented in the case of energetic renovations. Expanding the methodology to include embodied carbon will facilitate and incentivize the integration of WLC considerations in renovation projects throughout the sector.
- **Subsidies**
  Currently, there aren't many subsidies available for products with low embodied carbon. If that comes into existence, it can negotiate for the high cost of materials/low ROI and can diminish the economic concerns that they have to a considerable extent.
- **Cost Adjustment**
  Another opportunity that could help them deal with the high costs/low ROI are increasing the cost of traditional materials or decreasing the cost of biobased materials. Currently, this is not the case due to the low supply of biobased materials. This can be either done by the government bodies or the market parties such as the suppliers.VAT Breaks can also mitigate the economic concerns up to a considerable amount.
- **Knowledge**
  Knowledge especially among their technical actors within the supply chain on how to deal with such materials, would be a great enabler in the future whereas it is also important to share this knowledge and awareness of the urgency among others in the supply chain to ensure smooth communication
- **Innovation**
  Innovation is extremely important and should emerge either from the builders, architects or material suppliers which will in a way help mitigate the high-cost issues and also lack of material issues.
- **More pressure from their investors/higher authorities**
  It is a great opportunity for incorporating WLC in renovation projects. This leaves the investors with no choice but to proceed with the requirements.
- **Stricter climate ambition**
  Internally, the investors find the opportunity to leverage this process by having stricter climate ambition and including it in their investment plans which will help to take it a step forward.

- **Awareness**
  Awareness of future issues such as carbon debt, high mortgages etc will help the investors anticipate future issues and regulations giving them a push to consider including it within their approach.

Stakeholder Opportunity Mapping

The opportunities identified were mapped to the relevant stakeholders responsible for their implementation, revealing critical insights about influence patterns and implementation pathways. This stakeholder mapping demonstrates that real estate institutional investors occupy a central position, supported by internal teams of technical advisors, sustainability advisors, and asset managers.

The analysis reveals a clear hierarchy of influence.

- Governmental bodies emerge as the most influential stakeholders, where most opportunities are surrounded. It includes high-priority opportunities like carbon pricing/CBAM and medium-priority mechanisms like EU Taxonomy, policy and subsidies. Moreover, it also includes low-priority opportunities like VAT Breaks on materials. The concentration of high-impact opportunities under governmental control suggests that policy and regulatory frameworks are crucial enablers for systematic carbon reduction.
- NGOs like DGBC, CRREM, GRESB etc occupy a strategic position, particularly through methodological frameworks like CRREM, which can bridge the gap between carbon ambition goals and practical implementation.
- At the implementation level, architects, builders, and suppliers form an interconnected network essential for realizing medium-priority opportunities like material innovation . This technical implementation cluster highlights the importance of supply chain collaboration for practical carbon reduction. Knowledge development is essential for all parties within the implementation level making it a very crucial opportunity.

Notably, while investors hold a central position, their ability to effect change depends significantly on both upstream stakeholders (governmental bodies, NGOs) and downstream implementers (architects, builders). This positioning enables them to act as catalysts, translating high-level opportunities into practical implementation through their internal teams and stakeholder relationships. This stakeholder-opportunity mapping demonstrates that successful embodied carbon integration requires coordinated action across multiple stakeholder levels, with governmental bodies and investors playing pivotal but distinct roles in enabling and implementing carbon reduction strategies.

Figure 4.4: Opportunities mapping (Own figure)

Chapter 5

Strategies for Embodied Carbon Integration

This chapter outlines the progression of strategies for embodied carbon integration, starting with initial approaches informed by literature and interviews. It then covers stakeholder validation and concludes with refined strategies, differentiating between strategic and project-level implementation.

5.1 Initial Strategies

Considering the urgency of mitigating carbon emissions and the relative newness of the topic, it is important to outline practical ways in which real estate institutional investors can include embodied carbon in their renovation processes. The development of the strategies was guided by the need to create a practical approach that aligns with their current energetic renovation processes.

The initial strategy development process combined insights from three main sources to create practical embodied carbon integration strategies for renovation projects. The literature review provided an understanding of current renovation practices, existing carbon reduction methods, and market limitations. Expert interviews with real estate institutional investors revealed insights into the current process workflows, practical implementation challenges, drivers, opportunities, stakeholder considerations etc. These insights were then synthesized into strategies that align with the existing five-stage renovation process while maintaining operational efficiency and considering stakeholder requirements. This was done by also taking into account the investors' roles, the barriers they face, their motivators etc.

A brief overview of initial strategies is given below:

- Initial Assessment
  Asset prioritization based on operational carbon utilizing the existing methods and tools.
- Renovation Planning
  Target setting, material selection, design optimization and stakeholder collaboration requirements.
- Plan Presentation
  Tenant engagement approaches and communication strategies.
- Implementation
  Procurement criteria, stakeholder selection and incentivization strategies.
- Post Project Evaluation
  Performance documentation and feedback collection strategies.

These initial strategies, detailed in Appendix A, served as a foundation for further refinement through validation. The purpose of validation was to gather feedback from industry experts, assess the feasibility of the proposed strategies, and identify areas for improvement. The next section will present the key findings from the validation interviews, followed by the final proposed framework incorporating the feedback and suggestions received.

5.2 Validation

This section delves into the validation and refinement of the initial strategies through expert panel discussions, emphasizing their feasibility and practical effectiveness. Insights from these discussions informed key improvements in the initial strategies. The section outlines the purpose, validation methodology, participant overview, feedback received, and the resulting refinements to the proposed strategies.

5.2.1 Validation Purpose

The purpose of validation in this study is to assess the practicality and feasibility of the proposed strategies for integrating embodied carbon considerations into real estate institutional investors' renovation processes. Through expert panel discussions and consultations with industrial experts, including real estate institutional investors and DGBC representatives, the study aims to validate that the proposed solutions effectively address existing challenges while maintaining alignment with current renovation practices. Being a niche topic, this validation ensures the proposed strategies are both theoretically sound and practically viable, considering current barriers and opportunities while aligning with investors' motivations for carbon reduction.

5.2.2 Validation Method

The validation process was conducted through an expert panel discussion via Microsoft Teams, involving real estate institutional investors from the Netherlands and professionals from the DGBC. The session lasted for approximately 1.5 hours, with the objective of gathering comprehensive feedback on the proposed strategies for integrating embodied carbon considerations into the renovation processes.

Participants were selected to ensure a diverse and informed panel. Two institutional investors from the DGBC working group, who had been involved in earlier interviews, were chosen to evaluate the proposed strategies based on their insights and experiences related to the potential incorporation of embodied carbon into renovation processes. In addition, two external investors, who had not been part of the interviews or the working group of DGBC but were still part of the target focus group, were included to provide fresh, unbiased perspectives. This combination of internal and external participants helped to mitigate any potential bias and ensured that the validation feedback represented a broad spectrum of views within the industry.The table presents an overview of the participants of the expert panel discussion:

Assigned Code	Interview position	Firm
I8	Sustainability Advisor	Firm 8
I9	Sustainability Head	Firm 9
I10	ESG Manager	Firm 10
I11	Managing Director ESG	Firm 11

Table 5.1: Participant overview-expert panel discussion

The inclusion of DGBC experts ensured that the proposed strategies aligned not only with investor preferences but also with broader carbon reduction ambitions. The session began with a presentation

of the findings, delivered via slides, and was followed by an open ended discussion focused on feasibility, implementation challenges, and alignment with carbon targets. Feedback was collected and documented to inform the refinement of the strategies.

5.2.3 Recommendations from Validation

Feedback from the validation indicated that the proposed approach aligns well with current workflows, and the suggested strategies were identified as feasible. The integration of embodied carbon reduction practices within the familiar stages of energetic renovation was considered practical, particularly because such practices have not yet been widely adopted in renovation projects. By embedding these strategies into the existing renovation practices, the process becomes less overwhelming and more easily utilizable for stakeholders already familiar with these stages.

This section will detail the key feedback points, explain how these insights were incorporated into the final process, and discuss any feedback that was not integrated, including the rationale for those decisions.

The feedback received from the experts were the following:

- **Tenant Influence and Flexible Renovation Strategies**
  Investor I10 emphasized that tenants, particularly in sectors such as retail and offices, play a significant role in shaping renovation approaches, as their needs directly influence building performance expectations. To make the process adaptable, the investor recommended incorporating flexible renovation strategies that consider tenant demands. However, they noted that influencing tenants in residential properties can be challenging due to factors like high rent or limited awareness among them of sustainability impacts.

- **Integrating Sustainability into Financial Models**
  Investor I9 raised concerns about existing financial models, which often lack consideration for sustainability factors, especially embodied carbon. Investor I10 concurred, noting that while collaboration with valuators is useful, changing valuation methods for one building could lead to inconsistency across portfolios, posing market competitiveness risks. This insight suggests that the valuation stage of the process should include a phased or industry-wide approach to integrating sustainability into financial metrics, as it may take time for financial models to fully adapt.

- **Carbon Storage Metrics and Carbon Pricing**
  Investor I11 emphasized the benefit of introducing carbon storage metrics to encourage the use of bio-based materials. This would allow for a portfolio analysis of stored carbon, supporting the process's objectives. Additionally, investors generally agreed that carbon pricing is a valuable mechanism, though it's often used to offset operational carbon emissions. This feedback suggests enhancing the carbon pricing element in the process to promote a more proactive approach to embodied carbon management.

- **Common Language throughout the Sector**
  Investor I8 mentions that there is still a need to establish common language throughout the sector in order to make the integration of embodied carbon in renovation processes which will also mitigate the supply chain issues.

- **Decision Scenarios in Line with Maintenance Cycles**
  Investor I9 suggested that decision-making should be synchronized with maintenance cycles and that the renovation process must account for the carbon impact associated with the structural support needed for implementing operational carbon-saving measures. By integrating these considerations, prioritization within the renovation process could become more practical and aligned with maintenance-related decision points.

- **Certification and Knowledge Sharing**
  Investor I11 agreed that knowledge sharing as key to tackling embodied carbon. The investor also supported certifications as a market-driven solution to incentivize and standardize efforts in the industry. This feedback aligns with the process emphasizing the value of certifications to support sector-wide buy-in for embodied carbon integration.
- **Educating Asset and Property Managers**
  Investor I11 highlighted the importance of educating asset and property managers on embodied carbon integration. As the primary point of contact with stakeholders responsible for the implementation, well-informed managers can facilitate smoother communication and execution of renovation projects that prioritize both operational and embodied carbon considerations.
- **Expanding Low Carbon Building Initiatives**
  Investor I10 suggested that the Low Carbon Building Initiative, currently focused on newly built office, residential and hotel typologies, will be extended in future to include renovations across various building types can be used by the investors to achieve carbon reduction. This initiative apart from being a market-driven approach will also provide investors with a performance pathway for achieving embodied carbon reductions.

5.2.4 Process Refinement

Based on the validation feedback, several key updates were made to enhance the framework's practicality and effectiveness. Key updates are as mentioned below:

- First, the approach to carbon pricing has been adjusted to emphasize its application to actual emissions rather than merely as an offset mechanism. This supplemented by transparent reporting recommendations aims to promote accountability and encourage proactive measures for reducing emissions.
- Furthermore, the role of asset and property managers has been highlighted, recognizing them as crucial points of contact with implementation stakeholders. This addition acknowledges the need for their education on embodied carbon integration to facilitate smoother project execution. The influence of tenants has also been addressed, with a focus on developing flexible renovation strategies that cater to tenant demands, particularly in sectors like retail and offices.
- An additional opportunity identified is the expansion of the Low Carbon Building Initiative. This is included in the discussion chapter and it is a great opportunity if evolved to accelerate the process of WLC integration in renovation projects.
- Despite the valuable feedback received, certain elements of the process have been preserved. Specifically, the integration of sustainability into financial models remains a long-term objective. Adapting existing valuation methods is anticipated to require significant time and industry-wide collaboration, thus it's positioned as a future recommendation for valuators. The growing market demand for such models will likely align with upcoming regulatory frameworks, making this an essential area for development.
- While the importance of aligning decision-making with maintenance cycles is acknowledged, the process will maintain its focus on immediate, actionable steps that can be implemented in the short term. Considering maintenance schedules and determining whether to expedite or postpone renovation activities may be addressed in future iterations of the process. However, current constraints do not support such an approach at this time.
- Establishing a common language across the sector will necessitate industry-wide collaboration and is therefore included as a recommendation for future development.

5.3 Final Strategies

Through validation and refinement of the initial process, a comprehensive approach was developed to enable real estate institutional investors to incorporate embodied carbon reduction into their renovation processes. The final process addresses the urgent need to mitigate carbon emissions while acknowledging the relative newness and complexity of embodied carbon considerations in renovation projects. As a further improvement and to ensure systematic implementation, the strategies were distinguished into two levels: strategic and project-level integration. This dual-level approach recognizes that effective embodied carbon reduction requires both strategic-level preparation and project-level implementation steps.

At the strategic level, it establishes strategies such as carbon pricing mechanisms, approach-based target setting etc. At the project level, it integrates embodied carbon considerations into each stage of the existing energetic renovation process, ensuring practical implementation without disrupting established procedures. This comprehensive approach highlighted the need for systematic integration while maintaining operational efficiency. The strategies acknowledge current industry constraints, such as data limitations and regulatory focus on operational carbon, while providing a structured pathway for incorporating embodied carbon considerations. Combining strategic preparation with project-level strategies enables investors to drive change through clear targets and incentivization strategies across the value chain.

5.3.1 Strategic Level

Before implementing project-level embodied carbon reduction initiatives, real estate institutional investors must establish foundational elements that enable systematic carbon reduction. This strategic framework provides the organizational infrastructure necessary for effective implementation. These encompass organizational infrastructure development, portfolio-wide target setting, and external partnerships necessary for effective embodied carbon integration in renovation processes.

- **Carbon Pricing Implementation**
  They should also establish carbon pricing and this should also be communicated clearly in their internal documents. The carbon pricing should be based on the actual emissions rather than using it as a mechanism to offset the high carbon emissions. As highlighted by EPRA et al. (2024), to begin with, the investors can start with shadow pricing, integrating it into management reporting and investment decisions. They should start by using available data and set prices based on benchmarks like the EU-ETS, to calculate internal decarbonization costs and review policies from international organizations on national abatement costs. The paper also highlights that transparency in carbon pricing disclosure in annual reports is crucial for effective implementation.

- **Approach-Based Target Setting**
  Rather than establishing a science-based target, an approach-based target should be established. Investors should begin by identifying which materials or building elements are frequently replaced during renovation and maintenance projects and assessing their associated embodied carbon emissions. This begins with analyzing maintenance logs and renovation histories to identify frequently replaced building elements. This includes analyzing both materials that are replaced in large quantities, which may have low embodied carbon and those that are replaced less frequently but contribute significantly to overall emissions due to their high material-bound carbon footprint. By gaining insights into which elements—such as roofs, windows, facades etc —are renovated more often, investors can set targeted goals to reduce embodied carbon. It is important to start incorporating these targets into the investment plans as well.

  For analysing the embodied carbon of the materials, they should start with the National Environ-

mental Database (NMD). Initially, they should use category 3 data, which provides basic carbon assessments. As their expertise grows, they can progress to category 2 data and ultimately to category 1 data for more accurate calculations. Investors can also utilize open databases like the EC3 calculator tool and Inventory of Carbon and Energy (ICE) Databases, which provide additional reference points for carbon assessment. This systematic approach allows organizations to build internal expertise while gradually improving data accuracy.

- **Coalition**
  Institutional investors should form coalitions with other investors within the Dutch Green Building Council (DGBC) working group to develop and promote unified guidelines. These guidelines should be regularly updated based on evolving industry standards and practices, fostering a more integrated and consistent approach to embodied carbon reduction. As more investors start incorporating embodied carbon requirements into their renovation projects, other stakeholders throughout the supply chain will face increasing pressure to align with these emerging expectations.

- **Collaboration with Valuators**
  Investors should collaborate with valuators to develop frameworks that incorporate both the financial and non-financial benefits of embodied carbon strategies into property assessments. Addressing concerns regarding financial constraints will also be essential if the benefits of considering embodied carbon are visible in the valuation.

- **Training Asset/Property Managers**
  It is crucial to conduct training sessions and raise awareness about embodied carbon integration among asset managers and property managers. These individuals are key points of contact between investor groups and the market parties responsible for executing and monitoring renovation projects. Given their role in overseeing implementation, they bear the responsibility for ensuring that the renovation processes align with the investors' sustainability goals, making their understanding of embodied carbon integration vital for successful project execution.

- **Material Passports**
  Investors should create standardized frameworks for material passports, which would streamline the tracking and assessment of materials used in renovation projects. These passports would contain vital information about a material's environmental impact, recyclability, and life cycle, offering a consistent method for evaluating sustainability performance. By adopting a unified format for material passports, investors can more effectively assess the contribution of materials to embodied carbon reduction, leading to more informed decision-making in future renovations. Collaboration with experts can drive the development of these passports.

These strategic-level elements provide the foundation necessary for systematic embodied carbon reduction in renovation projects. By establishing carbon pricing mechanisms, approach-based targets, industry coalitions, and standardized documentation systems, real estate institutional investors create the organizational capability needed for effective implementation. While acknowledging current limitations and market constraints, these strategies enable investors to drive change through clear targets and incentivization strategies across the value chain. This systematic preparation at the strategic level ensures that subsequent project-level implementation can proceed effectively while maintaining functional effectiveness.

5.3.2 Project Level

After establishing the strategic foundations, real estate institutional investors must integrate embodied carbon considerations into their existing renovation processes. At the project level, these considerations are incorporated into each stage of the existing renovation workflow: initial assessment, renovation planning, plan presentation, implementation and monitoring, and post-project evaluation.

Each stage builds upon existing renovation procedures, ensuring that embodied carbon considerations complement rather than disrupt established practices. This practical approach enables investors to implement carbon reduction strategies while working within current market capabilities and stakeholder requirements. The following strategies outline how investors can integrate embodied carbon considerations into their renovation processes while aligning with both strategic goals and the practical constraints inherent to the implementation of such initiatives.

1. **Initial Assessment**

   In this stage, investors prioritize which assets to renovate. This prioritization is influenced by various factors, such as regulatory compliance, ambitions to reduce carbon emissions, overall portfolio performance, financial considerations, risk management, market trends etc.

   At this stage of this process, the real estate institutional investors should continue to prioritise their assets based on operational carbon emissions utilizing tools such as Power BI and methodology such as CRREM as done in the current scenario.

   This emphasis is due to a combination of several reasons. There is a significant lack of data and reliable calculation tools for assessing the embodied carbon of existing assets, making informed decision-making challenging. Investors are inclined to focus on future embodied carbon emissions rather than those already emitted. Additionally, current regulations primarily emphasize the need to reduce operational carbon, compelling investors to direct their immediate efforts in prioritising assets with high operational carbon for renovation.

2. **Developing Renovation Plans**

   In the renovation planning stage, real estate institutional investors typically focus on developing detailed plans for the renovation of assets prioritised during the first stage, including selecting materials, technologies, and design strategies to improve the overall performance of the assets. This process usually involves collaboration with other stakeholders such as architects, consultants, contractors etc to create comprehensive renovation plans that meet regulatory requirements and project goals.

   - In this stage, real estate institutional investors should establish clear requirements that reflect their strategic approach-based targets. A critical consideration at this stage is to determine the embodied carbon from the new materials as well as the embodied carbon that comes along with the operational carbon savings measures. Therefore, investors must carefully evaluate both aspects when setting requirements. By doing so, investors can ensure that the renovation plan not only meets operational carbon goals but also minimizes the carbon footprint associated with material use and construction activities, as defined by the approach-based targets. These requirements should be documented (in a document such as a program of requirements adapted for newly builts) and should form the basis while having discussions with contractors, consultants, architects etc while finalizing the renovation plans.
   - When establishing material requirements, investors should require contractors to provide embodied carbon comparisons of different options using available NMD data (starting with category 3) or also open databases such as ICE Databases. For insulation materials, which significantly impact lifecycle carbon emissions, conventional materials, such as expanded polystyrene and rock wool, typically emit between 7 to 15 kg CO_2e per square meter based on thickness. To achieve the same operational energy savings, using bio-based materials like straw, wood, or hemp for insulation can significantly reduce embodied carbon. Bio-based materials, such as hemp, not only have lower carbon emissions

but can also sequester carbon. For example, wood fibre insulation can emit a negative amount of CO_2e, ranging from -3.28 to -13.12 kg CO_2e per square meter with thicknesses between 40 mm and 160 mm, offering an environmentally friendly alternative to traditional options (Bienert, Kuhlwein, Schmidt, Gloria & Agbayir, 2023). Such choices with low embodied carbon should be prioritized while creating renovation plans. The investors should ask the contractors/ consultants for a clear comparison of different options thereby making sure that the option with the lowest embodied carbon is chosen. Investors should require contractors to prioritize such low-carbon alternatives while maintaining operational performance.

- Beyond material-specific requirements, investors should establish broader criteria in their document for utilizing reused and recycled materials wherever possible. This includes sourcing donor materials from other projects or organizations, which could provide high-quality, sustainable options at lower environmental costs. Additionally prioritizing local sourcing to reduce transportation emissions and considering design and construction process optimization.
- There should be discussions with tenants about embodied carbon reduction strategies to better understand their needs, particularly in retail and office spaces where tenants are responsible for their fit-outs. Understanding their specific needs allows for decisions to be made that better align with tenant demands. This approach promotes the development of flexible, adaptable designs that not only reduce the frequency of renovations in response to tenant needs but also accommodate future tenants, ensuring long-term sustainability and efficiency.

The renovation planning stage represents a critical phase where real estate institutional investors can significantly influence embodied carbon reduction through strategic requirements and stakeholder collaboration. By establishing clear criteria in their Program of Requirements while acknowledging current data limitations and market constraints, investors can drive the adoption of low-carbon materials and practices. This stage demonstrates how investors can effectively balance their strategic targets with practical implementation, ensuring both operational performance and embodied carbon reduction through informed decision-making and stakeholder engagement.

3. **Plans Presented for Approval**

In the plan presentation stage, renovation plans developed require careful consideration and approval from stakeholders such as tenants. Tenants, particularly in residential properties, are crucial stakeholders in this process. In the Netherlands, the legal requirement mandates that at least 70% of tenants must approve the renovation plans before work can commence in residential buildings. This tenant approval process ensures that a majority of residents agree with the proposed changes, which is particularly important when renovations may disrupt their living conditions.

In order to attain tenant approval the investor's should take the following steps :

- The investors should organize targeted educational workshops that explain renovation benefits in practical terms. These sessions should focus on direct tenant benefits such as improved living comfort through better insulation, enhanced indoor air quality etc. The workshops should address concerns about renovation disruptions and provide specific timelines for implementation. The presentation should avoid technical sustainability terminology and instead emphasize concrete benefits that tenants can understand and appreciate.

- Green contract options should be leveraged to attract tenants. The contracts should also outline specific measures to minimize disruption during renovation and provide post-renovation support.

4. **Implementation and Monitoring**

   The real estate institutional investors can set targets for this stage and even though they are not directly involved in this stage ,by establishing these criteria, they can also influence the primary stakeholders such as contractors responsible for implementing the renovation works. Investors primarily influence this stage on the selection of contractors /suppliers and the procurement of materials.

   - Investors should establish criteria in their contract documents regarding the procurement of low-carbon materials as finalised in the renovation planning stage. They should also demand Environmental Product Declarations (EPDs) from suppliers.
   - Investors should do a market analysis of stakeholders such as contractors, consultants, architects etc who have expertise in such endeavours and work with those parties as the knowledge/skillset is extremely important for the effective implementation of the carbon reduction strategies.
   - To incentivize supply chain actors to participate in the process, investors should create criteria in their contracts that establish long-term partnerships. Coupling this with initiatives like performance-based payments will encourage responsible engagement from market actors involved in the process.
   - During implementation, investors should prioritize working with asset and property managers who have completed the strategic-level training programs on embodied carbon integration. It is also crucial to effectively communicate the intended project outcomes to these asset/property managers.
   - Investors should require asset/property managers to ensure that material passports are regularly updated as per the unified format established at the strategic level and to provide regular progress updates on the renovation projects.

5. **Post - Project Evaluation**

   In the post-project evaluation stage, real estate institutional investors should focus on documenting and analyzing renovation outcomes to refine their approach-based targets and improve future renovation strategies. Given the constraints and early stage of embodied carbon integration, the evaluation should prioritize practical learning opportunities.

   - The investors should start by collecting information regarding basic performance information from the completed renovation project. This includes recording which materials were used, their quantities etc. Using NMD category 3 data as a starting point, they can note indicative carbon impacts of the materials.
   - Stakeholder feedback forms a crucial component of the evaluation. Property/asset managers, having received strategic-level training on embodied carbon integration, can provide valuable insights about implementation challenges and opportunities. Gathering feedback from tenants will also be valuable input. The input from these stakeholders will provide valuable insights to refine the strategies and collaboration processes for future projects.
   - The findings from the post-project evaluation should be documented and contribute to refining the organization's carbon reduction approach in several ways. This documentation helps refine procurement processes, enhance contractor selection criteria, and identify ad-

ditional training needs. While detailed carbon calculations may not be feasible at this early stage, gathering practical insights ensures continuous improvement in renovation practices.

The success of these strategies relies on effective stakeholder engagement, clear documentation requirements, and continuous learning from implementation experiences. While acknowledging current constraints, this approach enables real estate institutional investors to make gradual and meaningful progress in reducing embodied carbon in renovation projects. As industry practices and capabilities evolve, these strategies can be refined to achieve more significant carbon reductions across the building sector.

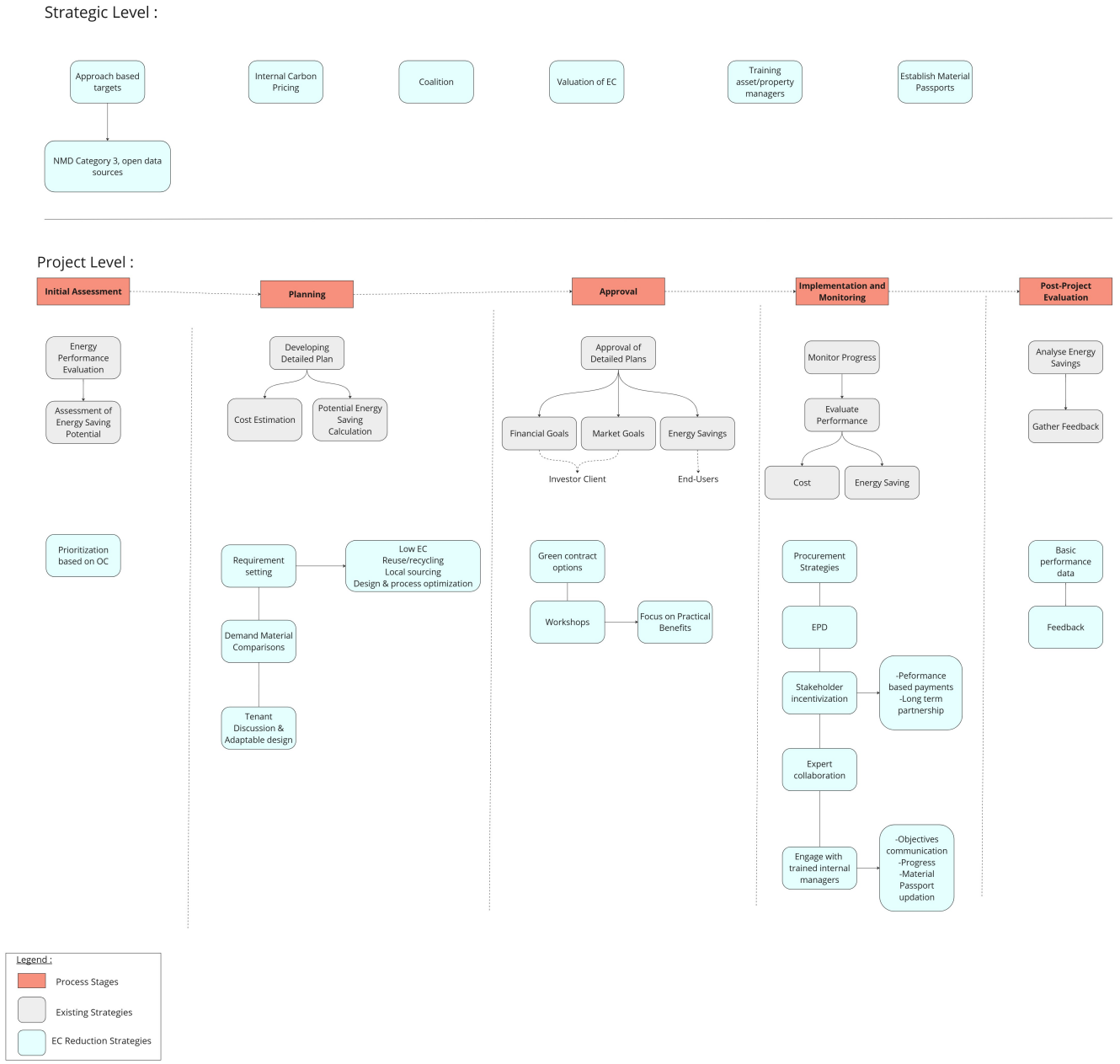

Figure 5.1: Final Strategies

Chapter 6

Discussions

This chapter presents a discussion of the research findings related to the integration of WLC considerations into the renovation strategies of real estate institutional investors in the Netherlands. It starts with a general overview of the basis of the research outcomes, describes the barriers, motivators, the process developed, the need for establishing a supportive context and the limitations of this study.

The following stakeholder mapping established the foundational basis for the research outcomes, underscoring the interconnected roles that other key stakeholders play alongside investors in achieving effective WLC integration. While this research focuses primarily on developing a phased approach tailored to the activities within the investor's control, it also identifies opportunities for broader collaboration. These recommendations aim to engage stakeholders whose roles, although outside the investor's immediate boundaries, are critical to the successful implementation of WLC strategies in renovation projects.

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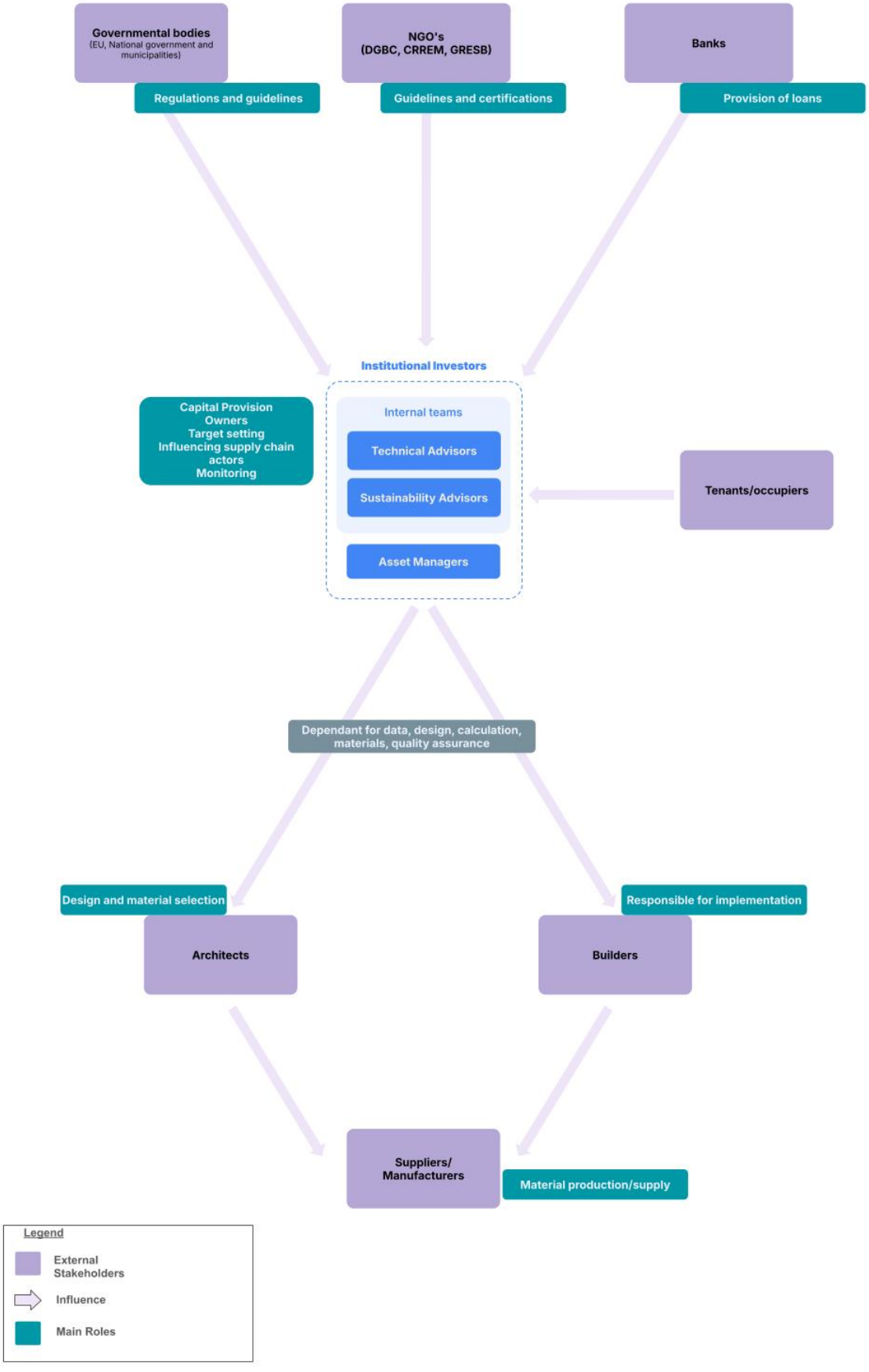

Figure 6.1: Stakeholder mapping (Own figure)

6.1 Barriers

The discussion below critically evaluates the barriers identified through literature and interviews, highlighting their implications in the renovation process

- **Immediate vs. Long-Term Barriers**
  The insights gathered from the literature review and interviews with institutional investors reveal a distinction between immediate and long-term barriers to the adoption of WLC practices. High costs, insufficient data and calculation methods, and low visibility in valuation stand out as immediate barriers that significantly hinder action. During the interview, while many investors demonstrate a willingness to invest in initiatives with low or no return on investment (ROI), not all are prepared to take action. This hesitation often stems from their reliance on various external parties, such as consultants and contractors, for accurate data calculations, as well as valuators for assessing the financial implications of these initiatives. Although there is a clear desire for progress, the lack of scalability among these market actors—often due to insufficient stimulants or a lack of necessary skills—complicates implementation.

  In contrast, long-term barriers identified, such as regulatory and policy issues and market demand-related challenges, may take considerable time to evolve. Interestingly, during the interviews, investors did not view regulatory measures as barriers; instead, they identified them as opportunities for fostering a supportive environment for implementing WLC strategies. They emphasized that the development of regulatory frameworks could create clearer guidelines and urgency, making it easier to engage other stakeholders and create momentum for the consideration of WLC.

- **Stakeholder Dynamics**
  The interconnected nature of barriers necessitates a comprehensive understanding of the roles played by various stakeholders. Institutional investors are primarily impacted by economic challenges, which influence their decision-making and risk-assessment processes. The immediate financial barriers they face, such as high costs and low ROI visibility, are closely tied to regulatory frameworks that either incentivize or deter investment in embodied carbon measures. This underscores the importance of engaging with policymakers to advocate for clear regulatory incentives that can facilitate the integration of WLC strategies. Regulators and policymakers are essential players in addressing barriers related to standards and transparency. The lack of cohesive standards across the sector complicates the ability of investors and supply chain actors to align their efforts. By establishing clear guidelines and incentives, regulators can foster an environment conducive to collaboration and innovation, ultimately driving the integration of WLC into renovation strategies.

  Supply chain actors, including contractors and material suppliers, face their own set of barriers, particularly technical challenges such as material shortages and hesitation to adopt new materials. The reluctance of these actors to innovate and upgrade stems in part from a lack of demand signals from institutional investors. This creates a feedback loop where the absence of investment in embodied carbon initiatives stifles innovation and supply chain advancement. Therefore, it is imperative for institutional investors to actively communicate their interest and demand in sustainable practices, thereby stimulating market readiness and encouraging supply chain actors to embrace new materials and methodologies.

- **Necessity versus Feasibility**
  In navigating the landscape of barriers, distinguishing between necessity and feasibility is vital. Immediate barriers such as high costs and insufficient data require urgent intervention, as they directly shape institutional investors' strategies and commitments to sustainability. Conversely,

barriers like market unreadiness and lack of standards throughout the sector are longer-term issues that can be addressed as industry norms evolve and awareness of WLC benefits grows.

The feasibility of overcoming knowledge-based barriers, such as lack of skill sets and technical challenges, presents a significant opportunity for institutional investors. Unlike other barriers, these issues can be tackled promptly and effectively. By investing in training and capacity-building initiatives, they can equip their teams and supply chain partners with the necessary expertise to implement embodied carbon strategies effectively.

- **Interconnectedness of Barriers**
  A critical analysis of the barriers reveals a complex web of interdependencies that must be understood to facilitate the effective integration of WLC considerations. For instance, the lack of incentives within the supply chain is tightly linked to market demand barriers. Without clear prioritization of WLC by institutional investors, suppliers and contractors/consultants lack motivation to innovate and upscale in WLC practices. Conversely, even if demand exists, its effectiveness is limited if contractors and consultants do not possess the necessary knowledge, resources, or technical capabilities to implement WLC strategies. Institutional investors depend on these market actors for accurate data, calculations, and implementation, making this gap in expertise a significant bottleneck. Additionally, split incentives between investors and tenants, although identified as a low-priority barrier during interviews, can complicate decision-making, particularly in projects where the benefits of embodied carbon investments are not immediately visible to all parties involved.

  Clear communication channels and mutually beneficial agreements and unified carbon reduction targets are essential for aligning interests and ensuring that these initiatives are implemented successfully.

In conclusion, this research highlights the critical barriers faced by real estate institutional investors in integrating WLC considerations into their renovation projects. By understanding the immediate and long-term nature of these barriers, as well as the roles of various stakeholders, investors can better navigate the complexities of the renovation landscape.

6.2 Motivators

Financial Performance remains a primary motivator, aligning with traditional investment priorities in case of energetic renovation as currently noticed. However, the financial case for embodied carbon considerations is more nuanced and long-term compared to operational carbon reductions. While energetic renovations often provide clear win-win scenarios with immediate returns, embodied carbon integration requires a more holistic, lifecycle approach to financial assessment. This shift in perspective is challenging but necessary, as it aligns with the growing recognition of climate-related financial risks. Regulatory Compliance and Risk Mitigation emerge as significant external drivers. The impending CSRD requirements, though currently perceived as a low-impact motivator during the interview, signal a forward-thinking investor's anticipation in the shifting regulatory landscape.

Corporate Strategy and Reputation factors, including commitments like DGBC's Paris Proof initiative, highlight the growing importance of sustainability in corporate identity. However, the medium-level impact attributed to these commitments suggests a gap between public pledges and operational priorities.

Industry Trends and Peer Pressure are driving change but with varying intensity. The external influence of investor-client pressure indicates that while there is momentum, it has not yet reached a tipping point. This suggests an opportunity for industry leaders to differentiate themselves by setting new standards for embodied carbon management. Interestingly, Environmental Awareness emerges as

the highest-rated internal motivator. This finding challenges the notion that institutional investors are purely driven by financial considerations. It suggests a growing recognition of the real estate sector's environmental impact and a sense of responsibility among decision-makers. However, translating this awareness into concrete action remains a challenge. The relatively low importance attributed to securing pension funds as found in interviews is surprising and potentially concerning. It may indicate a disconnect between long-term fiduciary responsibilities and current investment practices. As climate risks become more pronounced, aligning pension fund security with comprehensive carbon management strategies, including embodied carbon, will likely become increasingly critical. In contrast to the current approach in energetic renovations, which prioritizes immediate returns and "low-hanging fruit," embodied carbon integration necessitates a more strategic, long-term perspective. The emphasis on "highest impact for the lowest cost" in energetic renovations, while pragmatic, may be insufficient when addressing the complexities of embodied carbon.

6.3 Strategies for embodied carbon integration

The proposed process for integrating embodied carbon considerations into the current energetic renovation decisions for real estate institutional investors represents a significant step towards more comprehensive sustainability practices in the real estate sector. This process aims to address the growing importance of WLC thinking while acknowledging the practical challenges faced by investors in the Dutch market.

- **Theorotical contributions**
  This research addresses critical gaps in academic literature regarding the WLC perspective in renovation processes. While previous research has extensively covered operational carbon reduction in renovation, the systematic integration of embodied carbon considerations in renovation processes, particularly from real estate institutional investors' perspective, remained largely unexplored.

  The development of a dual-level approach distinguishing between strategic and project-level implementation takes into consideration the organisational, stakeholder and project-level strategies considering the current constraints making it a comprehensive approach which was currently lacking in the existing literature.

  As market capabilities evolve, this research provides a novel foundation for future studies examining the effectiveness of systematic carbon reduction strategies in renovation projects.

- **Alignment with Current Practices and Industry Needs**

  The process builds upon existing renovation workflows. The dual-level approach, which first establishes strategic-level strategies to set the foundation and then focuses on project-level strategies, provides a structured and adaptable approach to integrate embodied carbon into the current processes. This approach aligns with (Pomponi & Moncaster, 2016) recommendation that embodied carbon strategies should complement established industry processes. By maintaining the focus on operational carbon prioritization in the initial stages, the process acknowledges current industry priorities while gradually introducing embodied carbon considerations. It also takes into consideration the barriers and proposes mitigation strategies to overcome the barriers that were hindering them in the process. The phased approach to integrating embodied carbon assessments addresses a key challenge identified in the literature regarding the complexity of WLC considerations in renovation contexts (Röck et al., 2020). By suggesting the use of available databases like NMD and ICE as starting points, the process provides a practical pathway for investors to begin addressing embodied carbon without requiring comprehensive data from the outset.

- **Stakeholder Engagement and Roles**

  The emphasis on stakeholder engagement, especially with tenants and property managers, addresses a key challenge identified by (Giesekam, Barrett & Taylor, 2016) regarding the need for collaboration across the supply chain to reduce WLC effectively. The process recognizes the influence of key stakeholders including tenants on fit-out decisions and building adaptability, particularly in commercial and retail sectors.

- **Data Challenges and Opportunities**

  The process acknowledges the current limitations in embodied carbon data availability and proposes a pragmatic approach of starting with category 3 data from the NMD and open databases and progressing to more accurate categories as they become available or as more tools are developed. This phased approach to data quality improvement aligns with recommendations from recent literature on embodied carbon assessment methodologies (Röck et al., 2020).

- **Education and Capacity Building** The emphasis on education and training, particularly for property managers and other key stakeholders, aligns with Häkkinen and Belloni (2011) findings on the importance of knowledge dissemination in overcoming barriers to sustainable building practices.

- **Integration with Industry Initiatives**

  The proposed collaboration with organizations like the Dutch Green Building Council (DGBC) for developing standardized metrics and benchmarks is crucial. This aligns with calls from researchers for more consistent and comparable embodied carbon assessment methods across the industry (Röck et al., 2020).

- **Scenario Analysis and Decision-Making**

  In the Renovation Plans stage, a critical step is introduced to consider the operational carbon reduction measures and their associated embodied carbon and choose the one with the lowest embodied carbon irrespective of other influencing factors such as cost as it would be beneficial in the long run. This approach aligns with recent research indicating that, while operational carbon savings are essential, they can sometimes be offset by the embodied carbon within renovation materials (Röck et al., 2020). Prioritizing bio-based insulation materials exemplifies the practical application of recent findings on carbon sequestration potential in construction, highlighting the benefits of sustainable material choices (Bienert et al., 2023)."

6.4 Establishing a Supportive Context for WLC Practices

While the proposed process provides a framework for real estate institutional investors to integrate embodied carbon considerations into their renovation decisions, it's important to recognize that successful implementation requires a supportive ecosystem. The transition towards WLC thinking in the real estate sector is not solely the responsibility of investors but necessitates collaborative efforts across various stakeholders. The following opportunities were identified and attributed to creating a supportive environment for the effective implementation of the process by real estate institutional investors:

- **Incorporating Embodied Carbon into Valuation Processes**

  The integration of embodied carbon considerations into property valuation could provide a significant financial incentive for investors. This aligns with Warren-Myers (2012) findings on the importance of sustainability metrics in property valuation. This not only acknowledges the

environmental impact of renovation projects but also adds a financial incentive for investors to prioritize sustainable practices. However, as noted in the validation feedback, changing valuation practices faces significant industry resistance and may require long-term efforts (I10). Professional bodies like RICS can play a crucial role by developing standardized metrics and training valuation experts in assessing these metrics. This opportunity could make sustainable investments more appealing to environmentally-conscious stakeholders and investors.

- **Expansion of Carbon Risk Real Estate Monitor (CRREM) Methodology**

  Currently, CRREM focuses on operational emissions, offering a tool for investors to measure and manage these emissions in alignment with climate targets. Expanding this methodology to cover embodied carbon in renovation projects would provide investors with a comprehensive framework for assessing their carbon footprint over the entire lifecycle of a building. This aligns with recent research highlighting the need for integrated operational and embodied carbon assessments in real estate (Röck et al., 2020).

- **Fostering Collaboration and Upscaling within the Supply Chain**

  Collaboration and upscaling offer a practical opportunity for real estate institutional investors to influence the other parties in the supply chain. By fostering partnerships within the industry, investors can share resources, knowledge, and best practices by collectively setting such targets thereby in a way obliging the market actors to pertain to it (I3). Industry-wide collaboration is crucial for driving change. This supports Giesekam et al. (2016) findings on the importance of supply chain collaboration in reducing WLC. Industry organisations like IIGC, green building councils etc can facilitate these partnerships, organize workshops, and create platforms for industry players to come together, making collaboration an attractive pathway toward WLC reduction.

- **Expansion of EU Taxonomy**

  Aligning embodied carbon considerations with the EU Taxonomy could provide financial incentives for sustainable practices. Expanding the EU Taxonomy to include embodied carbon considerations would further encourage investors to adopt WLC approaches. Compliance not only enables access to green financing but also strengthens the credibility of sustainable investments in the eyes of global investors.

- **Subsidies**

  Subsidies offer direct financial support that can offset the higher initial costs of WLC considerations in renovations. When the government provide subsidies specifically for embodied carbon reduction projects, they make it financially viable for more investors to prioritize low-carbon materials and construction practices. Lowering upfront costs makes sustainable renovations more accessible, encouraging the real estate sector to adopt practices that align with climate targets. This is supported by the findings from (Zhang, Liu & An, 2024) wherein the subsidies from the government have proven to be a great way to induce such practices within the construction sector. Non-governmental organisations (NGO's) can help raise awareness of available subsidies, advocate for expanded programs and guide investors on accessing these financial incentives.

- **Carbon Pricing Mechanisms**

  The inclusion of carbon pricing, carbon credits, and Carbon Border Adjustment Mechanism (CBAM) within the real estate sector also provides a strong incentive for investors to reduce embodied carbon. By placing a price on carbon emissions, these mechanisms directly link financial savings to carbon reduction efforts. This approach drives market demand for low-carbon

options and aligns financial and environmental goals. However, these mechanisms should correspond to the real carbon emissions rather than seeing them as an option to offset the higher emissions (I11). Professional organisations like EPRA (European Public Real Estate Association) should collaborate with government bodies to ensure that national carbon pricing mechanisms account for embodied carbon, further incentivizing investors to pursue WLC reduction.

- **Knowledge and Training**

  Capacity building through education and training is essential. This supports Häkkinen and Belloni (2011) findings on the importance of knowledge dissemination in overcoming barriers to sustainable building practices. By investing in sustainability education, industry professionals and investors are better equipped to make decisions that consider both operational and embodied carbon. Professional real estate education institutes, construction industry training bodies, and sustainability certification organizations can collaboratively develop training resources and promote sustainability expertise across the sector. With enhanced expertise, investors can achieve better project outcomes and remain competitive in an evolving regulatory landscape.

- **Expansion of Certification Schemes**

  Enhancing certification schemes like BREEAM NL and the Low Carbon Building Initiative to include embodied carbon in renovations will provide standardized benchmarks and market recognition for sustainable practices. Broadening the scope of BREEAM NL certification to include embodied carbon in renovations presents an excellent opportunity to establish a recognized standard for sustainable renovation practices. Currently focused on operational energy, expanding the scope of BREEAM NL to address embodied carbon offers investors a measurable benchmark to meet sustainability goals in renovations, potentially boosting property value and attracting eco-conscious tenants. The DGBC could play a key role in guiding this expansion as currently in the Netherlands, they are responsible for issuing the certification thereby helping investors adopt comprehensive WLC standards in their projects.

  Similarly, the Low Carbon Building Initiative, which currently targets new office, residential, and hotel constructions, could drive sustainable renovation by expanding to include diverse building types and rewarding projects that incorporate such initiatives. By leveraging these broadened certifications, investors can enhance property marketability, secure funding, reduce regulatory risks, and appeal to tenants who prioritize sustainability.

6.5 Limitations

While this research provides a phased process for integrating embodied carbon considerations into renovation decisions for real estate institutional investors, several limitations should be acknowledged to provide a balanced perspective on the findings.

- The scope of stakeholder engagement in this study, while comprehensive, may not fully capture the perspectives of all relevant parties in the real estate renovation process. It might not adequately represent the views of contractors, suppliers, or policymakers, who also play crucial roles in embodied carbon reduction. This limitation could affect the holistic understanding of the challenges and opportunities in implementing the proposed process for the investors.
- The rapidly evolving technological landscape in carbon assessment and management poses another limitation. The proposed process, while based on current feasible practices, may require frequent updates to incorporate new tools and methodologies as they become available. For instance, the potential of emerging technologies like digital twins or blockchain in facilitating embodied carbon assessments and management is not extensively addressed in this study.

- The study lacks a detailed economic analysis of the costs and benefits associated with implementing the proposed process for real estate institutional investors. The absence of comprehensive financial modelling specific to this investor group may limit the persuasiveness of the approach, particularly for decision-makers primarily driven by financial considerations. Future research should address this by conducting an in-depth cost-benefit analysis tailored to real estate institutional investors, strengthening the embodied carbon integration in their renovation decisions.
- The variability in building types, ages, and construction methods presents another challenge and is not addressed by the proposed process. Different building categories may require more tailored approaches to embodied carbon integration, and the current study may not adequately capture these nuances. This limitation could affect the universal applicability of the process across diverse real estate portfolios.
- While the study acknowledges that real estate institutional investors are aware of embodied carbon considerations, it does not address the organizational change aspects required for the successful implementation of the proposed process. Despite this awareness, resistance to change and ingrained practices within these organizations could pose significant challenges that are not comprehensively explored in the current research. Additionally, the varying levels of readiness to implement embodied carbon considerations across different investors may affect the applicability and effectiveness of the proposed process. Future work could focus on developing change management strategies specific to these investors to facilitate the adoption of embodied carbon considerations in their renovation decision-making processes, building on their existing awareness.
- A significant limitation of this study is the absence of case studies demonstrating the implementation of embodied carbon considerations in renovation practices by real estate institutional investors. This stems from the early stage of embodied carbon integration in Dutch real estate renovation processes, where investors are aware of these considerations but have not yet begun implementing them, resulting in a lack of examples to learn from or analyze.

These limitations highlight areas for future research and underscore the need for ongoing refinement and adaptation of the proposed process as the field of embodied carbon management in real estate continues to evolve. Despite these limitations, the study provides a valuable foundation for integrating embodied carbon considerations into renovation decisions and offers a practical starting point for real estate institutional investors to address this critical aspect of sustainability.

Chapter 7

Conclusion and Recommendations

The conclusion and recommendations chapter summarizes the key findings of the research, reflecting on the integration of WLC considerations into the renovation processes of institutional investors. It is followed by the recommendation section that outlines the recommendations for the investors, DGBC and for further research, ultimately advancing the transition to a low-carbon real estate sector.

7.1 Conclusion

The real estate sector plays a significant role in global carbon emissions, with embodied carbon becoming an increasingly important consideration alongside operational carbon. This study aimed to develop a process for integrating WLC considerations, particularly embodied carbon into the current energetic renovation decisions for real estate institutional investors in the Netherlands, addressing the growing need for comprehensive carbon management in the built environment. Academic research has predominantly focused on energetic renovation processes, with limited emphasis on integrating WLC considerations into renovation practices. This research adopts a practical approach to address this gap, presenting a comprehensive framework for incorporating WLC into the renovation by addressing the barriers, opportunities, and motivators of these investors and also considering their roles. This novel approach provides such a comprehensive approach with strategies at the strategic level as well as the project level stages.

The research identified several key challenges faced by investors in incorporating WLC considerations such as data limitations, lack of standardized assessment methods, high upfront costs etc among many others. To address these challenges, a dual-level approach (strategic level strategies and project level strategies) has been developed that investors can follow to align with existing energetic renovation practices while gradually integrating embodied carbon considerations. Additionally, this research underscores and identifies the opportunities that are essential for creating a supportive environment to facilitate the successful implementation of strategies by investors.

At the strategic level, foundational elements are established through carbon pricing, approach-based targets, standardized documentation systems etc. These elements enable systematic implementation at the project level, where carbon reduction measures are integrated into five key stages of the existing renovation workflow: Initial Assessment, Developing Renovation Plans, Plans Presented for Client Approval, Implementation and Monitoring, and Post-project Evaluation. Each stage includes targeted actions to reduce embodied carbon, incorporating strategies designed to address the identified barriers within that specific step.

Validation interviews with industry experts confirmed the relevance and potential effectiveness of the proposed process, while also highlighting areas for further development. The research revealed that

successful integration of WLC considerations requires not only technical solutions but also stakeholder engagement, market-driven approaches, regulations etc.

Key findings include:

1. The importance of aligning WLC considerations with existing workflows to facilitate adoption.
2. The need for phased implementation to address current data and expertise limitations.
3. The critical role of stakeholder engagement, particularly with builders, tenants and property managers.
4. The potential of market-driven approaches, such as internal carbon pricing and certifications, to drive change.
5. The necessity of education and capacity building across the organization to support implementation.
6. The necessity of regulations and policy as a key driver for the facilitation of WLC considerations in renovation projects throughout the sector.

7.1.1 Answering the Research Questions

SQ1: What roles do institutional investors play in integrating WLC reduction into their renovation projects?

The research found that institutional investors play a crucial role in driving the integration of WLC reduction in renovation projects. These investors are owners who have capital provisions and are in the centre of the supply chain having a significant influence on the influencer value chain as well as the building value chain of the building system framework. They have the power to influence the supply chain by setting tender criteria and standards through procurement practices and driving market demand for low-carbon solutions. Their investment decisions can significantly impact the adoption of sustainable practices across the real estate sector. Moreover, as large-scale property owners, they have the potential to implement and test innovative approaches to carbon reduction, setting benchmarks for the industry.

SQ2: What barriers and motivators do institutional investors face in incorporating WLC reduction into their renovation efforts?

The barriers to integrating WLC considerations in renovations primarily include high costs, insufficient data and calculation methods, and a lack of expertise and relevant skills. Additional challenges arise from low returns on investment, material shortages, and a lack of sector-wide standards. Further complexities include limited incentives within the supply chain, reluctance from stakeholders to adopt new materials and organizational inertia. Other barriers are low visibility of benefits in asset valuations, inadequate scaling by construction companies, and market readiness issues, making it difficult to gain tenant agreement and balance incentives.

Conversely, motivators for adopting these considerations stem from regulatory pressures, anticipated future legislation, and a growing awareness of climate-related risks that can impact asset value. Investors are also driven by the client and stakeholder demands, commitments, awareness etc for sustainable investments and corporate sustainability goals.

In summary, the barriers primarily revolve around market and supply chain, knowledge and capacity, economic, stakeholder engagement and operational constraints while the motivators are influenced by regulatory, economic, and stakeholder pressures, along with potential reputational benefits. These findings underscore the complex landscape that investors must navigate when integrating WLC in considerations into their renovation processes.

SQ3: What strategies can be employed to integrate WLC considerations into their renovation processes while addressing the identified barriers and motivators?

Considering the complex landscape of WLC in renovation projects, this approach emphasizes multi-faceted strategies. These include stakeholder engagement, organizational strategies, portfolio-wide strategies, documentation practices, and project-level actions. Developed with a clear understanding of the barriers, motivators, and roles of institutional investors, these strategies offer a comprehensive framework for integrating WLC reduction into renovation processes. The strategies go beyond internal operations, highlighting the critical need for stakeholder collaboration, standardized documentation, and proactive engagement across the supply chain. By addressing the unique challenges faced by institutional investors, the proposed approach presents a practical and actionable pathway for incorporating WLC considerations, fostering environmental sustainability, and enhancing long-term value creation

SQ4: How practical and feasible are the proposed strategies for integrating embodied carbon into renovation processes?

Validation interviews revealed that while the proposed process aligns with current industry trends, its practicality varies among investors. More advanced organizations are already demanding comprehensive WLC considerations within the renovation projects, while most are still in the early stages of considering embodied carbon. The phased approach was seen as a great practical starting point, but there's a clear need for more sophisticated tools and standardized methodologies as the industry progresses.

MQ: How can real estate institutional investors incorporate WLC reduction into their renovation processes in the Netherlands?

The research proposes a gradual integration approach that combines strategies at both the strategic and project levels. This approach aligns with current energetic renovation practices while progressively incorporating embodied carbon considerations. At the strategic level, key initiatives include the establishment of carbon pricing mechanisms, the setting of approach-based targets, and the implementation of a material passport framework. At the project level, the focus is on integrating embodied carbon into existing renovation processes, utilizing available data sources and tools, and fostering continuous improvement. The approach also highlights the importance of stakeholder engagement, education, and collaboration with industry peers and organizations to develop standardized methodologies. Regular reviews and adaptations based on lessons learned and emerging best practices are also emphasized. The process underscores the need for consistent data sources, standardized assessment methods, and industry-wide collaboration to address current limitations and drive meaningful carbon reduction in the real estate sector.

7.2 Recommendations

This section outlines the recommendations for the investors, DGBC and for further research.

7.2.1 Real Estate Institutional Investors

1. Implement the proposed process in phases, starting with pilot projects to test and refine the approach.
2. In the initial assessment phase while prioritizing assets for renovation, a basic inventory of embodied carbon considerations with information such as the building age, renovation history, building type, major materials used in the buildings, material impact assessment etc. This can be done by utilizing available plans, renovation schedules and major materials present in the buildings and then establishing a rough estimate of the embodied carbon values of these buildings.

Understanding that the major emitters of embodied carbon are concrete, steel, and insulation materials such as expanded polystyrene, glass, aluminium etc can be looked into while considering the material impact assessments. Regarding the data constraints, this can help give a good starting point for investors to understand the embodied carbon impact of their assets. For calculating the embodied carbon of these, the data from the National Millieu Database(NMD) and also open data sources can be utilised. The Category 3 data in NMD can be utilised at this stage. In case of availability of more specific data, category 2 and category 1 can also be considered. Apart from these, open data sources can also be utilized such as the data from the Inventory of Carbon and Energy Database (ICE), EC3 databases etc.

3. Investors should assess the current level of WLC awareness within their organization and invest in targeted training for property managers, asset managers, and other relevant stakeholders. Educational efforts could include workshops on recent advancements in embodied carbon reduction, practical training in carbon assessment tools, and case studies demonstrating successful projects. These initiatives will strengthen the internal capacity of WLC management and prepare staff to implement the proposed process more effectively.
4. Establishing a cross-functional team dedicated to WLC management is also recommended. This team would oversee the implementation of the proposed process, coordinate with external consultants, and monitor and report on progress in carbon reduction.
5. Developing a clear roadmap for comprehensive WLC assessments is another critical step. This roadmap should outline milestones for data improvement, establish embodied carbon reduction targets, and integrate WLC considerations into all stages of the investment lifecycle. By setting specific goals and tracking progress, investors can make meaningful strides in reducing carbon impacts over time.
6. Engaging with industry peers can strengthen efforts, as sharing best practices and pilot insights helps develop standardized assessment methods and supports advocacy for favourable regulations.
7. To address financial constraints, investors should consider green financing options like green bonds, sustainability-linked loans, and partnerships with green banks.
8. Finally, establishing a robust monitoring and reporting system for WLC in impacts is key. Regular assessments of both operational and embodied carbon, integrated into asset management systems, will support transparent stakeholder reporting and reinforce the organization's commitment to sustainability.

7.2.2 DGBC

1. Develop standardized metrics and benchmarks for WLC in renovation projects, facilitating consistent assessment across the industry.
2. DGBC should develop standardized carbon pricing frameworks that reflect actual emissions and market conditions, providing real estate investors with practical benchmarks for implementation while considering current data limitations and industry readiness.
3. To gain a more comprehensive understanding of the dynamics surrounding embodied carbon considerations, future research should conduct similar studies for other actors in the supply chain, such as consultants, contractors, and material manufacturers within working groups of DGBC. Investigating their roles, challenges, and readiness to integrate embodied carbon strategies will provide valuable insights and help identify collaborative opportunities to enhance sustainability practices across the entire construction and renovation sector.

4. Expand existing certification schemes like BREEAM NL to include comprehensive WLC considerations for renovation projects.
5. Facilitate knowledge sharing and best practices among industry stakeholders through workshops, webinars, and publications.
6. Collaborate with international organizations to align WLC assessment methodologies and promote global consistency.
7. Develop and offer specialized training programs on WLC assessment and management for real estate professionals.
8. Advocate for financial incentives and subsidies for WLC reduction in renovations by lobbying for supportive policies, partnering with financial institutions, providing guidance on existing subsidies etc.

7.2.3 Further Research

1. Develop more sophisticated tools for scenario analysis between the different renovation options and trade-off analysis between operational and embodied carbon in renovation contexts. This is crucial as in the current context, there are no such tools that the investors can utilize to make comparisons between the different options which might affect their effective decision-making.
2. Explore the development of a maturity model for WLC management in real estate organizations. Currently, there exists no such model which will help these organizations to track their progress on the WLC reduction practices.
3. Conduct studies on incorporating WLC considerations into the current valuation models. Traditional valuation models often overlook sustainability criteria, including embodied carbon in renovation practices, and do not effectively capture their impact on property value.
4. Conduct studies to assess the long-term impact of WLC reduction strategies on building performance and value in the context of renovation addressing the current lack of empirical evidence in this area.
5. Investigate the potential of digital technologies, such as Building Information Modeling (BIM), in facilitating WLC assessments for existing buildings.
6. Analyze the economic implications of WLC integration in renovation decisions, including cost-benefit analyses and impacts on property values, to address the current financial uncertainty surrounding WLC in renovations.

In conclusion, this research provides a foundation for real estate institutional investors to begin systematically addressing WLC in their renovation decisions. As the industry moves towards more comprehensive carbon management practices, early adopters of such approaches may gain a competitive advantage. However, successful implementation will require ongoing collaboration, innovation, and commitment across the real estate sector. The proposed process and recommendations offer a practical pathway for investors to contribute to the urgent need for carbon reduction in the built environment.

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Appendix A

Interview Protocol

Interview Protocol
Who am I?
My name is Rinu, and I'm a graduate student at TU Delft. I'm working on my thesis titled, *"Whole Life Carbon Reduction: Investors Approach in Renovation Projects."*

What will I do with your information?
This interview will be recorded and transcribed for analysis, and all data will be anonymized. Your participation is voluntary, and no identifiable information will be included in the final report. All data will be securely stored and deleted once the research is completed.

A.1 Semi-Structured Interview Protocol

Questions and guiding themes of the interview
This interview focuses on understanding current renovation practices, barriers and motivators for embodied carbon integration, and gathering insights on implementation possibilities. Your expertise will help inform the development of practical strategies for embodied carbon integration in renovation processes. Your expertise will help inform the development of a tailored approach for WLC in renovation projects suited to the Dutch context.

Why is this person here?
You are being interviewed due to your expertise as a real estate institutional investor in the Netherlands. Your role is critical in understanding current renovation practices and the potential for embodied carbon integration in the current energetic renovation processes.

Sample Questions:

- Can you briefly describe your decision-making process while renovating buildings?
- How does your organization currently incorporate carbon reduction in renovation projects?
- What are your specific preferences when undertaking renovation projects?
- How do you currently prioritise the assets for renovation?
- What is the step-by-step process of energetic renovation that you follow?
- What role do you typically play in the process?
- Who are the key stakeholders involved during the process?

- What do you understand by the term whole life carbon ?
- Who do you think are the most influential stakeholders in WLC reduction in renovation projects?
- Based on your experience, what issues do you face while considering the incorporation of WLC in your current renovation processes?
- What motivates you to consider WLC in your renovation processes?
- What improvements or strategies would you recommend for adopting WLC in your renovation processes?

A.2 Validation Expert Panel Protocol

You are being interviewed to validate the proposed strategies for embodied carbon integration in renovation processes. The purpose is to assess the feasibility and effectiveness of the proposed dual-level approach.

Questions and guiding themes of the interview
This validation session aims to confirm the applicability and practicality of the proposed strategies for integrating embodied carbon into the current energetic renovation processes.

Why is this person here?
You are being interviewed due to your expertise as a real estate institutional investor in the Netherlands and also coming within the focus group either as a part of the working group or as an external.

Sample Questions

- How feasible are the proposed strategic-level elements in your organization?
- What challenges do you foresee in implementing these strategies?
- What additional factors should be considered to enhance effectiveness?
- Are the proposed implementation steps practical within current market constraints?
- What refinements would make the strategies more applicable to your organization?

TEMPLATE 2: Explicit Consent points

Please make sure that you select (and amend as necessary) any Explicit Consent points which are relevant to your study and exclude those which do not apply. You should also add further points and necessary to address your specific research situation.

PLEASE TICK THE APPROPRIATE BOXES	Yes	No
A: GENERAL AGREEMENT – RESEARCH GOALS, PARTICPANT TASKS AND VOLUNTARY PARTICIPATION		
1. I have read and understood the study information dated *18/05/2024* , or it has been read to me. I have been able to ask questions about the study and my questions have been answered to my satisfaction.	☐	☐
2. I consent voluntarily to be a participant in this study and understand that I can refuse to answer questions and I can withdraw from the study at any time, without having to give a reason.	☐	☐
3. I understand that taking part in the study involves: Audio/Video recorded interviews will be converted into text transcripts, and the recordings will be erased after the study is concluded.	☐	☐
4. I understand that the study will end on 31//10/2024. This date will only be finalised during the green light meeting.		
B: POTENTIAL RISKS OF PARTICIPATING (INCLUDING DATA PROTECTION)		
5. I understand that taking part in the study also involves collecting specific personally identifiable information (PII): name, designation, organization, location, and email address and associated personally identifiable research data (PIRD) with the potential risk of my identity being revealed	☐	☐
6. I understand that some of this PIRD is considered as sensitive data within GDPR legislation, specifically data related to their roles and responsibility	☐	☐
7. I understand that the following steps will be taken to minimize the threat of a data breach and protect my identity in the event of such a breach privately and securely storing the data on TU Delft One Drive with very limited access and deleting the data after the research purpose.	☐	☐
8. I understand that personal information collected about me that can identify me, such as name, designation, organization, location, and email address will not be shared beyond the study team.	☐	☐
9. I understand that the (identifiable) personal data I provide will be destroyed immediately after the research duration.	☐	☐
C: RESEARCH PUBLICATION, DISSEMINATION AND APPLICATION		
10. I understand that after the research study the de-identified information I provide will be used for the master thesis report that will be published and available publicly in the TU Delft repository.	☐	☐
11: I agree that my responses, views or other input can be quoted anonymously in research outputs	☐	☐
12. I agree that my real name can be used for quotes in research outputs	☐	☐
D: (LONGTERM) DATA STORAGE, ACCESS AND REUSE		
13. I give permission for the de-identified audio/video recordings, transcripts, and other required data that I provide to be archived in the TU Delft repository so it can be used for future research and learning.	☐	☐

PLEASE TICK THE APPROPRIATE BOXES	Yes	No
14. I understand that access to this repository is open but can also be restricted as per the request from the organization/collaborating parties.	☐	☐

Signatures

_____ _____ _____

Name of participant [printed] Signature Date

[Add legal representative, and/or amend text for assent where participants cannot give consent as applicable]

I, as legal representative, have witnessed the accurate reading of the consent form with the potential participant and the individual has had the opportunity to ask questions. I confirm that the individual has given consent freely.

_____ _____ _____

Name of witness [printed] Signature Date

I, as researcher, have accurately read out the information sheet to the potential participant and, to the best of my ability, ensured that the participant understands to what they are freely consenting.

Rinu Mariam Panicker 

_____ _____ _____

Researcher name [printed] Signature Date

Study contact details for further information:

Rinu Mariam Panicker

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Appendix B

Initial Strategies

The following diagram shows the initially developed strategies before including the improvements from the validation phase.

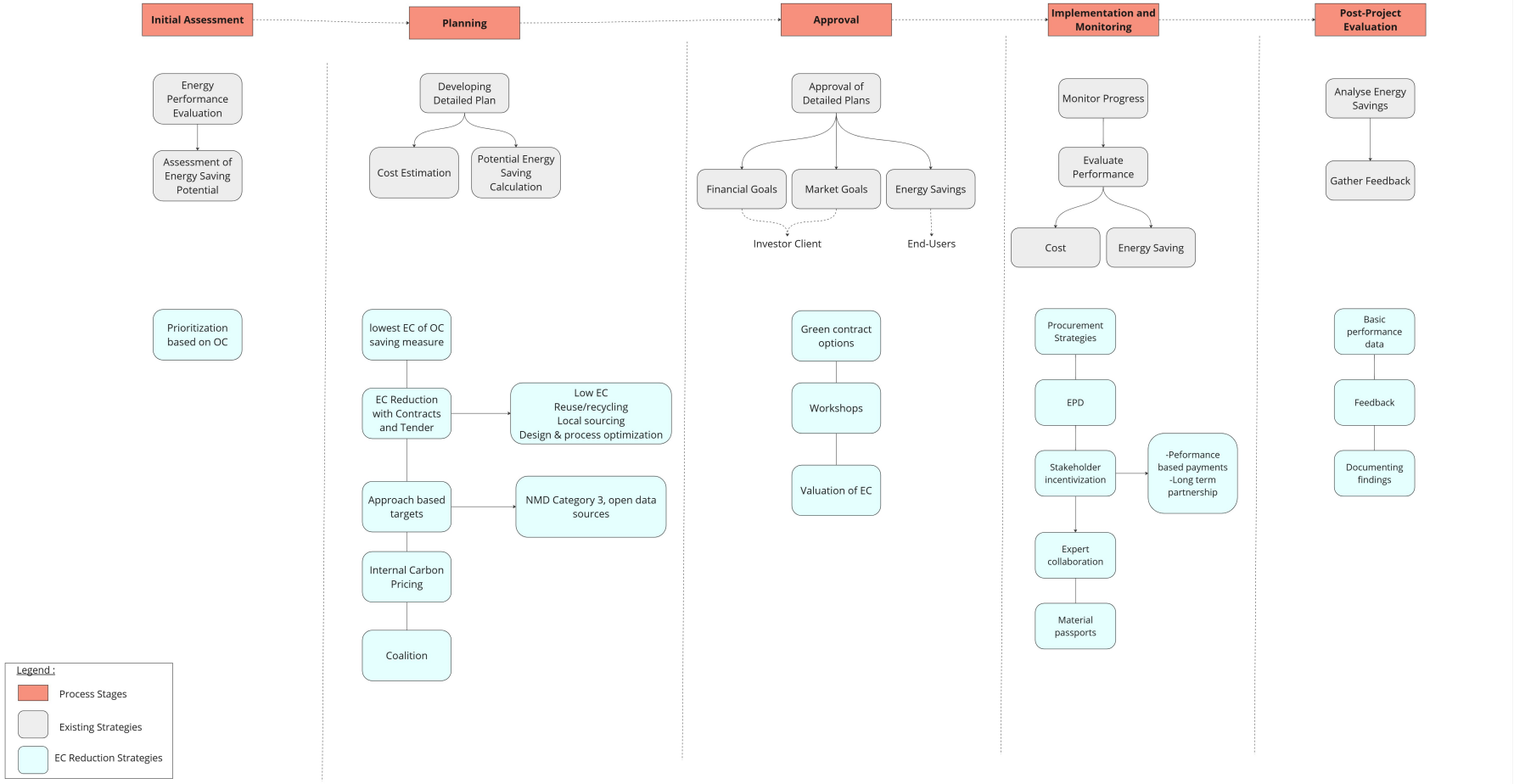

Figure B.1: Initial Strategies

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