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Transition Finance and KPIs for the Real Estate Sector: Alignment with EU Climate Policy Objectives

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1. Introduction

1.1 Research question

This thesis delves into the intricate risks posed by climate change and the crucial shift towards a low-carbon economy within the real estate sector. By meticulously examining strategic responses and financial instruments aimed at mitigating these risks, the study places significant emphasis on scrutinizing key performance indicators (KPIs) as crucial criteria for assessing the credibility of transition plans of asset managers active in the EU real estate sector. As indicated recently by GFANZ, the adoption of KPIs that are capable of measuring the real transition efforts are critical for investors that have pledged to decarbonize their portfolios. The research question focuses on identifying key performance indicators (KPIs) and banking product solutions to align the real estate sector with the EU's decarbonization policy objectives that could be applied to EU real estate managed portfolios. The research question engages mainly with climate mitigation and with the enhancement of energy efficiency and climate resilience. Climate decarbonization pathways in the EU should not just lead to Net Zero but also do it consistently with EU Green Deal objectives to ensure maximization of private and public transition efforts. The quality and credibility of climate prudential transition plans of banks and the Net Zero transition plans asset managers are the key for the resilience of the investments in the EU real estate sector. The robustness of the thread that links credible climate transition plans of real estate asset managers with EU Green Deal objectives and policy measures and with bank lending products is essential to reduce transition risks for the banking sector and to enhance financial stability: this issue, that is at the core of the new CRR3 and draft EBA Guidelines on ESG risks, impinges on the quality of climate prudential transition plans that EU credit institutions will be preparing. Additionally, the dissertation examines the significance of these solutions not only for the sector but also for financial stability at large.

1.2 Structure of the dissertation

The thesis analysis analyzes not only the available European literature but also contributions from the United States, given the interconnections between the two markets and the strong presence of US investors in the EU real estate market which dominates the global asset manager market. Hence, a review of decarbonization approaches in the EU for the sector cannot ignore the perspective of US investors while recognizing their need to adjust their strategies to meet EU Green Deal objectives and to contribute to ensuring financial stability also in the EU. Through a literature review of reports by prudential bodies and regulators, chapter 2 situates the real estate sector within the broader financial landscape, highlighting its pivotal role in maintaining economic stability and functionality and, hence, its systemic risk in a climate-related context. This foundational context not only underscores the

sector's centrality to the global economy but also sets the stage for a comprehensive exploration of its challenges and transformative potential.

Specifically, Chapter 2 discusses the cyclical impact of the real estate sector on financial stability, emphasizing how fluctuations in real estate can significantly affect economic steadiness, particularly in the European context amid current unstable conditions and rising climate concerns. The European Central Bank's analysis on "Real estate markets in an environment of high financing costs" (2023) further highlights the challenges posed by increased financing costs, which have dampened demand and pressured property prices downward. Additionally, the chapter further looks at the ramifications at real estate residential and commercial markets, where strong labor markets somehow lessen the credit risk for banks. The chapter will, therefore, provide a good basis to understand how such effects of climate-related risks are felt on the real estate industry and, ultimately, the economy at large.

Chapter 3, after having previously outlined the intricate interconnections between the real estate sector and financial stability within Europe, shifts the focus to the contemporary forces reshaping this landscape. This chapter explores a variety of influences, including demographic shifts, technological advancements, and environmental pressures, and assesses their potential impact on the sector. The aim of this chapter is to illuminate the highly complex environment in which the real estate industry must operate. Understanding these drivers is crucial for comprehending the demanding business, social, and regulatory contexts that necessitate adaptation and change within the sector. In this regard, the methodology of research is mixed with qualitative and quantitative analyses. The quantitative data of the research are the statistical and market studies, while the qualitative insights are based on expert interviews and cases. In particular, the literature review synthesizes existing research and market analyses to frame the discussion. For instance, the United Nations' "World Population Prospects 2022" and Eurostat's "Population Structure and Ageing" (2021) provide crucial demographic insights, while technological advancements are explored through reports like Markets and Markets' "Digital Transformation Market Size, Trends & Growth Report – 2030" (2023) and Deloitte Digital's 2021 survey on technology investments in commercial real estate. Environmental pressures are discussed using sources such as the Ministry of Housing, Communities & Local Government's "Building Standard" (2021). Additionally, economic impacts are assessed using the McKinsey Global Institute's "*Empty spaces and hybrid places: The pandemic's lasting impact on real estate" (2023)*. This comprehensive approach ensures a thorough understanding of the current forces influencing the real estate sector and their potential future impacts.

Building upon the conclusion of chapter 3, chapter 4 focuses on Policy shift in Europe as a driver of change, assessing the impact of the EU Green deal, EPBD, EU Taxonomy, Net-Zero Industry Act and the new metrics of Embodied Carbon on Real Estate Dynamics and Investment Strategies. This chapter, linked with the global drivers of changes, serves to illustrate how the regulatory pressure in Europe can profoundly reshape the sector dynamics. To provide a comprehensive understanding, the literature review focuses on the available body of work on the issue of these intersections. In detail, this chapter looks at studies and reports analyzing the goals of the EU Green Deal, the implementation strategies, and the expected impact on the sustainability practices to be carried out by the stakeholders within the real estate industry. Furthermore, it focuses on academic papers, governmental documents, and industry reports that analyze the changes introduced by the EPDB and their impact on building standards, particularly in retrofitting and designing new structures to enhance energy efficiency.
Further exploration includes literature related to the EU Taxonomy for sustainable activities, focusing on how it defines sustainable investments and its implications for real estate investments. Scholarly articles, regulatory documents, and case studies demonstrate the taxonomy's influence on investment strategies. Additionally, research papers, technical reports, and industry guidelines on embodied carbon metrics are investigated to analyze the role of these metrics in assessing building sustainability, and their impact on investment and development decisions. This chapter serves as the cornerstone of the dissertation, laying the groundwork for the final chapter's scrutiny of whether the available KPIs align with the standards and provisions set by the EU Climate Law.

Chapter 5 focus on specific climate-related risks impacting the real estate sector. After having analyzed the cyclical and structural challenges within this sector, in particular its susceptibility to economic and environmental changes, as well as after having identified in the previous chapters the main drivers of change and political changes in Europe, this chapter is poised to address the physical and transition risks arising from climate change. In particular, the literature review in this chapter delves into the sector’s significant exposure to both physical and transition risks associated with climate change. Physical risk directly threatens real estate properties through increased maintenance and repair costs and may result in a significant devaluation of the property. Simultaneously, transition risks are related to regulatory changes, market shifts, and changes in investor sentiment. A "Real Estate Sector Risks Briefing" published by UNEP FI emphasizes that, because the real estate sector contributes to approximately 40% of global greenhouse gas emissions, the sector has been critically looked at in terms of sustainability efforts.

After discussing the climate-related risks affecting real estate, chapter 6 analyzes the economic and financial impacts of these risks. In particular, the chapter highlights the declining attractiveness of carbon-intensive assets due to increasing climate commitments and carbon pricing mechanisms. Furthermore, it also examines the financial strain posed by rising energy costs, the need for significant capital investments to meet new regulatory standards, and the potential devaluation of non-compliant properties. This chapter dives into recent research to show how market dynamics are increasingly leaning towards sustainable practices. Specifically, it analyzes how rising carbon costs are expected to impact the economy and what are the implications for the real estate sector. Furthermore, the chapter highlights the importance of understanding and addressing these risks by investing in energy efficiency, working with policymakers, and conducting proactive risk assessments.

Chapters 5 and 6 are fundamental to understand exactly why climate finance is becoming crucial and why KPIs are needed to accelerate the climate transition.
In particular, the growing importance of climate finance in the real estate sector is a direct response to its substantial exposure to both physical and transition risks associated with climate change. As the real estate industry contends with extreme weather events, sea level rise, and regulatory shifts, it becomes crucial to allocate financial resources to strategies that enhance resilience and promote sustainability. Indeed, the sector, is under increasing pressure to reduce its carbon footprint and adapt to a changing market environment that favors environmentally conscious investments and operations. To navigate these challenges effectively, the development of clear Key Performance Indicators (KPIs) is essential to measure the performance of real estate asset managers in achieving transition. KPIs are, however, ineffectual without engagement between banks and asset managers aimed at ensuring provision of critical reliable data that specifically address the verification of these KPIs. Other important aspect are the choice of climate scenario and the underlying benchmarks to assess performance that should be science-based. Having analyzed the macroeconomic and financial stability aspects and subsequently analyzed the climate risks, together with an overview of the drivers of change, allows for an in-depth understanding of the topic. However, to achieve decarbonization, prudential supervision tools such as prudential transition plans are not sufficient, but indicators capable of accelerating the transition and looking at both mitigation and adaptation aspects are also needed. Many KPIs focus on "photographing" the situation without taking medium and long-term aspects into account. Additionally, KPIs provide transparency and accountability, aiding stakeholders in measuring and tracking the performance of investments against specific environmental outcomes. They also support informed decision-making and policy development, enabling the assessment of which projects or initiatives should be prioritized based on their potential climate impact.

Furthermore, the creation of standardized metrics and methodologies entices more investments in creating a framework to evaluate risks and returns. This goes a long way in mobilizing funds from both the public and private sectors. In general, mainstreaming climate finance in the real estate sector will help not just in easing risks, but also in grasping the opportunities that come with the transition to sustainability, thus keeping the real estate investments resilient and valuable in a climate-conscious market.

Before analyzing Green Financing and KPIs, chapter 7 delves into the current landscape of real estate finance, particularly focusing on traditional financing tools to evaluate their efficacy. By examining a wide range of sources, including empirical studies and theoretical frameworks, this chapter aims to identify the strengths and weaknesses of conventional real estate financing methods. The analysis is structured to highlight how traditional tools have been used historically and their current relevance in the context of evolving financial markets. There is an evaluation in terms of accessibility, risk management, cost effectiveness, and adaptability to the changing environmental regulations. This broad review serves a dual purpose: providing grounding for understanding the existing financial mechanisms for sustainability in real estate and setting a path for the further review of innovative, sustainable financial instruments.

Chapter 8 focus on introduction of climate finance and on an insightful overview of sustainable financial instruments available in the market. The literature review utilized for this chapter includes, among the others, the OECD report "Green Finance" (2022), which offers a quantitative assessment of market trends and highlights the growth and impact of green financial instruments. Additionally, standards set by the International Capital Market Association (ICMA), the Climate Bonds Initiative, and the Loan Market Association (LMA) are examined to provide a comprehensive understanding of the frameworks governing green bonds and green loans. The review also references empirical studies and reports by BNP Paribas and TheCityUK, detailing the significant expansion of the global green finance market. The rationale given in chapter 8 further fuels the need for the inquiry regarding KPI assessment that will have to accompany any accelerated transition in the forthcoming chapter 9. Chapter 8 allows for the understanding of the current sustainable financial instruments in place and the outcomes, thereby setting a basis of how the effectiveness of these instruments can be better put to use and measured through KPIs. This transition is much necessary, as KPIs aid the stakeholders looking into the progress and the effectiveness of the green finance initiatives for investment compliance with the climate objective and, therefore, in general, towards a transition to a sustainable economy. Furthermore, the dissertation culminates with the recognition of KPIs and methodologies

to accelerate transition finance in the sector leveraging the use of sustainable financial instruments. The chapter further delves into an analysis of the features of selected KPIs that could be applied to measure the credibility of transition plans of corporates in Real Estate in an EU policy context. The analysis is innovative as no credibility assessment criteria have been identified for EU corporates in Real Estate that need to satisfy European industrial transition objectives under the European Green Deal. In addition, current literature has failed to translate sectoral credibility attributes into KPIs that stakeholders, and in particular lenders and investors, can use to monitor the credibility of transition plans from an EU policy perspective.

Lacking an EU-wide transition plan credibility criteria on the Real Estate Sector, the chapter reviews transition plan credibility attributes set out by the UK Transition Plan Taskforce and, in particular, by the ACT Initiative and assesses whether and how these attributes could be transformed in KPIs that could ultimately be adopted in sustainability-linked real estate loans. As the narrative unfolds, the thesis concludes with a synthesis of findings, leveraging the analysis of KPIs and elucidation of models to chart a course guiding the real estate sector towards a sustainable and resilient future. The overarching aim of this dissertation is to provide a comprehensive framework that not only addresses the sector's climate mitigation challenges but also harnesses its latent opportunities in navigating the era of climate change. Starting from macroeconomic considerations and moving through the analysis of vulnerabilities and systemic risks, it becomes evident that decarbonization is a multifaceted strategy that improves risk indicators. For the real estate sector, the adoption of transition-specific KPIs for transition plans of real estate asset managers is a critical step in this journey that would benefit ultimate investors and credit providers, especially banks creating a “common language” capable of linking prudential plans of credit institutions with banking products and with CapEx investment plans of asset managers that are Net Zero-aligned. These indicators not only facilitate the measurement and management of climate-related risks but also enhance the sector's resilience, contributing to broader economic and financial stability. Thus, the thesis underscores the imperative of integrating these metrics into the strategic framework of the real estate asset managers to navigate the complexities of climate change effectively.

2. Background:

To lay a solid foundation for the thesis, this chapter aims to contextualize the sector within the broader financial system, emphasizing its crucial role for the well-being of the community. Understanding the close interconnection between the real estate and financial systems enables a more effective analysis of climate-related financial risks, providing insight into the significant potential impacts. The relationship between the real estate market and the broader financial system is both profound and complex. These sectors are fundamental pillars of the global economy, each exerting significant influence on the other, thereby shaping the economic well-being of societies worldwide. This section of the thesis explores the intricate dynamics between the real estate and financial sectors, highlighting how economic fluctuations in one sector can profoundly influence the other. In particular, Real Estate properties, encompassing residential and commercial spaces, represent a substantial portion of the wealth held by families and businesses across the globe. For instance, in Italy, the total value of the housing stock owned by both natural and legal persons was estimated at approximately €5,847.1 billion in 2020, demonstrating the sector's critical role in national wealth accumulation.[1] The profound impact of real estate on the financial system is exemplified by its ability to support economic activities and facilitate urban and infrastructural development. At the same time, financial institutions such as banks, insurance companies, and investment firms are pivotal in channeling the necessary capital for these activities. In particular these institutions play a central role in facilitating the flow of capital between savers, investors, and end users. For instance, mortgage financing provided by banks is essential for enabling access to homeownership, which in turn influences the financial health of these institutions by affecting the intrinsic value of their loan portfolios (*Cerutti, Dagher, & Dell'Ariccia, 2017*)[2]. The fluctuations in real estate prices not only affect individual investment decisions but also have broader implications for the performance of the stock market. This interconnectedness underscores the sector's centrality to the financial system and illustrates the potential cascading effects that can arise from significant shifts in property values.

According to Mian and Sufi (2018)[3], changes in housing prices can significantly affect household consumption and investment behaviors, thereby impacting overall economic activity.

To further understand these interactions, it is essential to consider the theoretical underpinnings that explain the mutual influence between the real estate and financial sectors. This background sets the stage for the next paragraph which deep dive on the interconnection of these two sectors.

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[1] Italy. Ministry of Economy and Finance. (n.d.). *Immobili 2023*. Retrieved from https://www1.finanze.gov.it/finanze/immobili/public/contenuti/immobili_2023.pdf

[2] Cerutti, E., Dagher, J., & Dell'Ariccia, G. (2017). Housing finance and real-estate booms: A cross-country perspective. *Journal of Housing Economics*, 38, 1-13.

[3] Mian, A., & Sufi, A. (2018). Finance and Business Cycles: The Credit-Driven Household Demand Channel. *Journal of Economic Perspectives*, 32(3), 31-58.

2.1. Interconnection of Real Estate and Financial Sectors

To fully understand the complex relationship between the real estate and financial sectors, an analysis of the dynamics that outline their interaction is essential. This section aims to provide an overview of how these two sectors interconnect and profoundly influence each other. The intricate interplay between the real estate and financial sectors is primarily evident through capital flows and investment patterns. At the heart of this relationship there is a crucial exchange: financial institutions function as engines of capital, while real estate provides fertile ground for its deployment.

Financial institutions, including banks, investment funds and private equity firms, are essential for capital in real estate. Banks, in particular, act as intermediaries between savers and borrowers, facilitating mortgage loans that allow individuals and businesses to acquire real estate. Mortgages, among other loans, stimulate economic activity, allowing home buyers to access needed capital and profit from it. Mortgage lending constitutes a significant portion of consumer credit in the Eurozone, amounting to almost 7.6 trillion euros in 2021, according to a report from the European Mortgage Federation[4].

In addition, investment funds, such as Real Estate Investment Trusts (REITs) and private equity firms, raise capital from a broad investor base and channel it into diverse real estate projects spanning the residential, commercial and infrastructure sectors. Diversification of real estate investments through these funds helps mitigate risks and provides stability to financial markets. According to an analysis of data from the FTSE EPRA Narie Developed Europe Index, European REITs delivered an average annual return of 7.2% in the 12 months following recessionary periods from 2000 to 2022, demonstrating their economic resilience and their role in the resilience of the real estate market[5]. To understand in detail the dynamics between finance and Real Estate it is also necessary to understand how fluctuations in real estate values have profound effects on the financial system. In particular, real estate values, which often serve as collateral for loans and mortgages, are critical to the asset side of bank balance sheets. Indeed, when property values rise, banks' collateral becomes stronger, allowing them to lend with greater security and increase overall liquidity in the financial system. Additionally, fluctuations in real estate prices can also pose significant risks. When property values decline, the collateral that supports the loans depreciates, putting the financial stability of banks at risk. This scenario can actually lead to a credit crunch, in which banks become more reluctant to lend, thus

[4] European Mortgage Federation (EMF). (2021). *Hypostat 2021: A review of Europe's mortgage and housing markets*
[5] FTSE EPRA Nareit. (2022). *FTSE EPRA Nareit Developed Europe Index*.

reducing the liquidity available in the financial system and potentially triggering an economic recession. From this dynamic, is it clear that fluctuations in real estate prices can have a profound effect on the financial system.

Looking at the real estate and financial markets of the United States, although the focus of the thesis is purely on the European one, offers a paradigmatic example of how these fluctuations can cause systematic risk. In the American experience, in fact, such fluctuations have been particularly evident, especially during the 2008 financial crisis. This historic event has shown how a significant drop in real estate values can have devastating repercussions not only at a local but also at global level. During the crisis, the depreciation of the real estate market led to huge losses in Mortgage-Backed Securities (MBS), negatively affecting the liquidity and overall stability of financial markets. The epicenter of the crisis was in the United States, but the ripple effects crossed the Atlantic, also profoundly impacting the European market. European financial institutions, many of which had invested heavily in American mortgage-backed securities, suffered huge losses, testing the continent's financial stability. The collapse of the US real estate market triggered a crisis of confidence that eroded the capital of European banks, forcing many governments to intervene with financial rescue plans.

The basic underlying dynamic is that during times of housing market booms, financial institutions often experience an increase in lending activity, supported by positive market sentiments and rising collateral values. Conversely, real estate market declines can trigger negative effects such as loan defaults and asset devaluations. These events can erode financial institutions' capital buffers and decrease their resilience to economic shocks. An interesting study by Brunnermeier, M., Rother, S., & Schnabel, I. (2020) demonstrates that real estate booms can increase systemic risk through credit expansion and rising asset values[6]. Furthermore, the study highlights how real estate cycles are closely linked to the liquidity dynamics of the financial system. During periods of expansion, excess liquidity can amplify the boom, while during periods of contraction, shortages of liquidity can aggravate the collapse, creating a negative spiral that can lead to a systemic financial crisis.

In addition, these fluctuations are often also intensified by the collateral role that real estate plays in loans. In fact, when real estate is used extensively as collateral for loans, the market value of this collateral typically increases with property values. This correlation encourages lenders to increase real estate financing, perceived as lower risk during market upswings. As a result, demand and prices for real estate increase as financial resources become more readily available. However, if property

[6] Brunnermeier, M., Rother, S., & Schnabel, I. (2020). Asset Price Bubbles and Systemic Risk. *The Review of Financial Studies*, *33*(9), 4272–4317. https://www.jstor.org/stable/48587212

prices start to fall, the value of the collateral declines, increasing risk for banks and complicating the financing process for real estate acquisitions. This scenario leads to a subsequent decline in both demand and property prices, illustrating how real estate cycles are often intensified by their collateral role. A study by the International Monetary Fund IMF (2018) highlights how changes in the values of real estate collateral have a direct impact on the stability of the financial system, contributing to financial crises through the "financial accelerator" mechanism (IMF, 2018)[7]. In other words, it highlights how relatively small changes in economic shocks can be amplified through financial markets, leading to larger changes in real economic activity.

Another crucial aspect to consider illustrating the connection between the two sectors concerns the financial instruments linked to the real estate sector and their role in risk management. In detail, fluctuations in real estate values significantly influence the prices and risk profiles of these financial products, influencing investor sentiment and shaping asset allocation strategies. For example, the 2021 annual report from the European Systemic Risk Board (ESRB) highlights how changes in property prices can have a significant impact on bank balance sheets and credit quality, contributing to potential financial instabilities[8]. Specifically, the report highlights how changes in property values can affect the solvency of financial institutions, as a decline in house prices can lead to an increase in mortgage defaults, deteriorating the credit quality in bank portfolios. This dynamic can trigger a ripple effect that puts pressure on banks' capital buffers and potentially threatens overall financial stability. The interrelationship between asset valuation and financial instruments within these sectors highlights the critical need for robust risk management practices and regulatory oversight. Indeed, the European Central Bank (ECB) has highlighted the importance of macroprudential tools to mitigate the risks associated with the volatility of real estate markets. The ECB uses various macroprudential supervisory tools, such as limits on loan-to-value (LTV) and debt service-to-income (DSTI) ratios, and capital-based measures to monitor and manage systemic risks arising from the real estate sector (ESRB Europe).

In addition, it is important to analyze that the interconnection between the real estate and financial sectors is also deeply influenced by monetary and financial policies. Central banks, in fact, play a fundamental role in this dynamic through the manipulation of interest rates, which are a fundamental lever for regulating economic activity and influencing borrowing costs, investment decisions and

[7] International Monetary Fund. (2018). *House Price Synchronicity, Banking Integration, and Global Financial Stability*. IMF Working Paper 18/115.
[8] European Systemic Risk Board. (2021). *Annual Report 2021*. ESRB. Retrieved from https://www.esrb.europa.eu/pub/pdf/ar/2021/esrb.ar2021~fdf3b4ba77.en.pdf

consumer spending patterns. Changes in interest rates, such as the European Central Bank's (ECB) adjustments to meet its mandate to maintain price stability and support economic growth, also have crucial effects on the real estate sector. In this regard, the study "The Interest Rate Exposure of Euro Area Households" published in the Journal of the European Economic Association, illustrates that changes in interest rates directly influence real estate financing costs, impacting mortgages, commercial loans and business financing construction, which in turn influence market liquidity and stability. Lower interest rates typically stimulate housing activity by reducing financing costs, thereby encouraging home purchasing and refinancing activity (Casiraghi et al., 2018)[9]. Conversely, higher interest rates tend to dampen housing demand and slow price appreciation, leading to a deceleration of the housing market. Interest rates not only affect borrowing costs but also play a crucial role in shaping investor sentiment and market expectations. Future movements in interest rates can influence yield curves, bond prices and stock valuations, thereby influencing investment strategies across different asset classes, including real estate. During periods of economic expansion, central banks may raise interest rates to prevent overheating and control inflationary pressures, which can moderate housing market activity.

In summary, the complex relationship between the real estate and financial sectors is deeply intertwined, characterized by mutual dependencies that significantly influence economic stability and growth. Through the mechanisms of capital flows, investment models and central banks' strategic use of monetary policies, these sectors collectively navigate a landscape rich in opportunities and vulnerabilities. The profound impact of interest rate adjustments on financing costs, coupled with the cyclical nature of property values influencing financial stability, demonstrates the complex dynamics at play.

The next section of the dissertation delves deeper into the specific effects that Real Estate dynamics have on financial institutions. In particular, building on the discussion in this paragraph, it focuses on the European context. The aim is to deep dive the discussion and illustrate how in Europe these fluctuations can influence the real economy.

2.2 Focus on the Cyclical Impact of Real Estate on Financial Stability: European Perspective.

What was analyzed in the previous paragraph clearly highlights how a fluctuation in the financial sector impacts the real estate sector and vice versa. In fact, past crises demonstrate how real estate markets are fundamental from a macroeconomic and financial stability point of view. Historically,

[9] Casiraghi, M., Gaiotti, E., Rodano, L., & Secchi, A. (2018). The Interest Rate Exposure of Euro Area Households. Journal of the European Economic Association, 11, 101-122.

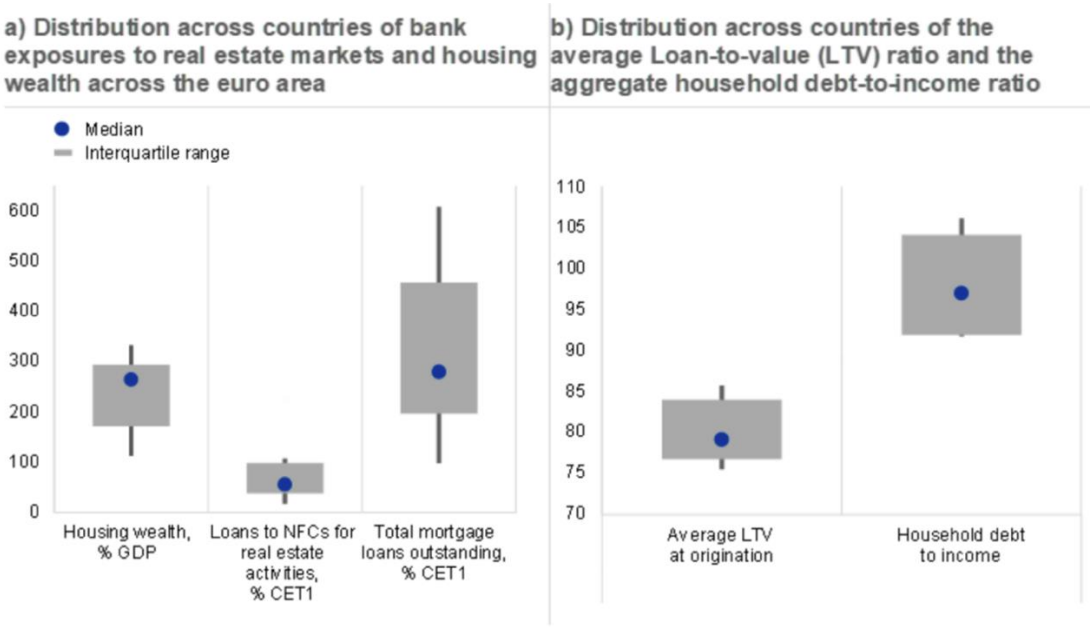
real estate markets have played a fundamental role in economic stability, with the Great Global Financial Crisis of 2008 an obvious example of the potentially devastating effects of unchecked real estate boom and bust cycles. This sub-section tries to go deeper into the debate and focuses on the European Perspective. Property prices were booming in the run-up to the crisis, stimulated by unprecedented increases in credit extension, and then collapsed immediately credit markets went into full-blown financial turmoil, an example of the typical boom and bust pattern preceding financial crises.

Indeed, recent research has shown that credit-fueled housing bubbles significantly increase the risk of a financial crisis and that, when such bubbles collapse, they are associated with deeper and more prolonged recessions. The fact that past financial crises in European countries have led to average production losses equal to 8% of GDP shows that credit-fueled real estate bubbles can actually be very costly to society[10] . It is important to note that the systemic importance of real estate markets is to be found in the strong link between them and important sectors of the economy. Firstly, the investments related to real estate (construction), consumption and services constitute a significant share of the economy. The total volume of commercial real estate investments (retail, office and industrial) in Europe reached €283 billion at the end of September 2022. The retail sector recorded the highest growth (+23%), followed by logistics (+12%) and offices (+10%)[11]. Secondly, the financial sector, and in particular banks, have a primary role in financing real estate investments. In most euro area countries, bank mortgage loan portfolios exceed 200% of the banks' Common Equity Tier 1 (CET1) capital ratio, and in many of them loans to companies engaged in real estate activities are also significant. Finally, the real estate sector represents a very important form of wealth storage for households, accounting for over 200% of the DGP in most euro area countries. Ultimately, high indebtedness and strong links with the economy determine the transmission of the cycles of expansion and contraction of the real estate sector to the financial system. Indeed, real estate purchases are often financed with a high share of debt (Chart 2, panel b), and high leverage in turn means high spending sensitivity and potential defaults to corrections in real estate markets. The graph 1 below summarizes the key concepts.

[10] Lo Duca, Marco and Koban, Anne and Basten, Marisa and Bengtsson, Elias and Klaus, Benjamin and Kusmierczyk, Piotr and Lang, Jan Hannes and Detken, Carsten, and Peltonen, Tuomas, A New Database for Financial Crises in European Countries (July 1, 2017). ESRB: Occasional Paper Series 2017/13, Available at SSRN: https://ssrn.com/abstract=4033025 or http://dx.doi.org/10.2139/ssrn.4033025

[11] Ceramica Info. (2022). Commercial real estate resumes growth in Europe. Retrieved 03/2024.

Graph 1: The graph shows the strong links between real estate markets, the economy, and the financial system, including bank exposures to real estate and household property ownership



Sources: Panel a: ECB; panel b: ECB and European Datawarehouse (EDW).

Over-indebtedness and high leverage have multiple implications; for example, small declines in property prices can lead to significant reductions in household wealth and the net worth of firms owning property, reducing their ability to borrow, consume, and invest. Consequently, reduced spending and investment might lead to economic contraction and potentially a recession. Moreover, high household and corporate indebtedness reduces financial reserves and resilience against income or property price drops, increasing the likelihood of widespread loan defaults. This susceptibility can lead to difficulties for banks and the financial system in general, demonstrating the critical interplay between real estate cycles and financial stability (ECB, 2022). Given these dynamics, it is evident that the cyclical impact of real estate on financial stability is profound, necessitating continuous monitoring and robust regulatory frameworks to mitigate adverse effects and enhance economic resilience. After having outlined the dynamic interplay between financial and real estate sectors, with a particular emphasis on financial stability in Europe, this dissertation now turns to the current factors that makes the real estate environment exceptionally demanding. The next paragraph explores the challenges posed by climate concerns and sustainability issues, contextualizing the discourse within the present financial landscape. Specifically, it outlines how financial stability can be further influenced by real estate when considering sustainability and environmental concerns, preparing the ground for the continuation of the dissertation. By examining these contemporary pressures, such has Cyclical and Structural challenges, the analysis aims to provide a comprehensive understanding of the complexities and urgencies facing the European real estate market today. The intent is to

contextualize the discourse within the present time, emphasizing the extremely demanding financial environment.

2.3. Evolving Dynamics in the Euro Area Real Estate Sector: Cyclical and Structural Challenges Amidst Rising Climate Concerns

In recent years, real estate markets have received increasing attention due to their significant fluctuations and dynamism fueled by both cyclical forces and structural changes. These changes, such as the shift to e-commerce and hybrid working models, have led to the accumulation of significant vulnerabilities in euro area real estate markets[12]. Residential real estate (RRE) and commercial real estate (CRE) each entered a period of recession by mid-2022. CRE saw a brief post-pandemic recovery, whereas RRE succumbed after a decade-long boom, a trend substantiated by supervisory data from the European Central Bank (ECB, 2023)[13]. These shifts necessitate a careful evaluation of the conditions and channels that could precipitate widespread financial instability, especially in a context of rising interest rates. An increase in interest rates has resulted in a reduced debt servicing capacity among borrowers, potentially leading to heightened losses for banks and, consequently, the financial sector at large. Specifically, the current high interest rate environment diminishes the accessibility and demand for real estate, thereby exerting downward pressure on prices and exposing banks to losses where real estate assets serve as collateral, thus increasing the loss given default (LGD) of banks[14]. Simultaneously, rising interest rates elevate financing costs and increase the probability of default (PD), particularly for borrowers facing income volatility. When considering RRE, the implications of higher financing costs after a prolonged period of growth are reflected in overvalued home prices. According to a standard asset pricing model, the relationship between real estate prices and interest rates is inversely correlated[15]. While factors such as accommodative monetary policies and easing mortgage conditions supported robust increases in house prices through 2022, tighter financing conditions have now triggered a downward pressure on these prices[16]. Nevertheless, structural and supply factors continue to bolster prices in the real estate market. The ongoing lack of completion of residential buildings in the euro area points to a structural gap between

[12] European Central Bank (ECB). (2023). Financial Stability Review, May 2023. "Vulnerable real estate markets are turning."
[13] European Central Bank. (n.d.). Banking Lending Survey (BLS). European Commission. (n.d.). Royal Institute of Chartered Surveyors. (n.d.). European Central Bank. (2023). Supervisory data.
[14] European Central Bank. (2023). Horan, A., Jarmulska, B., & Ryan, E. Asset prices, collateral and bank lending: the case of Covid-19 and real estate (Working Paper Series No. 2823). This Working Paper also outlines how, indirectly, a fall in house prices can an also have negative implications for household consumption via wealth effects or confidence and can reduce access to credit for firms that use real estate as collateral.
[15] European Central Bank. (2023). Dieckelmann, D., Hempell, H.S., Jarmulska, B., Lang, J.H., & Rusnák, M. House prices and ultra-low interest rates: exploring the non-linear nexus (Working Paper Series No. 2789).
[16] European Central Bank. (2023). *Euro area bank lending survey Q3 2023.*

supply and demand for homes[17]. However, rising construction costs, driven by supply shortages and high material costs, are exerting upward pressure on prices. The "Cost-of-Construction Index" (CCI) for the euro area increased by 6.62% year-over-year in the first quarter of 2023[18]. Furthermore, in the medium term, exposure to climate risk could influence property valuations, particularly for those locations and housing units with low energy efficiency[19]. Thus, while cyclical factors exert downward pressure on house prices, structural and supply-side factors persist in supporting these prices, with climate risk likely to have a significant impact moving forward. Considering CRE, the increase in interest rates, combined with general uncertainty and the inherently low liquidity of commercial real estate markets, precipitated a sharp decrease of 47% in the number of transactions conducted in the euro area during the first half of 2023 compared to the first half of 2022, as reported by the ECB[20]. This decline has obstructed price discovery, making it challenging to assess actual market dynamics. Furthermore, the euro area's largest listed real estate owners are trading at a discount of more than 30% to net asset value (NAV), their highest discount since 2008, reflecting the performance of real estate companies in more liquid stock markets. Additionally, like residential real estate, structural challenges and concerns over climate change are exacerbating downside risks in certain segments of the commercial real estate market. For the office segment, this partly reflects the demand for higher quality space, while concerns over climate change have been another significant driver of change. Market participants indicate that demand is increasingly concentrated in the market for high-quality buildings with good energy ratings, and low-quality buildings face rising retrofitting costs, make worse downward pressure on prices. Therefore, while the price outlook for the entire market is negative, the outcomes could be particularly dire in non-prime markets.

In conclusion, the Euro Area Real Estate sector is currently in a state of instability due to a multitude of factors, including increased financing costs, reduced accessibility and demand for real estate, and major challenges encountered by commercial real estate companies. Indeed, tighter financing conditions have reduced the affordability and demand for real estate assets, putting downward pressure on prices and increasing debt servicing costs for existing borrowers. Additionally, commercial real estate businesses are facing more severe challenges due to rising financing costs and decreasing profitability. The current framework of instability is further exacerbated by sharply increasing climate and transition risks. Growing concern about the impacts of climate change is

[17] Eurostat. Household composition statistics. Eurostat Statistics Explained. May 2024.
[18] INSEE. (2023). Construction cost index - first quarter 2023.
[19] Bank of Italy Occasional Papers, (735). Benetton, M., Emiliozzi, S., Guglielminetti, E., Loberto, M., & Mistretta, A. (2022). *Do house prices reflect climate change adaptation? Evidence from the city on the water.*
[20] Ryan, E., Jarmulska, B., De Nora, G., Fontana, A., Horan, A., Lang, J. H., Lo Duca, M., Moldovan, C., & Rusnák, M. (2023). Real estate markets in an environment of high financing costs. *European Central Bank Financial Stability Review.*

influencing how investors, financial institutions, and regulators view real estate, both residential and commercial. Fluctuations in house prices and construction costs, and the value of real estate is now determined not only by supply and demand mechanisms and classic economic cycles but also by the enormous pressure that the sector is experiencing due to extreme climatic events and the costs of transitioning to a lower carbon economy. It therefore becomes essential that preventive and adaptive measures are adopted to address these emerging risks, in order to ensure the long-term stability of real estate markets and the financial system as a whole. In this context, the analysis and management of climate and transition risks become essential for real estate sector players and financial institutions to protect their investments and preserve the value of assets over time. From the above analysis, it clearly emerges that the real estate sector is faced with significant challenges deriving both from market dynamics and particular financial situations and from the growing impacts of climate change.

2.4. Conclusion:

The intricate relationship between the real estate and financial sectors underscores the central role that real estate plays in the broader landscape of finance. As demonstrated throughout this chapter, the symbiotic nature of these sectors influences economic stability, market liquidity, and financial innovation. Real estate assets serve as both foundational elements and catalysts for financial activities, shaping investment strategies and asset valuations. This chapter gave a solid foundation of the dynamic that occur between the economy and the real estate and prepared the ground for the analysis of the drivers of changes and the following examinations of the climate-related risks. Without recognizing the sector's vital importance to the economy and society, it is impossible to comprehend the significant economic and regulatory changes that are greatly impacting it. As outlined at the very beginning, this thesis aims to analyze the impact of climate-related risks on asset valuations and financial stability within the real estate sector, with the ultimate objective to analyze the current state of sustainable finance instruments and KPIs to accelerate the transition.

However, before delving into the specific climate risks affecting the sector, it is crucial to provide a comprehensive overview of the primary drivers of change. Indeed, the evolving regulatory environment, technological advancements, and shifting business dynamics are critical areas that must be addressed to fully understand the future trajectory of the sector, and consequently address the transition in the sector. The next chapter explore these drivers of change in detail, examining how the business environment, demographic shifts, digitalization, and sustainability concerns are reshaping the real estate landscape. Technologies such as artificial intelligence, big data analytics, and blockchain are revolutionizing how properties are managed and transacted. A study by Kok and Kahn

(2012) demonstrates that energy-efficient buildings, supported by technological innovations, have higher occupancy rates and command premium rents, indicating the financial benefits of adopting such technologies[21]. Specifically, Kok and Kahn's research shows that green building certifications like LEED and Energy Star not only contribute to environmental sustainability but also enhance property values and energy performance. It also demonstrates how the integration of advanced technologies in property management and transactions further enhances operational efficiency and transparency, making real estate investments more attractive and financially viable.

Additionally, the Shift of business dynamics due to demographic changes and evolving consumer preferences also necessitate a reevaluation of strategies in the real estate sector. Furthermore, the increasing importance of Environmental, Social, and Governance (ESG) factors, driven by consumer and investor demand, is reshaping investment priorities by insurance companies and pension funds' deployment of capital in real estate asset funds in the EU, and to some an extent, also in the US.

Chapter 3 is dedicated to the analyzes of these drivers of changes while Chapter 4 will put an important emphasis on EU regulations. Specifically, the necessity to focus on EU regulation arises from the growing emphasis on environmental sustainability and the need to align with global climate goals. Studies have shown that regulatory frameworks, such as the EU Taxonomy for sustainable activities, are pivotal in guiding investments towards greener projects and ensuring compliance with environmental standards. The paper by Flammer (2021) highlights how regulatory pressures can drive corporate sustainability efforts and investment decisions in real estate[22]. In this regards, Flammer's research shows that green bonds, which are issued to finance environmentally beneficial projects, can significantly influence corporate sustainability practices. It also analyzes that regulatory pressures push companies to adopt greener practices, improve transparency, and attract socially responsible investors, ultimately reducing the cost of capital and enhancing long-term financial performance.

In detail, the ultimate objective of the dissertation is to start from these regulatory aspects to understand which KPIs can guide the transition of the sector based on the objectives established at community level. Therefore, the thesis seeks to analyze the main crucial policy factors in the sector such as the Energy Performance of Buildings Directive (EPBD), which forms a cornerstone of the European Union's legislative efforts to improve energy efficiency within its member states, and the Net Zero Industry Act, in particular focusing on heat pumps. In addition, important attention is also

[21] Kok, N., & Kahn, M. E. (2012). The impact of green building certification on property values and energy performance. *Energy Policy*, 46, 803-813.
[22] Flammer, C. (2019). Sustainable finance: The case of green bonds. *Academy of Management Journal*, 62(6), 1968-1980.

placed on parameters for embodied carbon, examining them as a key factor in the regulatory landscape, even though the EU has not yet introduced regulation on embodied carbon. However, it is important to note that five countries, notably France, have already established specific parameters.

Ultimately, by analyzing these drivers of change, including the EU Regulatory landscape, technological advancements, and evolving business environment, the dissertation tries to lay a comprehensive overview of challenges, opportunities and financial impacts on the sector. The aim is to provide a comprehension of the forward-looking regulatory framework that can help, eventually, evaluate the impact of policy-driven transition risks that need to be addressed in sustainable financial instruments and the appropriateness of KPIs capable of measuring the acceleration of the transition towards a more resilient and sustainable real estate market.

3. Drivers of Changes:

The real estate sector is significantly influenced by the evolving business environment, which is driven by globalization and technological advancements. These changes affect market stability, investment opportunities, and industry growth. Key factors shaping the real estate landscape include emerging technologies, demographic shifts, and the growing demand for sustainability. The global market faces volatility and economic uncertainties, with inflation being a major concern worldwide. European countries are dealing with rising interest rates as a response to exceeding inflation targets, and the industry continues to adjust after the global financial crisis and the COVID-19 pandemic, which altered monetary policies and increased interest rates. Geopolitical tensions, such as the conflicts in Ukraine and the Middle East, further impact economic stability and investor confidence, causing disruptions in energy supplies and affecting real estate markets. Investor sentiment remains cautious, with many adopting a wait-and-see approach due to potential recessions and moderate economic growth forecasts. Environmental, Social, and Governance (ESG) issues are becoming central to real estate investment, driving the sector towards sustainable practices for value creation and risk management. Understanding the business environment is crucial for stakeholders to manage risks and seize opportunities effectively. The real estate sector is shaped by the interplay of technological, demographic, and sustainability-driven changes, influenced by economic and geopolitical shifts. A comprehensive view of these dynamics helps predict trends, prepare for challenges, and identify opportunities, making the exploration of the business environment a practical approach to forecasting the sector's evolution. However**,** In the face of a complex and dynamic global environment, it remains essential to identify the pivotal elements that will significantly reshape the real estate sector in the years ahead. These drivers of change extend beyond regional boundaries, impacting markets worldwide and influencing both the European landscape and global real estate dynamics. A comprehensive analysis of the sector's global outlook is crucial to pinpointing the key forces poised to propel its evolution. These forces not only influence the immediate strategies but also dictate the long-term trajectory of the industry. Technological advancements are at the forefront, with innovations like artificial intelligence, big data analytics, and blockchain revolutionizing how properties are bought, sold, and managed. The adoption of smart building technologies and the Internet of Things (IoT) is enhancing operational efficiency and creating more sustainable living spaces. For instance, the integration of smart sensors can reduce energy consumption by up to 30%, according to a report by the International Energy Agency[23]. Demographic shifts and urbanization trends are also critical, as the world's urban population is expected to increase by approximately 2.5

[23] IEA (2017), Digitalisation and Energy, IEA, Paris, Licence: CC BY 4.0

billion people by 2050, as per United Nations projections[24]. This urban influx is not uniformly distributed, with cities in Asia and Africa experiencing the fastest growth, necessitating novel real estate solutions that address the heightened demand for housing and infrastructure. Furthermore, regulatory changes continue to evolve, particularly in response to climate change and sustainability goals. The increasing stringency of building codes and the introduction of carbon pricing mechanisms are pushing the industry towards more energy-efficient and environmentally friendly practices. For instance, the European Union's taxonomy for sustainable activities aims to set a global standard for what qualifies as an environmentally sustainable economic activity, influencing real estate investments significantly. Moreover, evolving consumer preferences, especially among younger generations who prioritize flexibility and sustainability, are driving demand for co-living spaces and green-certified buildings. The growing importance of ESG considerations reflects a broader shift in investor and consumer values, emphasizing sustainable and socially responsible investing. Surveys from major consulting firms like McKinsey have highlighted that properties with green certifications can command premium prices and attract more tenants, underscoring the financial viability of sustainable real estate practices[25]. By analyzing these overarching trends and dynamics, it is possible to have essential insights into the factors that will redefine the real estate sector's trajectory.

3.1. Changing Consumer Demographics:

In November 2022, the world population reached eight billion. This milestone was described by United Nations Secretary-General António Guterres as *"an opportunity to celebrate diversity and progress while considering humanity's shared responsibility for the planet"*. This growth in demographic terms is extremely heterogeneous and polarized between developed and developing countries. For example, according to UN estimates, in 2021 India, with 1.4 billion inhabitants, surpassed China as the most populated country in the world. India's population trend over the next 10 years is set to record the fastest growth in the world, adding 100 million people. In contrast, the developed world is ageing, as are China and many countries in South America and the Middle East. In the old continent, demographic decline and the aging of the population are proceeding at a rapid pace. The European population has experienced sustained and constant growth for over 50 years, increasing from 354.4 million in 1960 to 446.8 million in 2022[26]. However, projections for the near

[24] United Nations, Department of Economic and Social Affairs, Population Division. (2019). *World Urbanization Prospects*.
[25] McKinsey & Company. (2020). *The next normal: The recovery will be digital*
[26] European Commission. The Impact of Demographic Change in a Changing Environment. European Commission. Published January 2023.

future are not encouraging, predicting a strong aging of the population and a slowdown of births. In particular, the EU population is expected to continue growing, but at a limited pace, until 2029, after which it will start to slowly decline[27]. In comparative terms, according to the latest United Nations World Population Prospects, the percentage of the world's population living in the 27 countries that now make up the EU has fallen from 12% in 1960 to 6% today and is expected to fall below 4% by 2070[28]. In contrast, as mentioned above, there has been a notable increase in Africa's share of the world population, which rose from 9% in 1960 to 17% today and will reach 38% by 2100. This means that the balance of population growth population is moving towards Asia and Africa. In addition to the demographic decline, the aging of the population also has extremely significant impacts on the real estate sector. As of 1 January 2021, people aged 65 and overrepresented 20.8% of the EU population. This represents an increase of 0.2 percentage points compared to 2020 (20.6%) and an increase of 0.6 percentage points compared to 2019 (20.2%). Considering the previous decade, the percentage of elderly people increased by 3 percentage points (compared to 17.8% in 2021)[29]. By 2050, around 30% of the European population will be over 65 and there are expected to be fewer than two adults of working age for every elderly person (the projected elderly dependency ratio will be 56.7%), confirming a growing trend of old age dependency in the future.

For the real estate sector, an older population also creates the potential for a change in the rate of residential demand. In particular, an increase in the need for retirement and care home space is inevitable, and the demand for specialist accommodation is equally likely to increase. Specialized accommodation will need to meet the needs of pensioners who are able and choose to continue living in their own home. At the same time, Generation Z, those born between 1997 and 2012, is coming of age and has become the largest generation on Earth. This has important implications for the sector and for cities themselves. The most requested hubs change, the mix of real estate uses evolves and becomes more fluid. In particular, Generation Z is often called "Generation Rent", that is more inclined to rent than to purchase a property. This creates an increase in demand for housing especially in popular urban areas. As a consequence, there is an exponential increase in cohabitation and demand for shared housing solutions, influencing the type of real estate development required. Ultimately, changes in demographic structure have significant and predictive effects on housing costs, and these effects vary across rents and house prices. In modern demographic regimes, such effects are probably even greater, due to higher survival rates. In particular, in countries with rapidly aging populations, investment demand for housing will likely lead to lower house price growth as baby boomers retire

[27] Eurostat. (2023). *Short-term update of the projected population (2023- 2032). (online data code: proj_stp22)*
[28] United Nations, Department of Economic and Social Affairs, Population Division. (2022). *World Population Prospects 2022*.
[29] Eurostat. (2021). *Population structure and ageing.* Statistics Explained

and phase out. It is important to take into consideration that the world's demographic changes go hand in hand with urbanization. Today, approximately 55% of the world's population lives in cities and towns, and urbanization is expected to reach 68% by 2050[30].

3.2. Digitalization and Development of science and Technology

Digitalization is a predominant force of change in Real Estate for several reasons. The global digital transformation market is estimated to grow to $1,548.9 billion by 2027, forcing all sectors to make a complete shift and move from traditional to digital working models [31]. The real estate industry is now in the lead and following suit in the replacement of its outdated legacy systems with new, cutting-edge technologies that introduce new process and people innovations and, in turn, spurs the revolution in Industry 4.0 of commercial real estate organizations and residential. Especially in the US, number of real estate investors, asset managers, developers, agents, and brokers, among others, have invested significantly a lot in technological and organizational transformation to harness their return on investment, operational efficiency, and meeting the needs and volatile demands of customers. There are different elements that characterized this transformation in the Real Estate industry. First and foremost, digital transformation simplifies the complex process of buying or renting a house by offering a better human experience. For examples, the most advanced real estate firms are investing in mobile app with 3D home virtual tour feature. This clearly has some effect on the cost supported by the real estate agents, since is possible to record a home tour once and send it to potential buyers through a link. Indeed, the future of real estate is all about creating a unique, personalized customer experience through digitization that fosters meaningful interactions, collaboration, and productivity. Additionally, digital transformation makes real estate ecosystem more efficient. Cloud-based property management software and online contract generators are excellent examples of how new technologies make life easier and more convenient. Technology allows an increase in the quality and in the timing of the investor decision. Data analytics for real estate enables investors to visualize data and make faster, better-informed investment decisions.

Another predominant driver of changes is the so called on-demand delivery. Since the Gen Z is growing, on-demand services like space-as-a-service and temporary solutions are becoming more popular. In a survey conducted by Deloitte has emerged that among 400 senior commercial real estate executives, 36% have invested in Cloud computing and storage, 29% in Blockchain technology, 26% in Robotic process automation, 23% in Artificial intelligent and 22% in data

[30] United Nations, Department of Economic and Social Affairs, Population Division. World Urbanization Prospects: The 2018 Revision. New York: United Nations; 2018.
[31] Markets and Markets; Digital Transformation Market Size, Trends & Growth Report – 2030, July 2023.

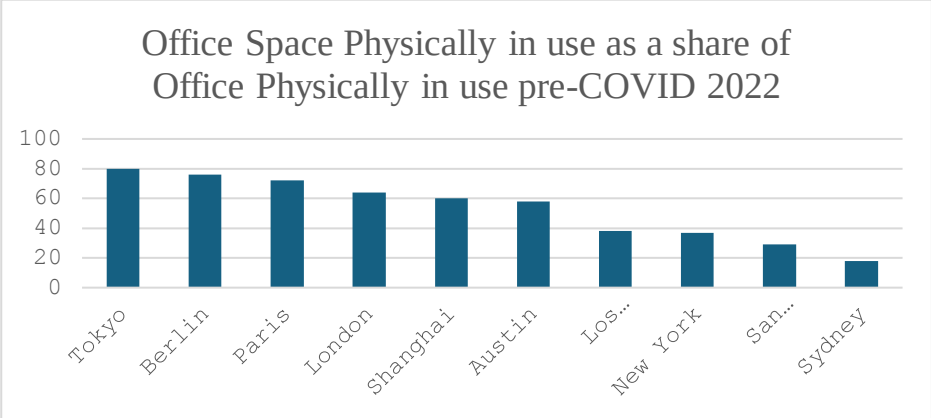
analytics [32]. The investment in these technologies is going to change completely the way how we conceive the sector. Starting from the Data analytics capabilities, it is evident that the possibilities to elaborate on a huge amount of accurate information real time, empowers Real estate firms, investors, and developers to make better decisions by giving them a clear picture of prime opportunities and accurate risk assessment. For instance, the use of Machine learning (ML) can predict exactly how properties will perform based on some key variables like traffic and demographic changes. The global big data analytics market is expected to grow by a compound annual growth rate of about 30% over the next decade, reaching $68 billion by 2025 [33]. Speaking about the Blockchain technology, instead, is probably the largest and more impactful thing that can happen to the real estate market. This is technology is bringing a lot of innovative ideas and benefits to the real estate sector, from improving safe transactions to automating property management. Blockchain technology, in fact, can introduce some cutting-edge technology like smart contract. With smart contracts in place, property transactions, that once involved countless documents, can now take place digitally between buyer and seller. Indeed, with smart contracts both parties' transactions become automated and hardly need any human interaction. Once set into action, everything built on the smart contract becomes self-executive. Furthermore, property management applications are becoming mainstream and Real estate companies are developing mobile apps that meet their clients' needs. The global property management software market size was valued at 3.04 billion USD in 2021 and was projected to register a 5.6 percent Compound Annual Growth rate (CAGR) from 2023 to 2023 [34]. To conclude this brief overview of the main technology drivers, is important also to mention the Building Management System (BMS). These software tools allow real estate firms to monitor and control the physical environment of a building. This includes property metrics like temperature, humidity, lighting levels, air conditioning, security systems, and more. This software is also used to automate certain property management tasks like scheduling maintenance work or controlling the flow of people into specific areas. BMS is mostly used to cut energy costs, and even governments see the benefit in saving up to 30% of energy. For example, in the European Union countries such systems will become recommended for buildings with an over 290 kW effective output [35].

[32] Deloitte Digital. (November 17, 2021). Share of commercial real estate executives planning a large investment in different technologies worldwide in 2022.
[33] Frost & Sullivan. (August 31, 2020). Big data analytics market revenue worldwide in 2019 and 2025 (in billion U.S dollars).
[34] Grand View Research (2022): Property Management Software Market Size Report, forecasts 2030.
[35] Ministry of Housing, Communities & Local Government: Building Standard, January 2021.

3.3. Hybrid Work

When the COVID-19 pandemic began, it dramatically changed the way people worked, lived, and shopped in cities around the world. After the pandemic, employees still spend far less time working at the office than they did before. According to a recent survey conducted by McKinsey, the office attendance has stabilized at 30 percent below pre pandemic norms[36]. The trend is here to stay for several reasons. Firstly, the rate of hybrid work has remained fairly stable since mid-2022. Second, three key numbers, the number of days per week that survey respondents go to the office (3.5), the number of days they expect to go to the office after the pandemic ends (3.7), and their preferred number (3.2), are not far apart. In addition, the survey shows that almost 10% of the people affirmed that they were both likely to quit their jobs if required to work at the office every day and willing to take a substantial pay cut if doing so let them work from home when they wanted. Furthermore, during the pandemic a wave of household left the urban cores of cities and fewer of them moved in. For example, New York City's urban core lost 5 percent of its population from mid-2020 to mid-2022, and San Francisco's lost 7 percent. The main reason was the out-migration. In contrast in the suburbs the population grew. This mean that the urbanization, especially in most of the European cities is linked with the suburbanization.[37] The Graph 2 illustrate clearly the effect of hybrid work between pre-covid and post covid and summarize the data provided above.

Graph 2: Office Space Physically in use as a share of Office Physically in use pre-COVID 2022, considering 10 cities.



Source: Personal processing on collected data on: Statista, Industries & Markets; Office Real Estate Trends, 2023.

[36] cKinsey Global Institute. Empty spaces and hybrid places: How hybrid work has changed society. McKinsey & Company. Published May 2023.
[37] McKinsey Global Institute. (2023, July 13). Empty spaces and hybrid places: The pandemic's lasting impact on real estate (Executive Summary). Authors: Jan Mischke, Ryan Luby, Brian Vickery, Lola Woetzel, Olivia White, Aditya Sanghvi, Jinnie Rhee, Anna Fu, Rob Palter, Andrè Dua, and Seven Smit.

The systematic changes like lower office attendance, accelerated out-migration from urban core of cities, caused by the pandemic, will push down demand for real estate in most of the cities. The analysis conducted by McKinsey reveals a pronounced downturn in the demand for office space, attributed to the pervasive influence of remote work practices and broader macroeconomic challenges. This trend is evident through escalating vacancy rates, diminished transaction activities, and declining sale prices and rents observed across various metropolitan areas Europe and America. As lessees opt for shorter lease terms amid uncertainties surrounding future office utilization, this shift could impede property owners' access to financing and exert downward pressure on property valuations. Furthermore, the study's projections indicate a protracted recovery trajectory for office space demand, with estimates suggesting a reduction ranging from 20% to 38% by 2030 across different scenarios and urban centers[38]. This recession is going to seriously impact office property pricing, and there is likely to be $800 billions of loss in real terms by 2030 across the nine cities being considered in this survey. At the same time, reduced demand is likely to result in an oversupply of office rental stock, especially in lower-graded and older office properties classified as Class B and Class C, as companies consolidate into better-quality settings that allow for physical experiences and a mix of working styles.

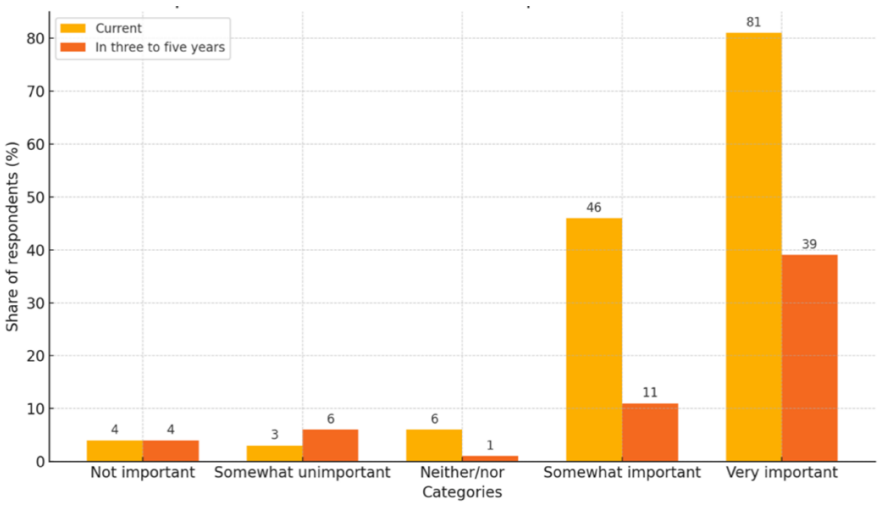
3.4. Environmental Sustainability

In recent years, the Real Estate sector is undergoing a profound transformation as sustainability grew in centrality. As discussed in the previous chapter, environmental risks are of paramount importance for the sectors since the financial stability of the whole industry is being challenged. Additionally, an increasing legislative pressure is affecting tremendously the asset manager and the whole real estate. For these reasons, there has been a paradigm shift towards incorporating environmentally friendly practices in real estate development and operations. For examples, green building certifications such as LEED and BREEAM (Building Research Establishment Environmental Assessment Method), have gained significant traction in the real estate sector. These certifications provide frameworks and metrics for assessing the environmental performance of the buildings. More importantly, investors are increasingly recognizing the value of these certifications in attracting tenants, enhancing asset value, and meeting regulatory requirements. Additionally, with the pressing need to comply with regulations and to combat climate change, developers are implementing energy-saving measures such as advanced insulation efficient HVAC systems, and smart technologies to optimize energy usage

[38] McKinsey Global Institute. (n.d.). *Empty spaces and hybrid places: The pandemic's lasting impact on real estate*. McKinsey & Company.

and reduce carbon emissions. Indeed, sustainable building materials and methods are becoming more popular in the business. Developers are giving priority to eco-friendly options, such as low-impact construction methods and recycled building materials. Reclaimed wood and recycled steel are examples of sustainable materials that not only lessen their negative effects on the environment but also improve the visual appeal of buildings. Furthermore, it's becoming standard practice to use construction methods that reduce waste production and encourage ethical sourcing. Important to say is that sustainability is becoming a more important consideration for investors when making decisions. Since sustainable real estate assets can produce high financial returns, environmental, social, and governance (ESG) considerations are increasingly being included into investment strategies[39]. The real estate industry is seeing a surge in impact investing, which seeks to produce both financial returns and favorable social and environmental effects. The trend toward responsible investing reflects people's increasing understanding of the benefits and long-term worth of sustainable real estate.

Graph 3: Real estate investors' opinion on the current and future importance of ESG criteria worldwide as of 2022



Sources: Personal processing of Data derived from AFIRA, CBRE Group, and Holland Partner Group, as compiled by Statista in 2024

The most direct consequence on the industry is a rise in demand for cases with higher energy efficiency. Homes with well-insulated windows, renewable energy sources like solar panels, and energy-efficient equipment are becoming more and more desirable to modern buyers. Furthermore, traditional building materials with a high environmental impact include steel and concrete. The

[39] Finance Research Letters (2022) Volume 50, Qin Zhang, Jin Boon Wong; ESG Reputational risks and board monitoring committees, ISSN 1544-6123.

industry is moving toward more environmentally friendly options including hempcrete, bamboo, and recycled plastics. These materials are not only more energy-efficient, but they also frequently offer better insulation. As a result, financial institutions are beginning to provide green financing choices in recognition of the significance of sustainability. These may include subsidies for homeowners wishing to make environmentally friendly improvements or reduced borrowing rates for properties with high energy efficiency ratings.

3.5. The Impact of drivers of changes on Real estate dynamics:

The paragraph below illustrates the main significant drivers on real estate that can guide the change in the sector. What it is crucial now is to try to understand deeper which are the potential impact of these drivers on the sector. This paragraph wants to illustrate the potential disruptions that these drivers can have on the sector. Specifically, the dynamics of the global real estate sector are being profoundly influenced by demographic changes, encompassing aging populations, generational preferences, and international migration patterns. According to the United Nations World Population Prospects, the global demographic landscape is polarized with burgeoning populations in countries like India and aging demographics in developed regions such as Europe, Japan, and parts of North America (United Nations, 2022) [40]. This global variation necessitates diverse real estate responses ranging from increased demand for retirement accommodations in aged societies to expanded urban residential developments catering to younger, growing populations. A study published in the *European Real Estate Society* by Essafi and Simon (2015) examines the impact of demographic changes on the French real estate market [41]. They found that real estate prices are significantly and positively affected by the total population number and total GDP, while negatively affected by the old age dependency ratio. This suggests that areas with a higher proportion of older individuals relative to the working population may experience decreased housing demand, potentially leading to lower real estate prices and less frequent transactions. The study provides an empirical analysis using data from 94 French departments from 2000 to 2013, underlining how demographic factors can significantly sway real estate markets in the context of an aging population. Furthermore, international migration has a significant impact on real estate markets. Migratory flows, driven by economic opportunities, conflicts, or environmental factors, alter the demographic compositions of urban areas, influencing real estate demand both temporarily and permanently. This is visible in cities that see fluctuating real estate prices and varied rental market dynamics based on immigrant

[40] United Nations. (2022). World Population Prospects 2022. Available at: https://population.un.org/wpp/
[41] ERES. (2017). Yasmine Essafi, Arnaud Simon; Housing Market and Demography, Evidence from a French Panel Data.

populations establishing new communities (World Bank, 2022)[42]. Economic disparities and their intersection with demographic trends also play a critical role. Thus, regions that attract young, economically active populations will experience rising real estate prices due to inflating demand. Areas that have diminishing or aging populations might face the opposite effect. These trends underline the need for real estate policy and development that is sensitive to local demographic and economic realities so that the sector may respond adequately to varied conditions of supply and demand across different regions [43]. Furthermore, in addition to the demographic's shifts, the digitalization is completely changing the markets and is driving a massive revolution. Indeed, digitalization is revolutionizing the real estate industry by driving significant changes in operational models and customer interactions. The global digital transformation market is projected to grow significantly, emphasizing the shift from traditional to digital paradigms across all sectors, including real estate. This transformation is characterized by the adoption of cutting-edge technologies that herald the onset of industry 4.0 within both commercial and residential real estate domains. One of the most transformative aspects of digitalization in real estate is the enhancement of the customer experience through technology. Advanced real estate firms are leveraging mobile applications equipped with 3D virtual tours, significantly reducing the logistical burdens traditionally associated with property viewings [44]. These digital tools not only streamline the process of buying and renting properties but also enable a personalized and efficient customer journey. Furthermore, the integration of cloud-based property management software and online contract generators is simplifying property management. These technologies improve the efficiency of transactions and management processes, making them more accessible and less time-consuming. For investors, the deployment of real estate analytics software and deal management platforms allows for the visualization of data, facilitating quicker and more informed decision-making processes. The adoption of on-demand and as-a-service models reflects the preferences of younger demographics, particularly Generation Z, who value flexibility and immediacy. These service models are transforming traditional real estate functions, making space more flexible and transaction processes more streamlined [45]. In addition to these changes, the application of blockchain technology in real estate transactions promises a revolutionary shift. Blockchain can enhance the security and efficiency of transactions through smart contracts, which automate and digitize the contracting process, minimizing the need for manual intervention and reducing the potential for errors and fraud.

[42] World Bank. (2022). Global Economic Prospects.
[43] ZHAW. (2020). Fundamental Drivers of Real Estate.
[44] Deloitte. (2021). Real Estate Industry Outlook.
[45] Statista. (2021). Investment in Technology by Commercial Real Estate Executives. Available at: Statista CRE Tech Investment

Additionally, the COVID-19 pandemic is a massive driver for hybrid work models that will have critical impacts on urban real estate markets around the world. According to a McKinsey survey, office attendance had dropped to 30% below pre-pandemic levels and is likely to stay this way. This reflects structural change in working practices and the use of real estate itself. Many have left the urban cores for suburban life, and the need for proximity to city-center office space is significantly reduced. In effect, this has decimated the populations of New York and San Francisco, but suburban residents have increased (McKinsey & Company, 2022). As analyzed before, this has resulted in a reduction in the demand for offices, high vacancy rates, weaker than expected transactions, and low prices and rents in major cities across Europe and America (Statista, 2022). Tenants now demand shorter leases, given uncertain futures on usage, and this is creating problems for property owners. It is expected that the space needed by organizations will be between 20% and 38% less in 2030, taking into consideration the sale of older and lower-grade properties, targeting high-quality, technologically equipped spaces, considering interactions that may be held occasionally in the office space (Statista, 2022). Cities like New York and San Francisco have seen noticeable declines in their urban populations, which correspond with an increase in suburban residency (McKinsey & Company, 2022). This shift is largely driven by the growing acceptance of remote work, which allows employees to live farther from their workplaces, diminishing the need for proximity to office spaces and thereby reshaping demand within urban centers. The decrease in office attendance has direct implications for the commercial real estate sector, particularly in terms of office spaces. Current trends indicate a reduction in demand for office real estate, with increasing vacancy rates, lower transaction activities, and a drop in sale prices and rents across major cities in Europe and America (Statista, 2022). This downturn is compounded by tenants preferring shorter lease terms due to the uncertainty about future office needs, which poses significant challenges for property owners, including restricted access to financing and potential devaluations of property assets. Moreover, projections suggest a long-term impact on office space demand, with potential declines ranging from 20% to 38% by 2030, depending on various recovery scenarios (Statista, 2022). This reduction in demand is expected to lead to an oversupply of office spaces, particularly affecting older and lower-grade properties (Class B and C). Furthermore, as organizations and employees favor high-quality, well-located, and technologically equipped spaces for occasional in-person interactions and collaborative work, the market for older office buildings may face prolonged challenges.

Lastly for the analysis, is important to say that the real estate sector is experiencing a significant transformation driven by the growing centrality of environmental sustainability. As the financial stability of the industry is increasingly linked to environmental risks, there is a notable shift towards

integrating sustainable practices into real estate development and management. This change is catalyzed by legislative pressures that compel asset managers and developers to adopt eco-friendly initiatives. In investors' perceptions green building certifications such as LEED and BREEAM are pivotal in this transformation. These frameworks provide metrics to assess a building's environmental performance, which is becoming crucial for attracting tenants and enhancing asset values. Investors are recognizing the added value of certified properties in terms of marketability, which is pushing the real estate market towards a sustainable future. Depending on the type of certification, they can also attest regulatory compliance. Moreover, to address the urgent need to combat climate change, developers are increasingly implementing energy-saving measures. These include the use of advanced insulation materials, efficient HVAC systems, and smart technologies designed to optimize energy usage and minimize carbon footprints. Interesting to add to this discourse is that the U.S. Green Building Council reports that LEED-certified buildings typically see a reduction in maintenance costs by about 20% compared to traditional buildings, and green retrofit projects can reduce operation costs by nearly 10% within just one year, showcasing the economic benefits of sustainable building practices[46]. Additionally, sustainable building materials such as reclaimed wood and recycled steel are gaining popularity not only for their environmental benefits but also for enhancing the aesthetic appeal of properties. The shift towards sustainability is also evident in the construction methodologies being adopted, which emphasize waste reduction and the ethical sourcing of materials. These practices are becoming standard as the sector moves towards a more environmentally responsible approach. The market demand for energy-efficient homes is also rising, with features such as well-insulated windows, renewable energy sources like solar panels, and energy-efficient appliances becoming highly desirable to contemporary buyers.

The following chapter delves into the EU regulatory drivers of change, specifically evaluating the impact of the Energy Performance of Buildings Directive (EPBD), the EU Taxonomy, and the metrics of embodied carbon on real estate dynamics. By discussing these primary drivers, the foundation is laid for a more comprehensive analysis from a regulatory standpoint. In detail, the EPBD aims to improve the energy performance of buildings within the EU, setting ambitious targets for new constructions and existing structures. This directive mandates energy efficiency improvements, necessitating significant investments in sustainable technologies and practices. Additionally, the EU Taxonomy establishes a classification system for environmentally sustainable economic activities. This regulatory framework provides a clear definition of what constitutes a sustainable investment,

[46] Vierra, S**.** (2016). *Green building standards and certification systems*. National Institute of Building Sciences, Washington, DC

thereby influencing funding and financing decisions within the real estate market. By promoting transparency and consistency, the EU Taxonomy encourages investments in projects that meet high environmental standards, driving the sector towards greener practices. Furthermore, embodied carbon metrics focus on the total carbon emissions associated with the lifecycle of building materials, from extraction and processing to disposal. These metrics are becoming increasingly important as the EU intensifies efforts to achieve carbon neutrality. By examining these regulations, the thesis aims to provide a nuanced understanding of the mechanisms through which the EU is promoting sustainability in real estate. This analysis will enhance the thesis by adding depth and complexity, offering a solid foundation for further exploration of these critical regulatory influences.

4. Focus on EU Regulatory Drivers of Change: Assessing the Impact of the EPBD, EU Taxonomy, Industry Act (Heat Pumps) and the New metrics of Embodied Carbon on Real Estate Dynamics and Investment Strategies

In the realm of real estate, the trajectory of change is often steered by a complex interplay of economic, regulatory, and environmental factors. Among these influential forces, regulatory frameworks wield significant power in reshaping industry dynamics and driving transformative shifts. At the forefront of regulatory initiatives within the European Union stands the Energy Performance of Buildings Directive (EPBD), a seminal piece of legislation designed to revolutionize energy efficiency standards across member states'-built environments. As scholars and practitioners alike navigate the intricate landscape of real estate dynamics, understanding the role and implications of the EPBD emerges as a paramount endeavor. This directive, with its multifaceted provisions and far-reaching impacts, stands not merely as a compliance requirement but as a pivotal driver of change within the sector. Additionally, among these regulatory instruments, the European Union's Taxonomy for Sustainable Activities stands out as a cornerstone of the EU's strategy to cultivate a resilient and environmentally conscious economy. This classification system, designed to identify and promote environmentally sustainable economic activities, carries profound implications for the real estate sector by redirecting investments towards properties that adhere to stringent sustainability criteria. Understanding the significance of the EU Taxonomy within the realm of real estate necessitates a comprehensive analysis of its technical guidelines and the resultant shifts in market dynamics.
In the EU taxonomy, significant emphasis is placed on the ten activities outlined within the real estate sector, particularly focusing on acquisition and ownership activities, which are of paramount importance for both asset managers and banks.

Additionally, as global efforts intensify to combat climate change, the real estate sector has recognized the significant role it plays through the introduction of new metrics focused on embodied carbon. Embodied carbon is swiftly becoming a crucial measure for assessing environmental impacts, particularly within the context of sustainable construction practices that aim for net-zero emissions by 2050. Although metrics are not yet applied uniformly at the EU level, a few countries have adopted them. Notably, particular emphasis is placed in France, which is at the forefront in introducing and adopting these metrics. This chapter also explores the various facets of embodied carbon in the real estate sector, underscoring its critical importance in the lifecycle of building

materials, from extraction through to disposal, and its contribution to global greenhouse gas emissions.

Another extremely important piece of paper is the Net-Zero Industry Act, part of the Green Deal Industrial Plan. This policy is designed to scale up the manufacturing of clean technologies within the EU. Specifically, its goal is to increase the EU's capacity to produce technologies that support the clean energy transition and emit extremely low, zero, or even negative greenhouse gas emissions. By 2030, the Act aims to ensure that the EU's manufacturing capacity for strategic net-zero technologies meets at least 40% of annual deployment needs. This dissertation examines the critical role of heat pumps in real estate within the framework of the Net-Zero Industry Act, highlighting their importance in reducing energy consumption, lowering greenhouse gas emissions, and enhancing energy efficiency in buildings.

The objective of this thesis is to conduct an in-depth analysis of these major regulatory policies impacting the real estate industry to determine which key performance indicators (KPIs) can effectively facilitate a credible transition towards compliance with these directives and regulations.
This research seeks to identify KPIs currently used in the real estate sector and evaluate their effectiveness in capturing the elements of transition as established by the EPBD, the EU taxonomy, embodied carbon metrics and the net-zero industry act. By analyzing these regulations, it is possible to understand what standards the sector actually needs to meet to achieve climate objectives. This analysis allows to evaluate when current metrics are able to measure the sector's alignment towards sustainability and regulatory compliance. In particular, this thesis aims to highlight the limitations of existing KPIs which are not able to capture the transition and mitigation elements necessary for significant progress. In fact, many current parameters simply maintain the status quo without contributing to or accelerating the transition towards sustainable practices. In essence, this research seeks to bridge the gap between existing regulatory frameworks and the practical implementation of sustainability metrics, offering insights into how KPIs can be leveraged to support and accelerate the transition to a low-carbon future. Identifying these gaps is critical to understanding why some KPIs fail to drive significant change within the industry.
To address these shortcomings, the research will propose a set of improved KPIs that align more closely with the objectives of European-level regulatory frameworks. By achieving these objectives, this thesis aims to provide a comprehensive framework for the real estate sector to adopt more effective and forward-looking parameters.

4.1. EU taxonomy

The EU taxonomy for sustainable activities is a key element of the European Union's strategy to foster a sustainable economy. This classification system defines environmentally sustainable activities, significantly impacting the real estate sector by channeling investments into properties that adhere to rigorous sustainability standards. This passage explores the nuanced impact of the EU taxonomy on the real estate sector, particularly focusing on activities eligible for taxonomy alignment. Special attention is given to activities related to the acquisition and ownership of buildings, which are highly relevant to this dissertation due to their significance for asset managers and banks.

The taxonomy sets precise criteria and objectives for determining whether economic activities can be considered environmentally sustainable. The EU taxonomy is based on six environmental objectives: climate change mitigation and adaptation, sustainable use and protection of water and marine resources, transition to a circular economy, pollution prevention and control, and protection and restoration of biodiversity and ecosystems. An economic activity is considered compliant if it stabilizes greenhouse gas emissions, aligns with the long-term temperature goals of the Paris Agreement, and reduces or prevents adverse impacts of current or future climates. An activity is deemed sustainable if it implements strategies to manage water resources sustainably, ensuring their use does not compromise future generations' needs. Transitioning to a circular economy involves increasing the durability and reusability of products, thereby reducing waste and minimizing resource use to create longer-lasting, more sustainable products. Pollution prevention and control involve avoiding the use of materials or products that may cause pollution, enhancing the quality of air, water, and soil, and implementing measures to clean up litter and other pollutants. Effective pollution control ensures a safe and healthy environment for all living organisms. The protection and restoration of biodiversity and ecosystems are vital for maintaining ecological balance and providing numerous benefits to humanity, such as ensuring the provision of food and water, regulating climate and disease, supporting nutrient cycles and oxygen production, and offering spiritual and recreational benefits.

To classify activities as environmentally sustainable, they must meet four overarching criteria. First, they need to substantially contribute to one of the environmental objectives outlined above. Initiatives must actively and effectively advance the sustainable use and protection of water and marine resources, the transition to a circular economy, pollution prevention and control, or the protection and restoration of biodiversity and ecosystems. Additionally, these initiatives must do no significant harm to the other environmental objectives. For instance, while focusing on water conservation, an initiative must ensure it does not negatively impact pollution levels or biodiversity. Furthermore, initiatives must meet the 'minimum safeguards,' such as adhering to the UN Guiding Principles on

Business and Human Rights, to avoid any negative social impact. Finally, compliance with the technical screening criteria is essential. These criteria provide detailed guidance on what constitutes a substantial contribution to the environmental objectives and ensure that activities are aligned with broader sustainability and regulatory standards. Meeting these criteria helps guarantee that the initiatives are not only environmentally beneficial but also technically and socially responsible.

In real estate, these criteria not only define sustainable investments but also reshape asset valuation across Europe. Adhering to these standards guarantees that projects making substantial contributions to climate change mitigation, while observing social safeguards, are recognized as sustainable. This alignment is expected to reduce investment risks and increase asset value, a trend increasingly evident in real estate markets where properties meeting sustainability standards fetch a premium compared to those that do not. By setting high standards for energy efficiency and environmental impact, the taxonomy aims to transform real estate practices, making them a pivotal force in achieving the EU's sustainability targets. New buildings must rank in the top 15% of local energy efficiency standards, while major renovations require a minimum 30% reduction in energy use[47]. These stringent criteria ensure that buildings consume less energy and contribute significantly less to greenhouse gas emissions.

The ultimate objective of these criteria is to redirect capital flow towards greener building solutions. The taxonomy's direct influence on investment strategies is substantial, channeling capital towards compliant properties and categorizing them as lower-risk and potentially higher-return investments. Empirical evidence supports the economic viability and market benefits of adhering to the taxonomy's criteria. For instance, Eichholtz et al. (2019) note a 40% reduction in median energy intensity from 2009 to 2018 across 26,000 buildings, underscoring the significant energy savings and cost reductions achievable through compliance with sustainable practices[48]. The taxonomy's impact extends into financing mechanisms within the real estate market. Green mortgages and bonds are becoming increasingly prevalent, offering better terms for properties that meet the taxonomy's environmental standards. Esposito et al. (2022) discuss how these financial products encourage the development of compliant properties and assure investors and lenders of their long-term viability and profitability[49].

In summary, the EU taxonomy is driving a comprehensive transformation in the European real estate market by embedding sustainability into financial and investment strategies. It sets new benchmarks for economic performance, risk management, and market valuation, making sustainability a central

[47] Zangheri, P., Castellazzi, L., D'Agostino, D., & Maduta, C. (2021). *Progress of the Member States in implementing the Energy Performance of Building Directive*. European Commission, Joint Research Centre (JRC).

[48] Eichholtz, P., Holtermans, R., & Kok, N. (2019). Environmental performance of commercial real estate: New insights into energy efficiency improvements. *The Journal of Portfolio Management*.

[49] Esposito, L., Mastromatteo, G., Molocchi, A., & Brambilla, P. C. (2022). Green mortgages, EU taxonomy and environment risk weighted assets: A key link for the transition. *Sustainability*, 14(3), 1633.

pillar of decision-making in real estate development. This influence is guiding current investments and shaping future developments, aligning the sector with the EU's broader sustainability goals and addressing global challenges.

4.1.1. Impact of EU Taxonomy

The European Union's taxonomy for sustainable activities has instigated a pivotal transformation in the real estate sector by setting forth a classification system that identifies environmentally sustainable economic activities. Indeed, for example, real estate activities that can be considered compliant with the EU taxonomy must meet specific criteria to be recognized as sustainable. First and foremost, new buildings must exhibit the highest level of energy performance, ranking in the top 15% of the local building stock in terms of energy efficiency. This means that new buildings must be among the most energy efficient in their area. Additionally, for significant renovations, a minimum reduction in energy consumption of 30% is required, ensuring that renovation efforts contribute significantly to reducing energy consumption and carbon emissions[50].

Specifically, the EU taxonomy identifies 10 activities within the real estate sector, detailing for each one whether they align with the taxonomy based on the objectives and criteria outlined in the previous paragraph. Table 1 below intends to summarize the activities covered by the EU taxonomy relating to Construction and activities in the sector.

Table 1: EU taxonomy aligned activities in Real Estate

Sector	**Activity**
Construction and Real Estate activities	**Acquisition and Ownership of buildings[51]**
	Construction of new buildings
	Demolition and wrecking of buildings and other structures
	Installation, maintenance and repair of charging stations for electric vehicles in buildings (and parking spaces attached to buildings)

[50] European Parliament and Council of the European Union. (2020). Regulation (EU) 2020/852 of the European Parliament and of the Council of 18 June 2020 on the establishment of a framework to facilitate sustainable investment and amending Regulation (EU) 2019/2088. *Official Journal of the European Union*, L 198, 13-43; European Commission. (2021). Technical guidelines on the application of the EU taxonomy for sustainable activities.

[51] The economic activities in this category could be associated with NACE code L68 in accordance with the statistical classification of economic activities established by Regulation (EC) No 1893/2006.

Construction and Real Estate activities	Installation, maintenance and repair of energy efficiency equipment
	Installation, maintenance and repair of instruments and devices for measuring, regulation and controlling energy performance of buildings
	Installation, maintenance and repair of renewable energy technologies
	Maintenance of roads and motorways
	Renovation of existing buildings
	Use of concrete in civil engineering

Source: Personal Elaboration.

For the purposes of the thesis work, without going into the details of each individual activity, the analysis specifically focuses on the acquisition and ownership of buildings. This activity is crucial for both asset managers and banks from both adaptation and mitigation perspectives. Indeed, the acquisition and ownership of buildings are essential for asset managers, as they allow portfolio diversification and the generation of stable income. These activities include market research, property valuation, purchase price negotiation, day-to-day property management, and regulatory compliance. Aligning with the European taxonomy ensures value appreciation, efficient risk management, and long-term success of real estate portfolios. Properties that adhere to the taxonomy's stringent sustainability criteria are increasingly perceived as lower-risk investments, thus attracting heightened investor interest and capital allocation. According to Alessi et al. (2019), these taxonomy-compliant properties are likely to experience a rise in demand, resulting in higher asset values and potentially better returns on investment[52]. The mechanism behind this is twofold: first, through the direct impact on asset pricing and, second, by influencing the risk assessment models used by investors and financial institutions. This dual effect is particularly evident in the green mortgage sector, where taxonomy-compliant properties are more likely to qualify for favorable financing conditions, further incentivizing investment in sustainable properties [53].

[52] Alessi, L., Battiston, S., Melo, A. S., & others. (2019). *The EU sustainability taxonomy: a financial impact assessment*. European Commission.
[53] Esposito, L., Mastromatteo, G., Molocchi, A., & Brambilla, P. C. (2022). Green mortgages, EU taxonomy and environment risk weighted assets: A key link for the transition. *Sustainability*, 14(3), 1633.

In climate mitigation, specifically regarding the acquisition and ownership of buildings, the EU taxonomy specifies how this activity can substantially contribute to the six environmental objectives, respect the Do No Significant Harm (DNSH) criteria, and meet the minimum safeguards. Particular emphasis in this analysis is placed on the mitigation elements. Concerning the contribution criteria, the taxonomy differentiates between buildings constructed before December 31, 2020, and those built after this date. For buildings built before December 31, 2020, they are considered to contribute substantially if they have at least an Energy Performance Certificate (EPC) class A. Alternatively, the building should be within the top 15% of the national or regional building stock in terms of operational Primary Energy Demand (PED), demonstrated by adequate evidence that compares the performance of the relevant asset to the performance of the national or regional stock built before December 31, 2020, and distinguishes between residential and non-residential buildings. For buildings constructed after this date, it is prescribed that they must meet the criteria set by the Delegated Act. In particular, the technical screening criteria specify that the new buildings contribute substantially to climate change mitigation if the Primary Energy Demand (PED)[54], which defines the energy performance of the building resulting from the construction, is at least 10 % lower than the threshold set for the nearly zero-energy building (NZEB) requirements in national measures implementing Directive 2010/31/EU of the European Parliament and of the Council[55]. The energy performance is certified using an as built Energy Performance Certificate (EPC). In addition, for buildings larger than 5000 m^2, the building should be tested by construction for airtightness and thermal integrity[56], and, in addition, any deviation in the performance levels established at the design stage or defect in the building envelope must be disclosed to investors and customers. Furthermore, it is specified that for buildings larger than 5000 m^2, the life-cycle Global Warming Potential (GWP)[57] of the building resulting from the construction has been calculated for each stage in the life cycle and is disclosed to investors and clients on demand.

[54] The calculated amount of energy needed to meet the energy demand associated with the typical uses of a building expressed by a numeric indicator of total primary energy use in kWh/m2 per year and based on the relevant national calculation methodology and as displayed on the Energy Performance Certificate (EPC).
[55] Directive 2010/31/EU of the European Parliament and of the Council of 19 May 2010 on the energy performance of buildings (OJ L 153, 18.6.2010, p. 13).
[56] The testing is carried out in accordance with EN13187 (Thermal Performance of Buildings - Qualitative Detection of Thermal Irregularities in Building Envelopes - Infrared Method) and EN 13829 (Thermal performance of buildings. Determination of air permeability of buildings. Fan pressurization method) or equivalent standards accepted by the respective building control body where the building is located.
[57] The GWP is communicated as a numeric indicator for each life cycle stage expressed as kgCO2e/m2 (of useful internal floor area) averaged for one year of a reference study period of 50 years. The data selection, scenario definition and calculations are carried out in accordance with EN 15978 *(BS EN 15978:2011. Sustainability of construction works. Assessment of environmental performance of buildings. Calculation method)*. The scope of building elements and technical equipment is as defined in the Level(s) common EU framework for indicator 1.2. Where a national calculation tool exists or is required for making disclosures or for obtaining building permits, the respective tool may be used to provide the required disclosure.

Regarding the Do No Significant Harm (DNSH) criteria, the EU taxonomy on climate change mitigation outlines general criteria related to climate change adaptation. Specifically, these criteria identify the physical climate risks that are material **(see note)**[58] for the activities defined by the taxonomy through a robust climate risk and vulnerability assessment. This assessment involves screening the activity to identify which physical climate risks could impact its performance over its expected lifetime and evaluating the adaptation solutions that can mitigate these identified risks.
Furthermore, the taxonomy specifies that the activity related to the acquisition and ownership of buildings must respect the minimum safeguards as outlined in point (c) of Article 3. Specifically, procedures implemented by an undertaking conducting an economic activity should ensure alignment with the OECD Guidelines for Multinational Enterprises and the UN Guiding Principles on Business and Human Rights. This includes adhering to the principles and rights set forth in the eight fundamental conventions identified in the International Labor Organization's Declaration on Fundamental Principles and Rights at Work, as well as those outlined in the International Bill of Human Rights. Regarding climate adaptation, the taxonomy identifies how this activity contributes substantially. It specifies that an economic activity related to the acquisition and ownership of buildings can contribute substantially if it has implemented physical and non-physical solutions ('adaptation solutions') that significantly reduce the most important physical climate risks that are material to that activity. A robust climate risk and vulnerability assessment is conducted to identify material physical climate risks for an activity by screening the activity for potential climate risks. The assessment then evaluates adaptation solutions to mitigate the identified risks. Additionally, it is specified that adaptation solutions implemented must not adversely affect others' resilience to climate risks, should favor nature-based solutions or blue/green infrastructure where possible, be consistent with relevant adaptation plans and strategies, and be monitored against predefined indicators with remedial actions considered as needed. Furthermore, if the solution involves physical changes, it must also comply with the do no significant harm technical screening criteria for that activity.

The analysis of the EU taxonomy, in particular regarding the acquisition and management of real estate assets, allows detailed assessments to be made on the existence of specific key performance indicators (KPIs). The importance to aligned specific KPIs to the EU taxonomy has been recognized also by the European Commission. Indeed, The European Commission has issued a Call for Advice[59]

[58] **The next chapter will specifically focus on physical and transition risks, providing a better understanding of these policy shifts and offering all the necessary elements to identify the KPIs.**
[59] European Commission (2020): *Call for advice to the European supervisory authorities on Key Performance Indicators and methodologies on the disclosure of how and to what extend the activities qualify as environmentally sustainable as per the EU taxonomy.* Ref.Ares(2020)4805202

to the European Supervisory Authorities (ESAs) to develop key performance indicators (KPIs) and methodologies for companies subject to the Non-Financial Reporting Directive (NFRD) to disclose their alignment with environmentally sustainable activities under the EU taxonomy.

Specifically, as previously mentioned, the thesis wants to scrutinize the existing metrics and see which of these are able to lead to a credible transition in the sector based on the objectives and criteria established by the European taxonomy. As will be analyzed later, at the moment at a European level there is a lack of KPIs capable of being forward-looking and accelerating the transition with credible transition plan.

4.1. EPBD

The Energy Performance of Buildings Directive (EPBD) stands as a cornerstone of the European Union's legislative efforts to enhance energy efficiency within its member states. This directive is designed to significantly reduce energy consumption in buildings and forms an integral part of Europe’s broader strategy aimed at improving energy efficiency, decreasing energy consumption, and reducing greenhouse gas emissions. The primary objective of the EPBD is to bolster energy performance across buildings in the EU through the establishment of minimum energy performance standards. These standards apply to both new constructions and existing buildings that undergo major renovations. In doing so, the directive not only supports the EU's commitment to increasing the integration of renewable energy sources into building designs but also enhances the availability of information on energy performance through Energy Performance Certificates (EPCs). These certificates are essential tools, providing building owners or tenants with vital information about the energy efficiency of properties and suggesting practical measures to enhance this efficiency. A particularly ambitious goal of the EPBD is the stipulation that all new buildings must be Nearly Zero-Energy Buildings (NZEBs) by specific deadlines—2020 for public buildings and 2021 for all new buildings. NZEBs are characterized by their very high energy performance, where the very low amount of energy required should be covered to a significant extent by energy from renewable sources. Moreover, the directive mandates the regular inspection of heating and cooling systems within buildings to ensure they operate optimally. These inspections aim to provide owners with recommendations for potential upgrades or replacements, thereby promoting energy conservation. For its implementation, the EPBD requires EU countries to transpose its directives into national law, adapting the benchmarks for building energy performances to accommodate the diverse climatic and local conditions across the member states. Through these comprehensive measures, the EPBD not only aims to reduce the energy consumption and environmental impact of buildings but also drives economic growth by stimulating investments in green technologies and creating jobs in the renovation

and construction sectors. The European Commission proposed a revision of the EPBD in December 2021 as part of the "Fit for 55" package, aiming to further reduce greenhouse gas emissions by 55% by 2030. This revision includes measures to improve the energy performance of buildings and increase the rate of building renovations. The ongoing evolution of the EPBD underscores its adaptability to new environmental and technological landscapes, reinforcing its role in driving economic growth through green technology investments and job creation in the renovation and construction sectors.

The European directive stipulates that member states must establish minimum energy performance standards for non-residential buildings, ensuring that these buildings do not exceed a maximum energy performance threshold expressed in kWh/ (m2.a). Additionally, member states must set a maximum energy performance threshold such that 16% of the non-residential building stock exceeds this threshold (referred to as the "16% threshold") and a second threshold that 26% of the non-residential building stock exceeds (referred to as the "26% threshold")[60]. The directive sets minimum energy performance standards, which must ensure that all non-residential buildings are below the 16% threshold by 2030 and below the 26% threshold by 2033. Furthermore, by May 29, 2026, each member state must define a national trajectory for the progressive renovation of the residential building stock, aligning with national targets for 2030, 2040, and 2050, with the ultimate goal of transforming the building stock into a zero-emissions stock by 2050. This trajectory must express a reduction in average primary energy consumption in kWh/ (m2.a) for the entire residential building stock over the period 2020-2050 and identify the number of buildings or housing units to be renovated annually, including 43% of the worst-performing buildings. Additionally, member states must ensure that the average primary energy consumption decreases by at least 16% from 2020 levels by 2030, by at least 20-22% by 2035, and that by 2040 and every five years thereafter, it is equivalent to or lower than the values determined at the national level for a progressive decline in average primary energy consumption until 2050, in line with the zero-emissions goal. The directive specifies that at least 55% of this reduction must be achieved by renovating 43% of the residential buildings with the worst energy performance.

In addition to reducing primary energy consumption, member states may establish supplementary indicators concerning the use of non-renewable and renewable energy and operational greenhouse gas emissions, expressed in kg of CO2eq/ (m2.a). To ensure the reduction of operational emissions, the minimum energy performance standards must consider Directive (EU) 2018/2001.

[60] Parlamento Europeo, Consiglio dell'Unione Europea. Direttiva (UE) 2024/1275 del Parlamento Europeo e del Consiglio del 24 aprile 2024 sulla prestazione energetica nell'edilizia (rifusione). Pubblicato 8 maggio 2024

Furthermore, member states must ensure that new buildings are solar-ready. This should be the case where it is technically, economically and functionally feasible for new public and non- residential buildings over 250m2 as of December 2026. All existing public buildings (over 2000m2) as of the end of 2027, all of those over 750m2 as of December 2028 and finally, all public buildings over 250m2 as of December 2030[61].

So, the EPBD does not establish specific values to be met but defines guidelines and goals to be achieved by each member state. Consequently, each state must establish, in accordance with the goals set by the directive, quantitative benchmarks such as thermal transmittance values or U-values (for external walls, roofs, or windows) or thresholds for primary energy consumption for both residential and non-residential buildings. For example, France, in its RT 2020 *(Réglementation Thermique 2020)*[62], which came into effect in 2022, has set precise standards in accordance with the European directive. Among the main quantitative standards set by the RE2020, the maximum thermal transmittance value (U-value) for external walls is set at ≤ 0.22 W/(m²K). This parameter is crucial to limit heat loss through the walls, improving the overall energy efficiency of the building. Furthermore, for roofs, the maximum thermal transmittance value is set at ≤ 0.18 W/(m²K). Reducing the thermal transmittance of roofs is essential to maintaining a comfortable indoor environment and reducing the energy consumption required for heating and cooling. Another quantitative standard is that the maximum primary energy consumption for new residential buildings is set at 50 kWh/m²/year. This limit considers all energy consumption related to heating, lighting, hot water production, and other energy uses of the building. Reducing primary energy consumption is essential to decrease the carbon footprint of buildings and to contribute to the carbon neutrality goals set for 2050. These standards represent a concrete commitment by France towards environmental sustainability and energy efficiency, in line with European directives and global climate goals.

4.1.1. Impact of EPBD

In the context of Europe's real estate market, the Energy Performance of Buildings Directive (EPBD) acts as a catalyst for substantial economic and financial transformations. The directive's focus on improving building energy efficiencies is not just a regulatory requirement but has become a significant economic driver, reshaping investment patterns and influencing market dynamics across the continent. Financially, the EPBD introduces significant upfront costs associated with retrofitting and upgrading buildings to meet specified energy efficiency standards. These investments, while

[61] Marine Leleux. "Energy Performance of Buildings Directive: A Step Closer to the Finish Line." *ING Think*, January 25, 2024.

[62] Ministère de la Transition écologique. Dossier de presse - RE2020: Pour une construction durable et résiliente. Publié 2021 Feb 18.

burdensome initially, are often offset by the long-term savings accrued from reduced operational costs. Properties compliant with the EPBD standards typically exhibit lower energy expenditures, which can significantly enhance their attractiveness to investors and buyers, leading to a potential increase in property values. Furthermore, the emphasis on sustainability has led to noticeable changes in corporate behavior within the real estate sector. Gałkiewicz & Wollmann (2023) document the enhancements in environmental reporting practices among real estate companies in German-speaking countries. Triggered by regulatory frameworks akin to the EPBD, these changes have significantly influenced investment decisions, demonstrating a shift towards more sustainable and environmentally conscious market valuations from 2020 to 2021[63]. Additionally, from an economic standpoint, the Directive stimulates the construction and energy sectors, driving demand for green technologies and services. This demand boost contributes to job creation and fosters innovation in building technologies, which are crucial for the sustainable growth of the economy. Moreover, the EPBD encourages the development of new financial products, such as green mortgages and energy-saving insurance packages, which further integrate sustainability into the financial fabric of real estate markets. The EPBD also poses challenges, particularly in terms of investment displacement and market segmentation. Smaller market players, such as individual landlords or small construction firms, might find the compliance costs prohibitive, potentially leading to market exits or reduced competitiveness. Furthermore, the real estate market might experience segmentation, with non-compliant properties facing devaluation or decreased liquidity. This bifurcation can lead to a two-tier market, where energy-compliant properties are more favored than their less efficient counterparts. Despite these challenges, the directive serves as a catalyst for long-term economic benefits, aligning with broader policy objectives of energy security and sustainability within the EU. The financial incentives and regulatory frameworks introduced alongside the EPBD support its implementation, easing the transition for stakeholders and mitigating the economic impact of initial compliance costs. To effectively align the building sector with the goals of the EPBD, it is essential to develop robust metrics that structure credible transition plans for the sector. As previously anticipated, the aim of this dissertation is to examine this policy and determine whether KPIs are available to capture the elements of the transition towards energy efficiency in buildings. Specifically, this analysis of the directive and the quantitative standards and benchmarks set by the EPBD is essential for identifying the KPIs that must be considered to align the sector with the directive's goals.

In conclusion, while the EPBD imposes significant regulatory and financial demands on the real estate sector, its broader economic implications are inherently positive, driving the sector towards

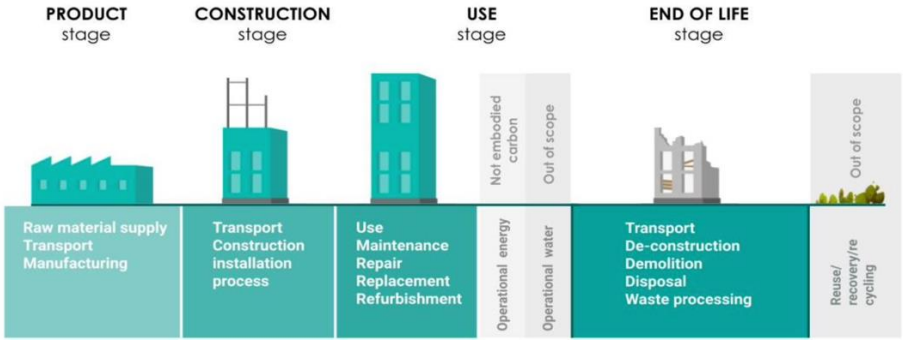
[63] Gałkiewicz, D. P., & Wollmann, B. (2023). Environmental (Sustainability) Reporting in 2020 and 2021 by Real Estate Companies from German Speaking Countries. *7th International Scientific Conference on Economics and Management: Selected Papers - EMAN 2023*.

greater sustainability and resilience. The success of the Directive, however, depends on the continued adaptation and support of KPIs that facilitate mitigation and transition, ensuring that the benefits of energy efficiency are universally accessible and economically sustainable.

4.3. New Metrics Embodied Carbon

Embodied carbon, particularly in the context of sustainable building practices aimed at achieving net-zero emissions by 2050, has emerged as a key metric in assessing the environmental impact of the real estate sector. This term encapsulates the total greenhouse gas emissions attributed to the non-operational phase of a building's lifecycle, including the extraction, production, transportation, and assembly of construction materials, as well as the end-of-life disposal. These emissions are locked in once a building is constructed, underscoring the urgency of addressing embodied carbon at the design and material selection stages. In other words, embodied carbon is present throughout the entire building lifecycle. The figure 1 below illustrates the complete lifecycle of buildings.

Figure 1: Lifecycle of building



Source: GRESB

Recent studies, such as the one by Architecture 2030, highlight that embodied carbon contributes to approximately 11% of annual global greenhouse gas emissions and represents 28% of the building sector's output[64]. The significance of these contributions is magnified by the shift towards operational energy efficiency in buildings, which paradoxically increases the proportional impact of embodied carbon emissions. This dynamic poses a formidable challenge as the sector strives to meet stringent climate targets. Moreover, as discusses in the drivers of changes, the expected surge in global urban population, projected to necessitate substantial new construction by 2060, threatens to intensify this

[64] Architecture 2030. (n.d.). *2030 Challenge for Embodied Carbon*. Architecture 2030.

issue further, potentially releasing over 100 gigatons of embodied carbon unless decisive and innovative mitigation strategies are employed[65]. As such, understanding and reducing embodied carbon is pivotal not only for aligning with the European net-zero ambitions but also for setting a global standard in sustainable construction. The built environment sector stands at the forefront of the global response to the climate crisis, tasked with the imperative to mitigate embodied carbon emissions as part of a broader net-zero strategy. The urgency of this task is evident in the European Union's increasing legislative focus. Initially targeting operational emissions from heating, cooling, and powering buildings, regulations now also address the often-overlooked embodied carbon emissions, recognizing their significant impact on overall greenhouse gas output as climate change effects intensify.

However, to date, regulatory initiatives within the EU have been uneven, with only a handful of member states, Denmark, Finland, France, the Netherlands, and Sweden, implementing comprehensive policies that address the whole-life carbon emissions of buildings, which include both operational and embodied emissions. Among these, France's RE2020 regulation, which came into effect in January 2022, represents one of the most ambitious efforts. This legislation not only sets progressive thresholds for reducing embodied carbon emissions in residential construction but also promotes the use of sustainable building materials as a dual strategy to decarbonize the energy consumption and material production processes.

In detail, the French State, with the help of sector players, has launched an unprecedented project to include in the regulation not only energy consumption, but also carbon emissions, including those linked to the construction phase of buildings. The objective of RE 2020 is, therefore, to design and build the future living places of the French by pursuing three main objectives supported by the government. The first concerns an objective of energy sobriety and energy decarbonization. The second a reduction of the carbon impact and the third a guarantee of comfort in case of strong heat. This is the first French regulation, and one of the first worldwide, to introduce environmental performance in new buildings through life cycle analysis.

The stipulated reduction targets, from *640 kg CO2-eq/m^2/year in 2022 to 415 kg CO2-eq/m^2/year* by 2031 for single housing, and from *740 kg CO2-eq/m^2/year to 490 kg CO2-eq/m^2/year* for collective housing, highlight a clear trajectory towards substantial carbon mitigation [66]. The metrics and targets are defined by the *"Code de la construction et de l'habitation (CCH),"* which establishes specific indicators for each type of building to calculate the set thresholds. For example, *Bbio*

[65] Drinkwater J. COP24: Time to address the building and construction sector's total emissions impact. World Green Building Council.

[66] European Commission. (2021). *Revised thermal regulation of Règlementation Environmentale (RE2020).*

(Bioclimatic Need) measures the energy demand for heating, cooling, and lighting, while *Cep, nr (Non-Renewable Primary Energy Consumption)* respectively evaluate the total primary energy consumption and non-renewable primary energy consumption.[67]. Important to underline is that the regulation uses modulation coefficients to adapt the requirements to the specific characteristics of the building, such as geographical location and size. These indicators ensure more sustainable and energy efficient buildings.

Similarly, Sweden's approach, underpinned by the Climate Disclosure Act for new buildings, mandates that developers must quantify the direct embodied emissions of new constructions as part of the building permit application process. This requirement underscores a shift towards transparency and accountability, ensuring that the embodied impacts of construction materials are considered from the initial production phase through to the end of the building's life cycle. These legislative advancements signal a transformative shift in the sector, not merely in terms of compliance but also in fostering a culture of sustainability that could precipitate broader changes across the industry. Companies proactive in integrating embodied carbon measurement into their projects are not only aligning with current regulations but are also positioning themselves advantageously for future mandates. Such measures invariably enhance the skill sets of their workforce, embed a sustainable ethos within corporate culture, and prepare the industry for an era where stringent regulations on embodied carbon become the norm rather than the exception. This proactive approach is crucial not only for meeting the ambitious 2050 decarbonization targets set by nations but also for catalyzing a comprehensive and enduring reduction in the environmental impact of the built environment. The architectural and construction landscape in Europe is poised at a critical juncture, facing complex decisions about the most effective methods to reduce carbon emissions across the continent. With approximately 80% of the building stock that will exist in 2050 already constructed, the imperative to retrofit existing structures to enhance operational efficiency is undeniable[68]. Yet, this necessity brings with it the challenge of managing the increase in embodied carbon resulting from renovation efforts aimed at reducing operational emissions—emissions that are currently excessively high. This European challenge involves a dual approach: on one hand, there is the need to continue reducing the carbon footprint of new constructions, and on the other, there is the urgent requirement to undertake renovations that not only lower operational emissions but also minimize embodied carbon. The task is to balance these strategies to achieve reductions across the entire lifecycle of buildings.

[67] Annexe à l'article R172-4. Code de la construction et de l'habitation. Légifrance. Published 2022.
[68] World Economic Forum. (2022, November 7). *Why retrofitting older buildings is key to achieving net-zero cities*.

4.3.1 Impact of new Metrics of Embodied carbon

The integration of embodied carbon metrics into the real estate sector signifies a pivotal shift towards sustainable development, reshaping the economic and financial paradigms that underpin the industry. These metrics, which account for the carbon emissions associated with the materials and construction phases of a building's lifecycle, are becoming increasingly instrumental in aligning the sector with global sustainability goals, particularly the target of net-zero emissions by 2050 as stipulated in the Paris Agreement. The recalibration of investment flows is one of the most notable impacts of embodied carbon metrics. A growing body of evidence suggests that properties demonstrating low embodied carbon metrics attract a higher proportion of green financing. For instance, green bond issuances, which are often earmarked for projects with verified low embodied carbon, surged to $257.7 billion in 2019, up by 51% from the previous year, according to the Climate Bonds Initiative[69]. This trend underscores a systemic shift towards sustainability in financial markets, with both institutional and private investors increasingly prioritizing projects that minimize carbon footprints from the outset of construction. This shift is not merely a trend but a fundamental realignment towards sustainable investment, supported by a robust framework of financial incentives and regulatory support. Furthermore, the operational costs associated with buildings are profoundly influenced by these metrics. Properties designed with lower embodied carbon are likely to incur reduced lifecycle costs, primarily through energy efficiencies and lower compliance costs associated with stringent environmental regulations. For instance, the adoption of advanced building materials with minimized carbon footprints can lead to significant reductions in energy consumption, a key factor in operational cost savings. The International Energy Agency highlights that energy efficiency measures in buildings can reduce energy use in both new and existing buildings. These efficiencies translate into direct financial benefits, enhancing the economic viability and marketability of properties.

The tightening of regulations around embodied carbon is creating a complex compliance landscape, with economic incentives for early adopters. Indeed, companies that integrate low embodied carbon metrics can enhance their brand reputation and gain competitive advantages. Properties with verified low embodied carbon are preferred by environmentally conscious consumers, leading to higher rents and occupancy rates. Additionally, investing in low embodied carbon properties aligns with Corporate Social Responsibility (CSR) goals, improving relationships with stakeholders and reinforcing a company’s reputation in sustainable development.

Despite the lack of a uniform regulation and widely applied across member states, the dissertation tries to look at these metrics to see whether the KPIs available can concretely monitor and accelerate

[69] Climate Bonds Initiative. (2020). *2019 Green Bond Market Summary*.

the transition. The core objective is to evaluate if KPIs can be developed and integrated to better measure and accelerate this transition, with a particular focus on the metrics of Embodied Carbon.
In essence, the dissertation explores the potential of these KPIs to provide a more comprehensive and credible framework for integrating Embodied Carbon metrics into actionable transition plans

4.4. Industry Act e Heat Pumps

For the analysis in this dissertation, another extremely important piece of legislation in the context of real estate is the Industry Act, particularly regarding key technologies related to heat pumps. The Industry Act, as part of the Green Deal Industrial Plan, aims to scale up the manufacturing of clean technologies within the EU. This Act focuses on technologies that play a crucial role in decarbonization, supporting strategic net-zero technologies that are commercially viable and have high potential for rapid scalability. These technologies are essential for enhancing the EU's industrial competitiveness and the resilience of its energy system, facilitating the transition to clean energy.
This strategic Act is significant because the global market for key mass-produced net-zero emissions technologies is expected to become three times larger by 2030, reaching an annual value of around EUR 600 billion, and to nearly increase sixfold by 2050.[70]. Only at the European level the EU net-zero ecosystem worthed EUR 100 billion and the projections estimate a massive increase of 15 times in global electric vehicle production. Specifically, speaking for Heat Pumps, the deployment of such technology will increase more than six times by 2050 compared to today and production of hydrogen from electrolysis or natural gas-based hydrogen with carbon capture and storage will reach 450 Mt in 2050. This will translate into global cumulative manufacturing investments of USD 1.2 trillion required to bring enough capacity on track with the global 2030 targets[71].
Consequently, be at the forefront of this impressive market expansion, and proactively incentivize the European market by implementation new measures, is key to be a leader and gain significant market share. In detail, the Net Emissions Industry Act aims to improve investment certainty, strategic direction and coordination by setting clear objectives and monitoring mechanisms.
Furthermore, the Act seeks to reduce administrative burdens on the development of zero-emission technology projects by streamlining administrative requirements, facilitating authorization processes, and establishing regulatory sandboxes to create a regulatory environment capable of stimulating innovation. To foster competitive market dynamics, the Act provides access to the market through public sector procurement and auction measures, as well as programs to support consumer demand. Additionally, the law facilitates carbon capture and storage projects by increasing the availability of

[70] "Energy Technology Perspectives" (2023), International Energy Agency.
[71] Energy Technology Perspectives (2023), International Energy Agency.

CO2 storage sites, supports innovation through regulatory sandboxes, enhances skills for the creation of quality jobs in zero-emission technology sectors, and coordinates industrial partnerships for zero-emission technologies.[72]. Specifically, the main key technologies regulated by the Act are: Solar photovoltaic and solar thermal; Electrolysers and fuel cells; Onshore wind and offshore renewables; Sustainable biogas/biomethane; Batteries and storage; Carbon capture and storage; Grid technologies and Heat pumps and geothermal energy. The Heat pumps, in particular, are extremely important for this dissertation since represent a key technology in the Real Estate Sector, especially considering the coherence with the other EU policies. The proposal is indeed coherent with the EU's approach to achieving a fair and just green transition [73]. Additionally, it is also coherent with the objectives of the "55% Ready" package, which focuses on the decarbonization of the EU industry, particularly in sectors where emissions are difficult to abate. The package emphasizes increasing electrification and promoting cleaner vehicles and fuels in a technologically neutral way[74]. In the context of the Net-Zero Industry Act, heat pumps are crucial for real estate, especially in light of the European Union's decarbonization goals for buildings. They offer significant energy efficiency and cost savings by transferring heat instead of generating it, achieving efficiencies of 300-400%[75]. This leads to substantial reductions in energy bills, making properties more attractive in the real estate market. Additionally, heat pumps play a vital role in reducing greenhouse gas emissions, aligning with the EU's targets of a 55% reduction by 2030 and climate neutrality by 2050. Sufficient is to note that, considering the Residential sector, around 80 % of the final energy consumption is used for space and water heating[76]. The use electricity, which can increasingly come from renewable sources, thus significantly lowering the carbon footprint of buildings. Moreover, heat pumps align with EU policies and regulations, such as the Energy Performance of Buildings Directive (EPBD), which mandates that new buildings must be nearly zero-energy buildings (NZEB). The next Chapter discusses, form the basis of the comments of the European Heat Pumps Association (EHPA), the main impact of this Act on Heat Pumps and, consequently, on Real Estate.

[72] European Commission. Net-Zero Industry Act. European Commission website. Published 2024 Feb 6.
[73] Council Recommendation of 16 June 2022 on ensuring a fair transition towards climate neutrality (OJ C 243, 27.6.2022, p. 35).
[74] Communication from the Commission to the European Parliament, the Council, the Economic and Social Committee and the Committee of the Regions "55% Ready: Achieving the EU's 2030 climate target on the path to climate neutrality" (COM (2021) 550 of 14.7.2021).
[75] International Energy Agency (IEA). (2018). "The Future of Cooling: Opportunities for energy-efficient air conditioning." Paris: IEA.
[76] Eurostat. Energy for heating and cooling: renewables on the rise. Products Eurostat News. Published February 3, 2023.

4.4.1. Impact of Industry Act on Heat Pumps and Real Estate

The Net-Zero Industry Act (NZIA) will have a significant impact on the heat pump sector, aligning with EU climate goals. One of the main effects is the increase in domestic production, aiming to produce at least 40% of zero-emission technologies by 2030, thereby reducing dependence on imports and strengthening the supply chain. Additionally, the simplification of administrative procedures will facilitate faster installations and greater scalability, responding to the growing demand for efficient heating solutions.

Both public and private financial incentives are crucial in the NZIA, with various mechanisms to support the heat pump sector. This influx of public funds and private investment will increase production, reduce costs, and make the technology more accessible and attractive to consumers. The NZIA also emphasizes skills development to support the industry by improving training programs and ensuring a skilled workforce for the manufacturing, installation, and maintenance of heat pumps, which is essential for industry growth and the implementation of high-quality projects.

Prioritizing heat pump projects to reach net-zero targets will ensure they receive priority support and funding, accelerating their deployment and improving the EU's overall climate impact. One of the most immediate and profound impacts resulting from the NZIA will be the increased adoption of heat pumps in both new construction and renovations of existing buildings. In fact, heat pumps will become a standard feature in modern, energy-efficient buildings. Their ability to provide substantial energy savings compared to traditional heating systems will make them very attractive to developers and property owners alike. For new builds, integrating heat pumps from the start will not only reduce long-term operating costs, but will also improve the building's market attractiveness, attracting environmentally conscious buyers and tenants who prioritize sustainability and reducing bills. In existing buildings, retrofitting with heat pumps will become a priority to meet growing energy efficiency standards and to benefit from the financial incentives provided by the NZIA. These incentives will help offset the initial costs of installing heat pumps, making it a financially viable option for many property owners. As a result, buildings equipped with heat pumps are likely to see increased property values and higher rental or sales prices, driven by demand for greener and more economical living and working spaces. For property owners, switching to heat pumps will result in significant long-term savings on energy bills and a reduction in the carbon footprint of their buildings. As regulatory standards evolve to drive energy efficiency, properties without heat pumps may face depreciation in value and increased compliance costs. The timely adoption of heat pump technology will be key to maintaining property values and ensuring competitiveness in a market that increasingly prioritizes sustainability.

However, according to EHPA, the act is too unambitious and lacks the necessary details to fully support the heat pump sector in contributing to the decarbonization of European buildings and industry. Going into specifics, the act provides for a heat pump production capacity target of 31 GW by 2030. This target is in fact much lower than the EHPA's own forecasts. Even a conservative growth scenario would lead to 47 GW by 2030, more than 50% above the expected target. In fact, it is estimated that in 2022 alone, heat pumps produced in Europe with a total capacity of 21.95 GW were installed in Europe. According to the EHPA, it would be more relevant to include the RepowerEU plan's objective of doubling heat pump sales by 2026 and add intermediate targets. Furthermore, currently 60% of heat pumps sold in Europe are produced in Europe; Therefore, the 40% production capacity target set for all technologies identified in the act is once again considered too low for the heat pump sector. However, according to the EHPA, the NZIA significantly addresses the shortage of skilled workers and the need to ensure a smooth supply chain. EHPA estimates that the number of employees needed to meet 2030 sales is between 450,000 and 500,000 full-time equivalents (FTEs), compared to approximately 117,000 today. While some of these will be retrained boiler installers, others will be new to the industry. As a result, although the NZIA is a positive response there is a lack of ambition and a lack of specific metrics and process to move the sector closer to decarbonization targets.

In the Real Estate sector, this problem translates into a lack of KPIs capable of effectively integrating technologies such as heat pumps in the evaluation of the performance of real estate assets with a view to transition. Without specific details and metrics on the Heat Pumps industry, the Real Estate sector cannot adequately monitor energy performance in transition plans. Once again, the objective is to evaluate what types of heat pump-specific KPIs and metrics can be developed to support the sector in a holistic and overall assessment of the energy efficiency of buildings, and consequently in the financial assessment of properties.

4.4. Conclusion

The chapter examined the landscape shaped by the EU's regulatory frameworks, revealing a clear transformation driven by mandates for energy efficiency and sustainability. These regulations are pivotal, aligning real estate practices with the broader environmental objectives of the European Union and fostering a market that values resilience and sustainability. Indeed, these regulatory measures are steering the real estate sector towards a more sustainable, resilient future, aligning with the EU’s broader climate goals and setting new benchmarks for sustainable development and investment. This Chapter, providing a clear overview of the main EU policies regulation for Real

Estate, laid the foundation for the analysis of KPIs. The analysis of potential KPIs based on these regulations is paramount for several reasons. First and foremost, KPIs serve as the quantifiable benchmarks that translate broad regulatory goals into specific, measurable outcomes. By providing clear metrics, they enable real estate professionals to assess and demonstrate compliance with regulatory standards such as the EPBD, EU Taxonomy, and embodied carbon metrics. This not only ensures adherence to legal requirements but also enhances transparency and accountability within the sector. Moreover, KPIs help identify gaps and areas for improvement within current practices. By highlighting where existing metrics fall short, they provide a basis for developing more effective measures that can drive substantial progress towards sustainability goals. For instance, traditional KPIs that merely maintain the status quo need to evolve to capture the dynamic elements of transition and mitigation required for significant advancements in energy efficiency and carbon reduction. In essence, the analysis of possible KPIs based on EU regulations is crucial for bridging the gap between regulatory frameworks and practical implementation. It empowers the real estate sector to not only comply with regulations but to actively contribute to the broader goals of reducing carbon emissions, enhancing energy efficiency, and promoting sustainable development.

Furthermore, this discussion of regulatory drivers set the stage for a subsequent analysis of the broader challenges posed by climate change. After examining the drivers of change and EU regulatory frameworks in Chapters 3 and 4, the dissertation proceeds to analyze physical and transition risks to build upon the established context. By first establishing how these frameworks are transforming the industry, encouraging green investments and setting high standards for energy efficiency, the thesis laid the groundwork for understanding the sector's preparedness to face new risks. Indeed, in today's rapidly evolving business environment, the real estate sector must adapt by incorporating the analysis of physical and transition risks into its strategic framework. The analysis of physical and transition risks follows naturally after chapters 3 and 4 because it builds on the detailed understanding of the business environment and regulatory landscape established in these chapters. Specifically, physical risks involve evaluating the environmental impacts on real estate, such as extreme weather events and rising sea levels. These risks necessitate adaptations in real estate developments to mitigate potential threats. Indeed, as global warming accelerates, it brings forth significant physical risks such as increased frequency of extreme weather events, rising sea levels, and intensified natural disasters. These physical changes pose direct threats to property integrity and sustainability, potentially leading to higher costs of maintenance, repair, and insurance. Transition risks, instead, emerge as the market adjusts to the new regulatory landscape and the growing demands for sustainability. This includes shifts in investor preferences and financial assessments, where

properties not aligned with the new standards may see a depreciation in value or face challenges in attracting investment. The forthcoming discussion will delve into how climate change accelerates the occurrence of severe weather events and increases the economic burden on property maintenance and insurance. Moreover, it examines the transition risks involved as real estate markets adjust to stringent climate policies and shifting investor sentiments. This analysis aims to provide an in-depth understanding of the interplay between established regulatory frameworks and the evolving risks, highlighting how the sector can navigate these changes to maintain economic viability and uphold environmental commitments. Through this nuanced exploration, the narrative extends beyond regulatory compliance, framing these frameworks as foundational elements that prepare the real estate sector for the complex challenges ahead. In conclusion, the shift towards analyzing physical and transition risks in real estate is essential for navigating the complexities of the modern business environment.

5. Physical risks and Transition Risks in Real Estate

Building on the solid understanding of the EU policies shift and drivers of changes, this chapter the focus toward a critical analysis of the specific risks pivotal in the current and future landscape of real estate: physical and transitional risks. In particular, this chapter narrows down the discussion from the general drivers of change to the specific risks posed by climate change and the transition. In particular, it analyzes the components of physical and transition risks that real estate stakeholders must navigate.

The pace of global warming is accelerating faster than previously predicted. Global warming is likely to reach the threshold of 1.5 degrees, which climate experts call the critical limit, as soon as 10 years from now. Climate change is causing higher temperatures, more frequent droughts, intense and prolonged rainfall, thus severely impacting the economy. Both climate change and the social and economic response to combat it are impacting the real estate market in different ways. First, climate change increases the likelihood of physical damage to homes, causing an increase in the expected costs of maintaining, repairing, and preventing damage, as well as mitigating the disruption resulting from such damage, impacting the overall value of real estate. From a financial perspective, this implies that when market participants, such as homebuyers, insurers or banking institutions, factor in expected costs related to physical damage to homes into their purchasing decisions, this generates downward pressure on property prices. homes. In addition, climate policy aimed at reducing emissions from the sector has strong consequences on the market and on price dynamics. This will require further investment in this case to comply with regulations and lower house prices. Consequently, it is expected that the inherent friendliness of market participants will increasingly favor sustainable construction over time. Furthermore, the entry of new technologies into the market will make sustainability a more attractive option. These advances will lead to a further decline in interest and a declaration of the value of less sustainable housing.

The following chapter, after a brief introduction, delves into a overview of both physical and transitional risks within the real estate sector. Additionally, a dedicated chapter is spent to scrutinizing the economic implication of these risks within the industry.

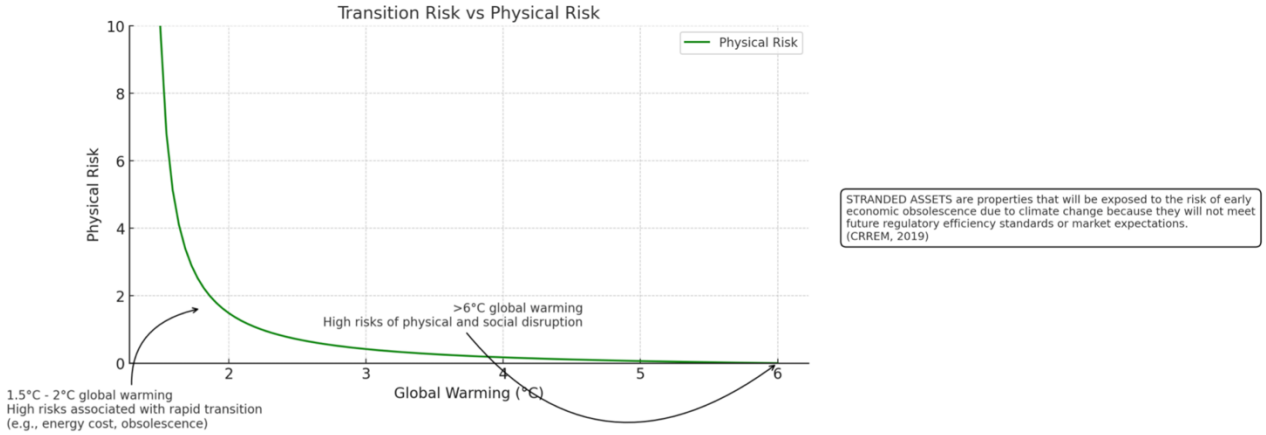
5.1. Introduction:

Climate change poses a threat to economic growth, quality of life and political stability globally. To prevent the serious consequences of future climate change, it is essential to implement a significant reduction in greenhouse gas emissions. Without immediate adequate action, climate change has the potential to generate serious damage to economic and social stability. Currently, the planet has

already warmed by more than 1°C compared to the pre-industrial era, with prospects for further temperature increases of between 3 and 4°C by the end of the century, according to current emissions trends (IPCC 2021). Andrew Moffat and William Nordhaus, who spearheaded the examination of climate change's economic implications, conducted a meta-study, and concluded that the effects of climate disruption will result in a two percent annual decline in world GDP [77]. According to the IPCC, an increase in world average temperatures of 4 OC is fair to predict to result in losses of 1 to 5 percent of global GDP (IPCC, 2007). The enormous impact of climate risks has also been well identified by the World Economic Forum. The risks associated with climate change, which represent a threat to civilization, have in fact pushed the World Economic Forum to include climate change at the top of its annual report on global risks (World Economic Forum 2021). In 2022, buildings and other construction sites contributed over 40% of the world's carbon dioxide emissions. In particular, construction accounted for about 13 percent of the total, while building-related direct and indirect emissions produced 27 percent. Indirect emissions are associated with off-site energy generation or transportation, while direct emissions are associated with the usage of natural gas, coal, and oil in buildings. It is evident that in order to tackle climate change the sector needs to become more sustainable. Considering that the real estate sector directly and indirectly contributes to almost 40% of all greenhouse gas emissions globally, it is inevitable that the sector will face unprecedented decarbonization that will expose it to risks that could undermine its financial strength. These risks include both direct physical and indirect transition risks. As global warming and uncontrolled greenhouse gas emissions accelerate, physical risks such as natural disasters and extreme weather events are expected to increase. To mitigate such physical risks, the transition to a low-carbon society is necessary, which entails transition risks (Graph 4).

[77] Breckenfelder, J., Mackowiak, B., Marques, I., Olovsson, C., Popov, A., & Porcellacchia, D. (2023). *The climate and the economy* (No. 2793). European Central Bank. See also the study in OECD (2015) that arrive at a similar number: about two percent. The study argues further that if the temperature increase would reach 4O C, then the costs could amount to up to 10 percent of GDP. Weizman (2009) argues that the costs of climate change are considerably larger when low-probability high-impact catastrophes are considered.

Graph 4: The graph illustrates the dynamic relationship the occur between transition and physical risk



Sources: Personal processing of data retrieved from CRREM 2022

As a result, climate change has quickly gone from a fringe concern to a key agenda item for the real estate industry. The pressure on the real estate sector is increasingly strong from several points of view. First, investors are increasingly committed to reducing net emissions and increasing the resilience of their portfolio towards investments aligned with SBTi and ESG criteria. Furthermore, the increasingly stringent regulation by regulatory bodies on reporting standards and energy efficiency requires asset managers to adapt in a rapidly changing and rather unstable context. At the same time, the tangible impacts of climate change, such as storms, floods, wildfires, and extreme heat, are accelerating, underscoring the importance of timely action. These dynamics highlight a critical moment in which real estate leaders must address both the physical implications of climate change and the economic, social, and regulatory changes necessary for decarbonization. Indeed, the goal of achieving a net-zero emissions future, which extends to 2050, represents a crucial phase in which real estate stakeholders must reevaluate and strengthen their portfolios. This climate transition imposes new imperatives for asset revaluation and future-oriented investments, but at the same time it also offers great opportunities for innovative, long-term investment and value creation. With respect to asset managers, the transition to a lower carbon economy poses various challenges and valuation risks. Indeed, studies point to projections of significant devaluations on real estate portfolios, primarily driven by increased risks such as flooding and job losses attributable to the climate transition. For instance, a study conducted by McKinsey discusses the direct impact of climate transition risks, including increased rates of flooding and job losses, on real estate values. The study emphasizes the necessity for real estate leaders to consider these factors in their strategic planning and portfolio valuation. In response to these challenges, major real estate players must identify misvalued assets, decarbonize portfolios and capitalize on the opportunities embedded in the climate

transition. As climate risks manifest with greater frequency and severity, the real estate sector faces existential threats to asset cash flows and future valuations. The consequences and implications for the real estate sector resulting from the transition to a lower carbon economy may be different. First, buildings that do not comply with the Paris-aligned 1.5°C decarbonization requirements will be increasingly exposed to transition risks and may even become "stranded assets". The term "stranding risk" implies potential write-downs due to the direct impacts of climate change and write-downs related to the transition to a low-carbon economy. The devaluation of assets and the risk that some assets become stranded represents the primary concern of asset managers as the value of assets can suffer significant depreciation. The climate transition will have impacts on both individual buildings and entire real estate markets. The investments needed to avoid or reduce the worst physical risks will drive a historic reallocation of capital. It is important to consider that around 80% of the building stock expected for 2050 is already part of the building stock, this implies a huge retrofit effort. According to some estimates by McKinsey, it is estimated that on average annual spending on physical goods between 2020 and 2050 would amount to 1.7 trillion dollars per year[78]. This will change the structure of our economy and impact the value of markets, companies, and their locations. These major changes require real estate players to look ahead to understand regulatory, economic, and social changes that may impact assets. It is therefore crucial for real estate players to develop capabilities to understand climate-related impacts on asset performance and values. In particular, real estate owners and investors will need to understand how these climate and policy changes impact revenues, operating costs, capital costs and the capitalization rate of assets. This includes developing analytical capabilities to consistently assess both physical and transition risks. Analyzes should include both direct effects on the assets and indirect effects on the markets, systems, and societies with which the assets interact. Below, after a brief overview of the context in which asset managers operate, the dissertation intends to provide an overview of the main transition risks and physical risks to which the sector is most exposed. Subsequently, their economic impact on revenues, operating costs, capital costs and the asset capitalization rate are analyzed. After this brief introduction, the thesis now explores the physical and transitional risks in detail, trying to deepen the discourse on the impacts of these risks and preparing the ground for the following chapter on the recognition of the sustainable finance instruments currently available on the market. The thesis now proceeds with analyzing the physical and consequently the transitional risks.

[78] McKinsey & Company. Boland, B., Levy, C., Palter, R., & Stephens, D. (2022). *Climate risk and the opportunity for real estate*.

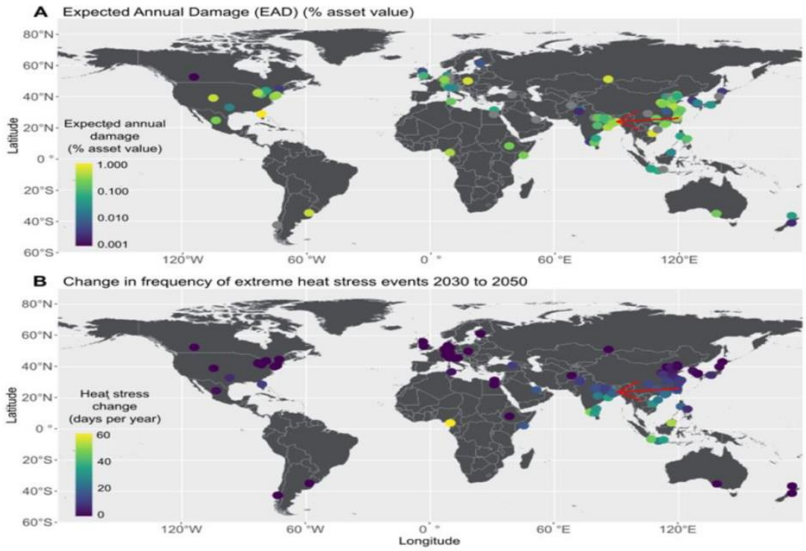
5.2. Physical and Transition Risk

5.2.1 Physical risk:

The real estate sector is increasingly exposed to a number of significant physical risks resulting from the increase in the frequency and intensity of extreme weather events. According to the 2021 Global Economic Losses from Disasters report published by the International Disaster Database (EM-DAT), global economic losses from extreme weather events exceeded $200 billion per year[79]. These events include exceptionally high rainfall, floods, hurricanes, forest fires and chronic risks such as hydrogeological disruption and sea level rise in low-altitude areas, posing a significant threat to the stability and resilience of the real estate sector. The increase in the frequency and intensity of such events is often attributable to climate change, which amplifies the effects of already existing atmospheric phenomena. According to the Intergovernmental Panel on Climate Change (IPCC), if greenhouse gas emissions are not significantly reduced, economic damage from extreme weather events could triple by 2050. According to S&P Global Rating Report by 2050, if global warming does not stay well below 2 degrees Celsius (2C), up to 4,4% of the world's GDP could be lost annually[80]. Insured losses related to natural disasters exhibited a 5%-7% annual growth between 1992 e 2022, with more severe climatic events accounting for the majority of insured losses. In a report del 2022 dell'UN Office for Disaster Risk Reduction, it foreseen that by 2030 the number of disasters will increase by 40% compared to 2015, with an estimate of 250 accident yearly. Consequently, Real Estate sector will be impacted tremendously by the increasing in the frequency and in the acuteness of climate physical risk. An ISS ESG's Physical Risk Analysis on Real asset allows for identifying assets at risk, describing the change in risk over time, and breaking down financial impacts by geography and hazard. The analysis is applied to a fictious real estate portfolio of 100 assets globally distributed proportionally to the world's population and gross domestic product (GDP). The figure below describes in detail the findings of that analysis.

[79] Centre for Research on the Epidemiology of Disasters - CRED. (2022). *2021 Disasters in numbers*. PreventionWeb.
[80] SP Global. (November 2023). Munday, P. Amiot, M. Sifon-Arevalo, R. Sustainability Research, Economic Research, Sovereign Credit Ratings. Lost GDP: Potential Impacts of Physical Climate Risks

Figure 2: Global portfolio of Real Estate Assets, with Modelled Futured Damage due to Climate-Change Physical Risks



Source: ISS ESG Physical Risk Real Asset Analysis

The figure 1 part A shows, under a plausible warming scenario, in 2050 the total annual damage resulting from acute physical threats. An asset from a hypothetical portfolio of 100 assets is represented by each circle. The color represents the total predicted annual damage from wildfires, tropical cyclones, river floods, and coastal floods (as a percentage of asset value). In the Figure B, instead, in a plausible warming scenario, the number of intense heat stress episodes (days per year) will change from 2030 to 2050. This data highlights the importance of addressing physical risks related to climate change and extreme weather events in the real estate sector, as well as the need to take adaptation and mitigation measures to protect property, communities, and infrastructure. In this context, it becomes essential that the real estate sector implements adaptation and mitigation strategies to address such risks. Only through timely and targeted action, based on data and in-depth analysis, will be possible to ensure the sustainability and resilience of the real estate sector in the face of the growing challenges posed by extreme weather events. Table 2 presents the main physical risks to the sector.

Table 2: Physical Risk in the Real Estate Sector

Risk	Summary
Seal Level rise and coastal flooding	Sea level rise and coastal flooding will become more frequent and severe, increasing property damage, and causing higher repair and maintenance costs.

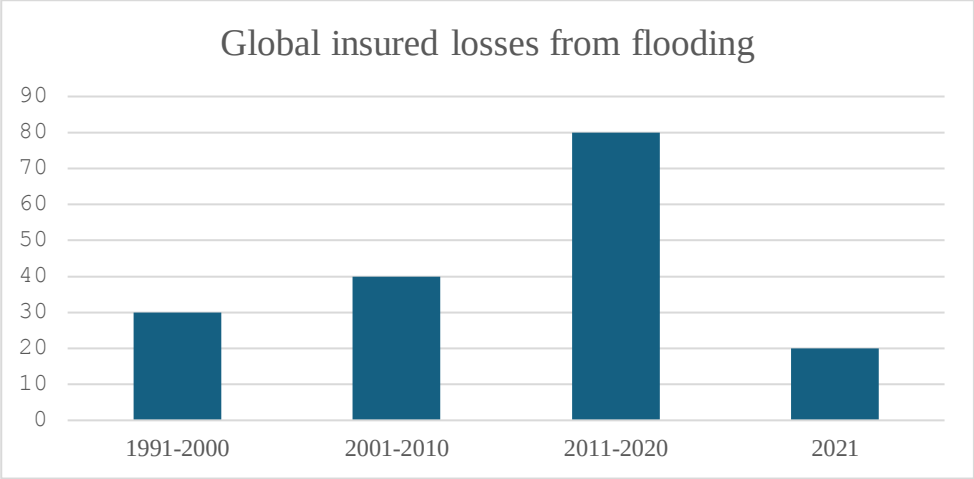
Inland flooding	Inland flooding due to the greater frequency and severity of coastal storms or extreme precipitation events can increase property damage. Driven by rapid urbanization, it can also cause the costs of repairing and maintaining properties to rise.
Extreme storms and wind	Greater severity and frequency of extreme storms, such as hurricanes, can cause damage worth billions of dollars. Extreme storms can negatively impact the value of commercial real estate in the near term.
Wildfires	Millions of residential and commercial buildings have been built in areas prone to wildfires. With the intensity and severity of such fires increasing, the likelihood of these properties being destroyed by a wildfire rises.
Subsidence	An increasing number of real estate assets are likely to be at risk of subsidence in the coming years, potentially causing serious structural damage to buildings.
Heat and Water Stress	Rising heat will create new cooling needs for buildings, increasing operating costs. Water stress will also lead to higher operating costs due to increased water prices, the need to improve water efficiency, and the regulation of water use.

Source: Personal Elaboration.

Climate change significantly threatens the real estate sector with coastal flooding due to rising sea levels and increased inland flooding from intense rainfall overwhelming drainage systems (NYC Planning, 2018). Approximately 40% of the global population lives within 100km of the sea, with two-thirds of the largest cities are located on the coast (UN). More precisely, approximately 23% of

the global population directly faces the risk of flooding exceeding 0.15 meters [81]. Additionally, by 2050, sea level rises are expected to affect land inhabited by 300 million people annually (Climate Central, 2019). This escalation raises repair and maintenance costs, disrupts businesses, and increases insurance premiums, affecting real estate prices and market stability (First Street Foundation, 2021). Additionally, inland flooding, though not directly on the coast, often results from coastal storms or intense precipitation events[82].The combination of population growth and urbanization has increased society's exposure to urban flooding [83]. This type of flooding can damage real estate, raise maintenance, and repair costs for property owners, compromise essential infrastructure, and destabilize the economy. Worldwide insurance losses from flooding are rapidly rising, according to a Swiss Re research. Between 1991 and 2000, these losses amounted to nearly US$30 billion. The graph 5 below illustrates the global insured losses from a time frame between 1991 to 2021.

Graph 5: Global insured losses from flooding from 1991 to 2021 (in US$ Billion)



Source: Personal Elaboration with data retrieved from Swiss Re, 2020.

Furthermore, Global warming is expected to result in more intense and frequent tropical storms, such as hurricanes, cyclones, and typhoons. With the growing demand for coastal properties, these assets face increasing exposure to risks from tropical storms. For instance, it is estimate that more than 32 million homes along the Atlantic and Gulf coasts, with a combined property value of US$8.5 trillion, are at risk of hurricane wind damage.

[81] Salhab, Melda; Rentschler, Jun. 2020. People in Harm's Way: Flood Exposure and Poverty in 189 Countries. Policy Research Working Paper; No. 9447. © World Bank, Washington, DC. http://hdl.handle.net/10986/34655 License: CC BY 3.0 IGO.

[82] U.S. Climate Resilience Toolkit. (n.d.). Inland flooding. Retrieved from https://toolkit.climate.gov/topics/coastal-flood-risk/inland-flooding

[83] Swiss Re Institute. (2022, September 1). *Economic Insights – Flood: new risk-based pricing capabilities, new opportunities to close protection gaps* (Issue 20/2022). Retrieved from https://www.swissre.com/dam/jcr:e152fdfc-ae16-4225-8705-b5948f4a47cc/2022-september-sri-economic-insights-flood-risk.pdf

Yet, with the intensification and severity of wildfires attributed to climate change, real estate in vulnerable regions faces escalating risks. Millions of residential and commercial buildings have been constructed in areas prone to wildfires and this risk is rapidly affecting the value of commercial building. Indeed, property values in fire-prone locations may be further depressed by potential purchasers and renters turning away from the increased risk of their houses succumbing to wildfires. Considering the flooding, more severe and frequent wildfires will cause property damage and increase the expense of upkeep and repairs. As a direct consequence, insurance premiums may rise as a result of rising real estate expenses (Forbes, 2022b). Additionally, as global temperatures rise and dry weather becomes more prevalent, the likelihood of subsidence due to climate change increases. According to an interesting analysis, the British Geological Survey predicted that by 2030, 6.5% of buildings in Britain are expected to be impacted, up from 3% in 1990 (British Geological Survey, 2021

5.2.2 Transition Risk

As previously reported, the real estate sector's role in the construction and operation of buildings around the world makes it responsible for approximately 40% of total global greenhouse gas emissions. As a result, the ambition to reach zero emissions requires major changes in the sector and exposes it to various transition risks, such as declining market attractiveness, increased regulation, and reputational risk. Transition risk in the real estate sector arises from various factors, including rising costs attributed to carbon pricing, along with other elements such as high energy expenses, stringent building regulations and evolving market perceptions. These perceptions may be influenced by, among other considerations, increased public awareness, reduced demand for energy-intensive properties, and poor greenhouse gas emissions performance. Furthermore, companies may encounter competition, reputational damage, and legal liabilities as additional risks in this environment. Properties that fail to meet the 1.5°C aligned decarbonization standards of the Paris Agreement will face increasing exposure to transition risks and could potentially be considered “stranded assets”.
The transition risks facing the real estate sector also pose a risk to the workers and communities that rely on the sector for jobs and income. It is therefore important to align financing with a just transition approach that considers the impact of the transition on the groups most at risk in the real estate sector, including workers and local communities. The following text aims to give a brief overview of the main transition risks to which the sector is most exposed. Table 3 summarizes the main risks, followed by an analysis of each.

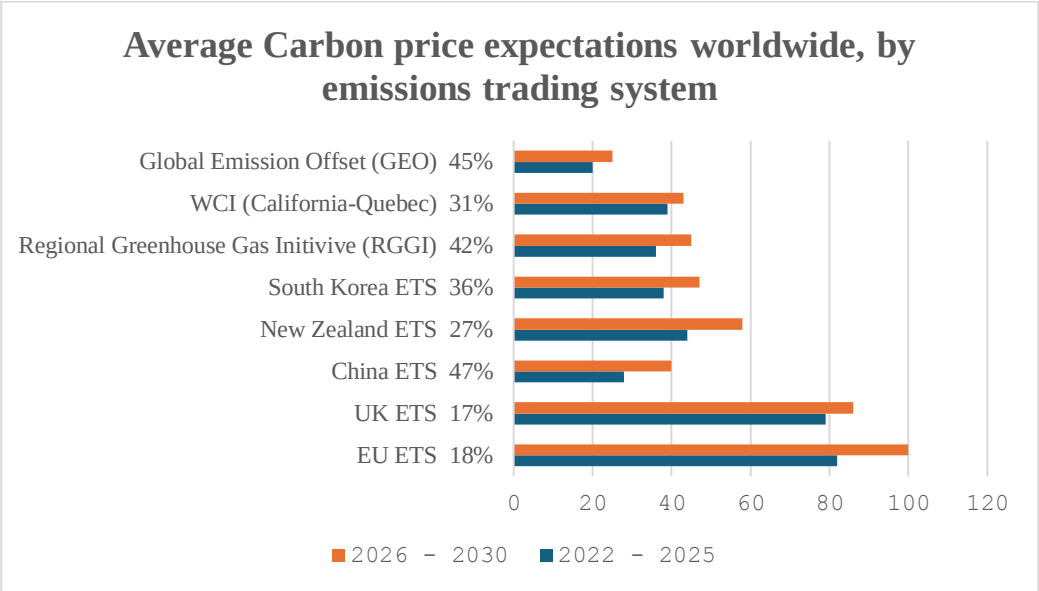
Table 3: Transition Risk in Real Estate

Risk	Summary
Increasing regulation and policy pressure	The sector will be impacted by increasing regulation and new policies, such as stricter building standards, carbon pricing, and additional reporting standards.
Cost of indirect emission	Activities like construction, refurbishment, and demolition contribute significantly to indirect emissions. Although a real estate company may not have direct control over these emissions, it could exert influence over their magnitude. As carbon-intensive building materials become more costly in the coming years, construction costs will rise.
Shifting market preferences	As awareness of climate change grows, tenants and potential buyers are beginning to expect more from the real estate sector regarding emissions reductions. The sector faces new risks as preferences shift towards high-efficiency buildings with renewable energy sources.
Change in investor sentiment	To align portfolios to climate goals, investors could attempt to offset emissions elsewhere in their portfolio to counter high-emitting buildings or favor low-emitting real estate assets.
Reputation risk	Inaction to decarbonize could result in the real estate sector facing public pressure to reduce its share of emissions.

Source: Personal Elaboration.

From the analysis in the previous chapter becomes clear that one of the main transition risks is associated with the increasing regulation and policy pressure. For example, some jurisdictions, like the one in UE, are considering new efficiency requirements to improve the energy efficiency and electrification of buildings, for example by improving thermal insulation and banning the use of fossil fuel and gas-based heating systems (Source: UNEP FI, 2022). While such regulations are likely to be accompanied by government subsidies, households and businesses could incur high compliance costs or risk having their assets priced out of the market. For instance, the Renovation Wave introduces stringent regulatory requirements that all EU member states must integrate into their national building codes. These include mandatory energy performance upgrades and the incorporation of renewable energy technologies in both residential and commercial properties. Properties that fail to meet these new standards risk becoming non-compliant, leading to potential devaluation—a phenomenon known as "stranding" of assets. The European Commission estimates that 75% of the EU's building stock is currently below these desired performance levels, highlighting the scale of the challenge ("State of the Energy Union," 2021). Additionally, the cost of emissions represents a huge risk since the use of carbon-intensive building materials is driving up costs, making construction more expensive. The World Bank released data indicating that global revenue from carbon pricing increased from 12 billion dollars in 2012 to 86 billion dollars in 2022. It is shown below an interesting graph (Graph 6) that illustrate the average carbon price expectations worldwide, by emissions trading system.

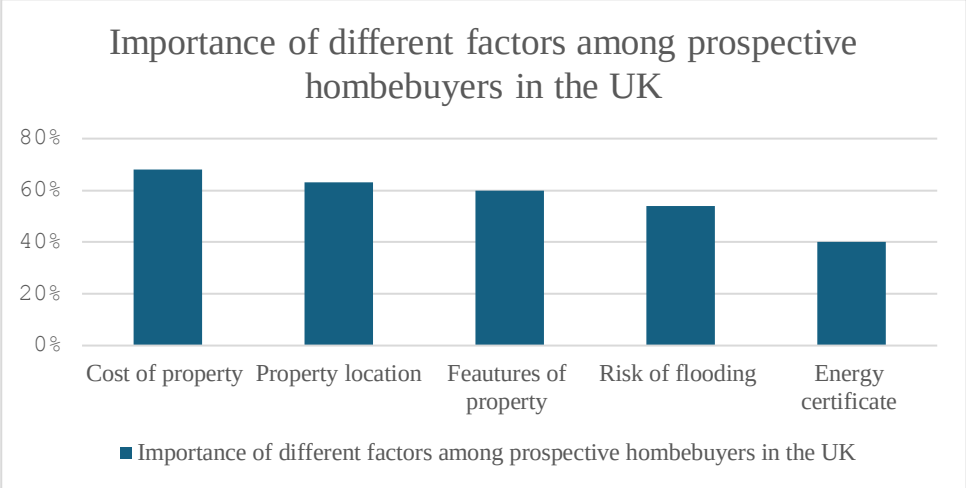
Graph 6: Average Carbon price by emission trading system



Source: Personal Elaboration based on data retrieved from Statista.

It is clear that, in the European context, the cost of coal is the highest, followed by the UK and China. Another crucial transition risk arises from the shifting market preferences for residential and commercial buildings, driven by growing awareness of climate change and its impacts. A survey conducted in 2023 in UK found that 40 percent of UK adults planning to buy a home in the next 10 years deemed the energy performance certificate rating as a very important factor.
The graph 7 shows that 54% of homebuyers take into consideration the physical risk of flooding when a new home being and 40% the energy efficiencies[84].

Graph 7: Importance of different factors among prospective homebuyers in the UK



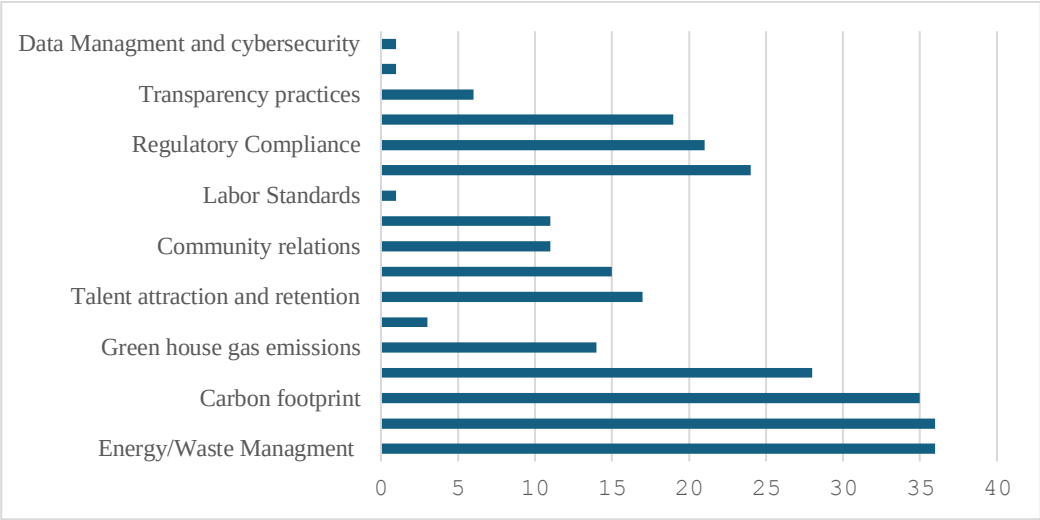
Sources: Elaboration of the Author with data retrieved from Statista

Additionally, A growing number of investors are aligning their portfolios with the goals of the Paris Agreement, joining initiatives such as the Net-Zero Asset Owner Alliance and Climate Action 100+. As a result, sustainability and climate change are becoming primary considerations in real estate investment decisions (Source: Urban Land Institute, 2020)[85]. To align their portfolios, investors can look to offset emissions elsewhere in their portfolio to balance high-emitting buildings or favor low-emitting real estate assets. With the price of carbon rising in markets such as the European Union Emissions Trading System and the increasingly bleak outlook for carbon-intensive buildings, investors are likely to turn to more cost-efficient real estate investments. energetic view. According to a survey conducted by AFIRE among [86] real estate investor worldwide, ESG is going to play an

[84] IETA. (May 23, 2023). Average carbon price expectations worldwide from 2022 to 2030, by trading system (in euros per metric ton of CO_2. In Statista.
[85] Urban Land Institute. (2020). Climate Risk and Real Estate: Emerging Practices for Market Assessment. Retrieved from https://urbanland.uli.org/sustainability/uli-report-how-investors-assess-climate-risk-at-the-market-level
[86] AFIRE. (2022). 2022 International Investor Survey Report. Retrieved from https://www.afire.org/survey/2022survey/

increasingly important role in the future. The graph 8 below synthetizes clearly the key ESG metrics taken into consideration by Real Estate investors.

Graph 8: Main ESG metrics taken in consideration by real estate investors expressed in percentage.



Source: Elaboration of the Author bases on data retrieved from AFIRE; CBRE; Holland Partner Group.

6. Impact of Physical and Transitional risk on Asset performance and Values

As previously discussed, the magnitude and extent of both physical and transitional risks can significantly influence asset performance and value within the real estate sector. These risks, whether physical or transition, directly, and indirectly affect revenue, operating costs, capital costs, and capitalization rates. Transitional risks, in particular, deserve attention due to their considerable impacts on these financial metrics. The direct impact on revenue arises from the decreased attractiveness of carbon-intensive assets to occupiers committed to climate initiatives. For what concern the carbon- intensive assets, it is important to mention that in 2023, 73 carbon pricing initiatives globally covered 23% of annual greenhouse gas emissions[87]. The trend towards carbon pricing is expected to escalate, with the World Bank noting a substantial increase in global revenue from carbon pricing from $12 billion in 2012 to $86 billion in 2022. With carbon costs rising, the market dynamics are shifting towards materials and services that have a lower carbon footprint, influencing both construction practices and property values. Significant changes in carbon pricing are expected globally, with predictions suggesting a price increase to $150-200 per ton of CO2e by 2050[88]. This escalation poses a 'carbon risk' that could impact economic output severely if

[87] World Bank. (2023, May 23). Record high revenues from global carbon pricing near $100 billion.
[88] Fidelity International. (2021). Strategic asset allocation in climate change and inflation.

unaddressed, with potential GDP losses up to 18%, as per Swiss Re[89]. This financial perspective is crucial for the real estate sector, as higher energy costs correlate with lower property values. Indirect effects may include reduced local real estate demand and occupancy due to sectoral declines. Operating costs may directly increase due to elevated utility expenses resulting from carbon-intensive building systems, while indirectly, carbon charges imposed by location regulations may contribute to this rise. Furthermore, significant capital investments may be necessary to comply with local energy efficiency and emissions standards or tenant preferences, such as early retrofitting of heating/cooling systems and the procurement of lower-emission building materials like steel, cement, and timber. Indirectly, capital costs may escalate due to heightened financing expenses as investors and lenders adjust for market-level transition risks, especially in economies reliant on carbon-intensive industries. Indeed, one of the most significant financial risks comes from the substantial investment required to upgrade buildings to meet new standards. For example, UK estimates that between £35 billion and £65 billion will be needed to bring homes up to Energy Performance Certificate standards by 2035[90]. These expenses may not always be offset by government subsidies, leading to potential financial strain for homeowners and investors. Moreover, properties that do not comply with new regulations risk becoming devalued or unmarketable. This is particularly critical in markets where a high percentage of the building stock is below desired energy performance levels. For instance, the European Commission has noted that 75% of the EU's building stock is currently underperforming, which highlights the scale of potential devaluation risks[91]. The timing and implementation of these policies also introduce a significant level of uncertainty. Delayed or sudden implementation of policies, as seen in the Bank of England's scenario analysis, can lead to varied economic impacts and mortgage losses[92]. This uncertainty can deter investment and complicate long-term planning for businesses and investors. Operational challenges also arise as firms need to adapt to new building codes, energy performance certificates, and other regulatory requirements. This necessitates changes in operational practices, involving significant adjustments in project management, supply chain logistics, and compliance strategies, which in turn can increase operational costs. As the sector moves towards sustainability, transition risks also emerge during the adjustment period. The shift towards energy-efficient and decarbonized buildings may render existing buildings obsolete faster than anticipated, affecting their lifespan and profitability. Additionally, the broader economic impact of these policies, including potential effects on housing prices and employment in the construction and real estate sectors, also poses risks. Increased costs of compliance may be passed on to consumers,

[89] Swiss Re Institute. (2021). *Climate change - Annual report 2021*. Swiss Re.
[90] BEIS Committee. 2019. Energy efficiency: building towards net zero: Government Response to the Committee's Twenty-First Report of Session 2017–19. 30 October 2019.
[91] European Commission. (Updated 2024, March). EU Building Stock Observatory (BSO). Energy Efficiency - Energy.
[92] Bank of England. (2021). *Results of the 2021 Climate Biennial Exploratory Scenario (CBES)*.

affecting affordability and market demand. In response, real estate companies and investors are undertaking risk assessments to understand the potential impacts of new policies on their portfolios. This includes scenario planning to account for various policy implementation timelines and market responses. Many are also investing in new technologies and building practices that enhance energy efficiency, potentially mitigating some of the risks associated with compliance and opening new market opportunities in the growing sector of sustainable real estate. Active engagement with policymakers and participation in the regulatory discussion can help shape outcomes that are more favorable or at least predictable, thus reducing uncertainty. Moreover, diversifying assets and exploring opportunities in markets or segments less affected by stringent regulations can reduce overall exposure to policy risks. Similarly, the magnitude of physical risk aligns with the key indicators mentioned earlier. An analysis of revenue reveals the escalating impact of severe weather events and natural disasters, causing disruptions directly to asset operations and indirectly reducing real estate demand in affected local markets due to infrastructure disruptions. For instance, flooding directly increases maintenance and repair costs for property owners, which can be substantial depending on the severity of the flood and the vulnerability of the infrastructure. The immediate aftermath often sees a decline in property values in affected areas. For example, research has shown that in England, properties damaged by floods were valued at nearly 25% less than non-affected properties[93]. While these prices often return to normal within a few years, the temporary depreciation affects homeowners' equity and can influence decisions on purchasing or investing in real estate within flood-prone areas. Additionally, investments aimed at enhancing building resilience against rising physical risks, such as green roofs and protective measures for electric and mechanical systems, can significantly raise capital costs. Operating costs are also significantly affected by increased physical risks, leading to higher maintenance expenses and substantially elevated insurance costs as insurers adapt underwriting models to account for physical risks. Furthermore, as noted by Deroubaix[94], the increasing global temperatures necessitate higher energy use for cooling buildings, with the International Institute for Sustainable Development (IISD, 2020) projecting a tripling of energy needs for space cooling by 2050 in hot and tropical regions. Concurrently, the Intergovernmental Panel on Climate Change (IPCC, 2022) highlights the explosive growth in cooling appliances, expected to increase from four billion to 14 billion by 2050, indicating a surge in energy consumption and associated costs. Additionally, properties in water-stressed regions are confronted with higher costs due to the need for water sourcing and efficiency measures. Blackrock identifies that approximately 60% of global real estate investment trusts located in high water stress areas like

[93] Environment Agency. (2021). *Evidence on the costs of floods in England and Wales*.
[94] Deroubaix, A., Labuhn, I., Camredon, M. *et al.* Large uncertainties in trends of energy demand for heating and cooling under climate change. *Nat Commun* 12, 5197 (2021).

Malaysia, the Philippines, Japan, Hong Kong, and Australia will face increased expenses[95]. To conclude, both physical and transition risks play critical roles in shaping asset performance and value within the real estate sector, with direct and indirect consequences across revenue, operating costs, capital costs, and capitalization rates. Understanding and mitigating these risks are paramount for sustainable and resilient real estate investment strategies. In this regard, depside the profound impact of climate related risk on the financial performance of Real Estate sectors, is significant to acknowledge that almost 60% of companies in the S&P 500® (market capitalization of $18.0 trillion) and more than 40% of companies in the S&P Global 1200 (market capitalization $27.3 trillion) hold assets at high risk of physical climate change impacts[96]. Wildfires, water stress, heatwaves, and hurricane (or typhoons) linked to increasing global average temperatures represent the greatest drivers of physical risk[97]. All the various financial impacts of climate change-induced risks to real estate assets are grouped in the table 4. Specifically, the table below summarizes the direct and indirect impacts of climate change within each of the four financial categories—Revenue, Operating Cost, Capital Cost, and Capitalization Rate—providing some holistic picture about potential consequences for real estate.

Table 4: Financial impact of Transition and Physical risk on key variables

	Transition Risks		**Physical Risks**	
	Direct effect	**Indirect effect**	**Direct effect**	**Indirect effect**
Revenue	Unattractiveness of a carbon-intensive asset to an occupier that has made a climate commitment	Decline in a sector or local economy resulting in lower real estate demand/occupancy	Disruptions to an asset's operations from severe or repeated physical-hazard events (e.g., major floods)	Reduced real-estate demand in a local market given disruptions to surrounding transportation or other infrastructure
Operating cost	Increased utility costs in carbon-intensive building systems	Carbon charges on an asset given local regulations	Increased maintenance	Increased insurance costs as insurers

[95] Majority of REITs Will Experience Water Scarcity by 2030, BlackRock Says." *Chief Investment Officer (CIO)*. Published July 30, 2020.
[96] Lord, R., Bullock, S., & Birt, M. (2019, November 25). *Understanding climate risk at the asset level: The interplay of transition and physical risks*. S&P Global.
[97] S&P Global. (2019). *Understanding climate risk at the asset level: The interplay of transition and physical risks*. S&P Global. Retrieved from https://www.spglobal.com/en/research-insights/featured/understanding-climate-risk-at-the-asset-level-the-interplay-of-transition-and-physical-risks

			costs as physical risks increase	recognize physical risks and adjust underwriting models
Capital cost	Significant capital investment required to meet local energy efficiency/emissions standards or tenant demands (e.g., early retrofit of heating/cooling systems), increased need to purchase lower emissions building materials (e.g., steel, cement, timber)	Increased financing costs as investors and lenders price in transition risks (e.g., in carbon-intensive economies dependent upon carbon-intensive industries)	Investment required to improve the resilience of building to increasing physical risks (e.g., elevating lobby, green roofs, protective reflective and mechanical systems)	Increased capital investments (e.g., developing fees) required to protect broader communities from climate risks (e.g., floodwalls, green infrastructure for heat mitigation)
Capitalization Rate	Changes in capitalization rate due to perceptions of both participants			

Source: Personal Elaboration.

6.1. Conclusion

The previous chapter analyzed the financial impact of physical and transition risks on real estate, considering key variables such as revenue, operating costs, capital costs, and capitalization rates. It underscored the imperative for the financial sector to dynamically adapt and strategically align with the evolving demands of a market increasingly influenced by climate-related and economic challenges. At this juncture, the thesis provided a robust framework for understanding how deeply these environmental risks can influence market valuations and the overall financial stability of the real estate sector. Consequently, it becomes essential to delve deeper into real estate finance to identify and develop financial strategies that can effectively respond to and mitigate these impacts. Real estate finance serves as the backbone that supports the sector's ability to adapt to and absorb the

ramifications of these risks. By discussing financial instruments and methods post-risk assessment, is possible to identify how investors, developers, and financial institutions can recalibrate their approaches to funding, investing, and managing real estate assets under increased risk conditions. Chapter 7 illustrates real estate finance and provides an overview of the main traditional instruments available in the market. This sets the stage for Chapter 8, which analyzes innovative financial products and arrangements emerging in response to these risks. These financial solutions, such as sustainability-linked loans and green bonds, play a pivotal role in driving the sector towards sustainability and resilience. They provide the necessary capital to implement risk mitigation strategies, such as retrofitting buildings to enhance their resilience or investing in new developments that adhere to stringent environmental standards. This chapter bridges the gap between identifying potential threats and actively engaging in financial practices that protect and create value for real estate investments in the context of environmental realization and economic volatility. Moreover, the chapter delves into the nuanced ways these financial instruments are structured to align with environmental goals. For instance, sustainability-linked loans typically feature interest rates tied to the borrower's performance on specified sustainability targets, thus incentivizing greener practices. Similarly, green bonds are earmarked exclusively for projects that deliver environmental benefits, thereby channeling investments towards sustainable real estate projects. These instruments not only help mitigate risks but also enhance the market's resilience by promoting sustainable practices and long-term value creation. Additionally, the chapter explores the role of regulatory frameworks and policy interventions in shaping the financial landscape of the real estate sector. Governments and regulatory bodies are increasingly recognizing the importance of sustainable finance and are implementing policies that encourage or mandate the adoption of green financial products. These policies can include tax incentives, subsidies for green developments, and stricter environmental regulations for new and existing buildings. By aligning financial incentives with environmental objectives, these regulations help to mainstream sustainable finance in the real estate sector. In conclusion, this chapter emphasizes the critical role of innovative financial strategies in addressing the complex interplay between environmental risks and real estate finance. By leveraging traditional and emerging financial instruments, the sector can not only mitigate risks but also capitalize on the opportunities presented by the transition to a more sustainable and resilient market. This proactive approach is essential for ensuring the long-term financial stability and growth of the real estate sector in an era of unprecedented environmental and economic challenges.

7. Real Estate Transition Finance

7.1. Transition finance and Credible Transition Plans

The EU Commission has indicated that, in a European context, "*transition finance should be understood as the financing of climate- and environmental performance improvements to transition towards a sustainable economy, at a pace that is compatible with the climate and environmental objectives of the EU*"[98], therefore, highlighting that the compatibility with EU Green Deal[99] objectives and with other EU policy initiatives is another relevant component of transition finance at EU level.

The EU Commission has also provided a definition of "transition finance" as, *inter alia*, "*the financing of investments compatible with and contributing to the transition, that avoids lock-ins, including: … (c) investments in undertakings or economic activities with a credible transition plan at the level of the undertaking or at activity level; [or] (d) investments in undertakings or economic activities with credible science-based targets, where proportionate, that are supported by information ensuring integrity, transparency and accountability*"[100].

Transition finance, thus, refers to financial investments and mechanisms aimed at supporting sectors and industries, such as real estate, in the transition from high-carbon to low-carbon operations. This type of financing is therefore crucial to enable the transition towards more sustainable and environmentally friendly practices and to ensure that industries can achieve climate objectives and regulatory requirements while remaining economically and financially sustainable. Specifically, transition finance is designed to bridge the gap between traditional finance, which often supports business-as-usual operations, and green finance, which exclusively finances projects with clear environmental benefits. This type of finance plays a critical role in helping sectors that contribute significantly to greenhouse gas emissions, to gradually transform their operations, technologies and infrastructure to reduce their environmental impact. The need for transition financing in the real estate sector is driven by the urgent challenges of climate change, regulatory pressures and changing market dynamics. Since the real estate sector contributes significantly to greenhouse gas emissions, it becomes essential to invest in highly energy-efficient technologies, renewable energy sources and sustainable construction practices. In this direction, transition financing facilitates these investments, allowing the sector to reduce its carbon footprint and contribute to global climate mitigation efforts.

The financing instruments for the transition, as set out by the EU Commission Recommendation, are diverse and include green bonds, sustainability-linked loans, and dedicated investment funds.

[98] Commission Recommendation (EU) 2023/1425 of 27 June 2023 on facilitating finance for the transition to a sustainable economy, C/2023/3844, *OJ L 174, 7.7.2023, p. 19–46,* ELI: http://data.europa.eu/eli/reco/2023/1425/oj

[99] Communication of the Commission of 11 December 2019 (COM(2019) 640 final).

[100] Commission Recommendation (EU) 2023/1425 of 27 June 2023 on facilitating finance for the transition to a sustainable economy, cit., at Article 2.2, p.23

Additional instruments include green equity, green loans and Mortgage. While these tools may all be encompassed by the definition of transition finance, only those that are essential for providing the capital needed to implement energy-efficient technologies, adopt sustainable construction practices, and ensure compliance with rigorous environmental standards can be defined as true transition finance. These instruments are crucial to achieving decarbonization in line with the objectives of the EU Climate Law, which aims to make Europe the first climate-neutral continent by 2050. This need to be expanded: Indeed, in an EU context the definition of real estate transition finance should not be made in vacuo but reflect policy objectives under the Green Deal and leading best practices by EU Member States This leads to the definition of the main areas of impact of transition finance in the real estate sector, namely embodied carbon, energy efficiency, new energy sources (such as heat pumps) and construction practices. The purpose of this dissertation is to identify the key performance indicators (KPIs) that can be effectively integrated into a transition finance plan to achieve the decarbonization of real estate in line with EU policy objectives. Specifically, after analyzing the Net-Zero Industry Act, Metrics for Embodied Carbon, and the EU taxonomy, the research aims to determine which KPIs can accelerate the development of a credible transition plan. Before delving into the specifics of KPIs in transition finance and their role in transition plans, it is important to define what constitutes a "credible transition plan." Since there is no no common definition of “credible” transition plans in EU hard law, the main legal source helping to define the concept of “credibility” of transition plans is the Commission Recommendation (EU) 2023/1425 of 27 June 2023[101], on facilitating finance for the transition to a sustainable economy (the “EU Recommendation on Transition Finance”), which provides various recommendations that transition plans should be following both at entity and activity levels. According to the EU Recommendation on Transition Finance, credible transition plans are a key tool for companies to articulate their targets and actions for transitioning to a climate-neutral or sustainable economy. According to the EU Recommendation on Transition Finance, credible transition plans are essential for companies to outline their targets and actions for transitioning to a climate-neutral or sustainable economy. The EU Commission states that these plans should include information on milestones, activities, processes, and resources, and should be time-bound, science-based, and actionable. They need to be integrated into the overall business strategy and cover the transition to environmental objectives. Furthermore, credible transition plans should uphold the integrity, transparency, and accountability of targets, avoid long-term commitment to greenhouse gas (GHG)-intensive or environmentally harmful activities (known

[101] Commission Recommendation (EU) 2023/1425 of 27 June 2023 on facilitating finance for the transition to a sustainable economy, C/2023/3844, *OJ L 174, 7.7.2023, p. 19–46*, ELI: http://data.europa.eu/eli/reco/2023/1425/oj

as "carbon lock-in")[102], and ensure a robust governance process to support their implementation and oversight.

The credibility of a transition plan is paramount in decarbonizing the real estate sector while maintaining financial and economic stability. The impact of a plan's credibility extends to credit risk valuation[103], capital allocation[104], reputational risk, and potentially the definition of greenwashing boundaries and related legal liabilities[105]. Credibility is crucial not only for the near, medium, and long-term prospects of non-financial corporations (NFCs) but also for investors and credit institutions. These stakeholders rely on credible transition plans to assess potential transmission channels, particularly those affecting the reporting entity and its alignment with warming objectives. At this juncture, before delving deeper into the existence of accurate and forward-looking KPIs that can align the real estate sector with the environmental objectives of EU policies, it is important to analyze how the transition can be financed, and which instruments are available in the market for Real Estate. Once the EU main policies for real estate set the standards and establish the time frame, it is essential to evaluate financial products to determine whether they are adequate to meet these standards. The next paragraph explores the financial products available for the transition and for the green finance in Real Estate. Consequently, this dissertation analyzes the necessary KPIs to monitor and capture the mitigation and transition elements.

[102] OECD (2023), Mechanisms to Prevent Carbon Lock-in in Transition Finance, Green Finance and Investment, OECD Publishing, Paris, https://doi.org/10.1787/d5c49358-en.

[103] Association Europe Finances Régulations (2023). *Transition plans: ensuring their comparability, credibility and effectiveness to accelerate the low carbon transition*, Debate Paper, Issue n° 5/2023, November 2023, https://www.aefr.eu/en/debate-papers. Accessed on 15 March 2024. European Central Bank, *"Failing to plan is planning to fail" – why transition planning is essential for banks*, Supervisory blog 23 January 2024, https://www.bankingsupervision.europa.eu/press/blog/2024/html/ssm.blog240123~5471c5f63e.en.html#:~:text=Key%20findings%20from%20the%20ECB's,roughly%2090%25%20of%20these%20banks. Accessed on 15 February 2024. European Central Bank, Risk of misalignments of banks' financings from EU climate objectives, January 2024, www.bankingsupervision.europa.eu/ecb/pub/pdf/ssm.bankingsectoralignmentreport202401~49c6513e71.en.pdf. Accessed on 15 February 2024.

[104] United States Environmental Protection Agency (2024), Climate Transition Planning, https://www.epa.gov/climateleadership/climate-transition-planning. Accessed on 15 March 2024. IIGCC (2023), *Investor Expectations of Corporate Transition Plans: From A to Zero*, at https://139838633.fs1.hubspotusercontent-eu1.net/hubfs/139838633/Past%20resource%20uploads/IIGCC_Investor-expectations-of-corporate-transition-plans_Final.pdf

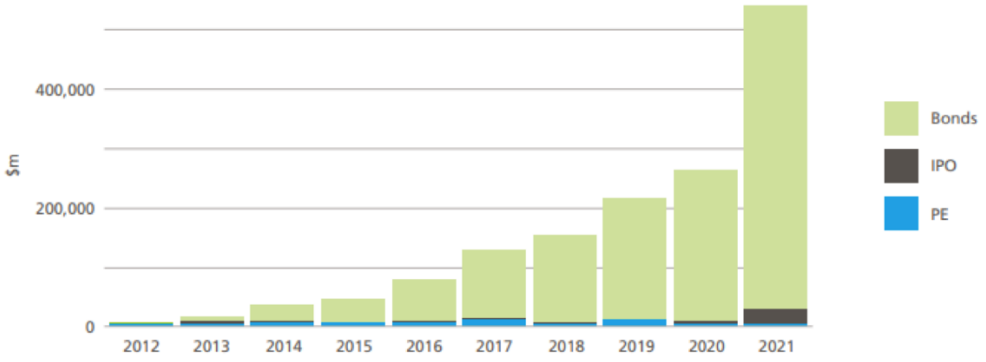
[105] J. Bingler, C. Colesanti Senni, D. Fixler, T. Schimanski (2023), *Net Zero Transition Plans: Red Flag Indicators to Assess Inconsistencies and Greenwashing*, wwfint.awsassets.panda.org/downloads/red-flag-indicators-for-transition-plan-inconsistencies-and-greenwashing-26-sept.pdf. Accessed on 30 March 2024

7.2 Real Estate Transition and Green Finance

After analyzing climate-related risks and the need for transition finance, the thesis explores research on real estate and green finance, focusing on the primary sustainable financial instruments available in the market. This paragraph lays the foundation for a deeper examination of the KPIs crucial for accelerating the transition in the following chapter. At this stage of the dissertation a crucial question arises: *How can investors ensure that the proceeds from green financing products are allocated to real estate projects that effectively mitigate climate change?* and consequently, *which are the KPIs to look at to align the sector towards EU policies' objectives?* Although there is no agreed definition of what precisely qualifies as an "environmentally beneficial" and "climate transition aligned" use of proceeds, several standards have become recognized by the broader market. Green bond market standards were set by the International Capital Market Association (ICMA) and the nonprofit Climate Bonds Initiative. Green loans market standards were set by the Loan Market Association (LMA) in coordination with the Loan Syndications and Trading Association (LSTA) in the United States and the Asia Pacific Loan Market Association (APLMA). Environmental impacts embedded in these green principles for real estate projects are assessed utilizing Energy Performance Certificates (EPCs) and Green Building Rating Systems (GBRSs). In this regard, green debt instruments align the incentives of borrowers and lenders toward sustainability, therefore making it easier for asset managers to meet growing investor appetite for ESG-labelled investment solutions. Is it clear that the Sustainable finance plays a crucial role in directing private investment towards the transition to a low-carbon, sustainable economy. In recent years, sustainable finance products and approaches, such as green bonds and ESG integration, have expanded significantly worldwide. In this context, green financing and the use of ESG factors have also grown within real estate finance markets, recognizing the substantial potential for the buildings sector to aid in decarbonizing the global economy. This section explores the key financial products available in the market and defines what constitutes Green Finance. Additionally, it provides an overview of the significant market expansion in this sector. According to the World Economic Forum, "Green finance (GF) is any structured financial activity that has been created to ensure a better environmental outcome." (Fleming, S., 2020)[106]. The active engagement of the financial sector in driving the 'green revolution' is substantiated by empirical evidence. As highlighted in a recent study conducted by BNP Paribas in collaboration with TheCityUK, the worldwide green finance market has experienced significant expansion, surging from $5.2 billion in 2012 to a substantial $540.6 billion by 2021 (as illustrated in graph 9).

[106] Fleming, S. (2020). What is Green Finance and why is it important? World Economic Forum.

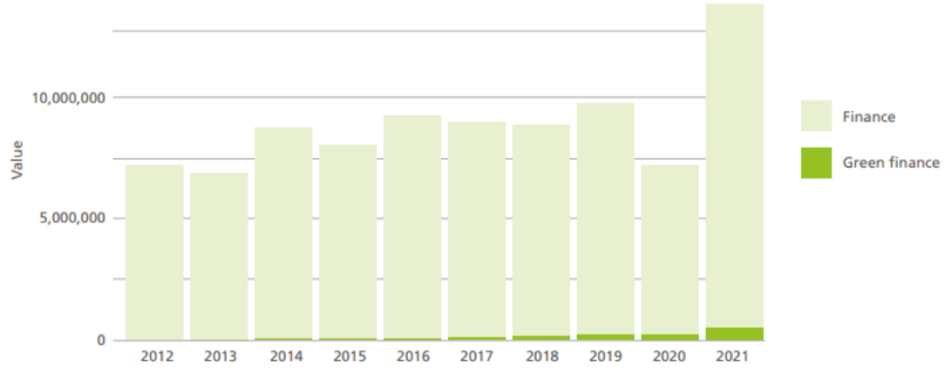
Graph 9: The evolution of global green finance – Bond, IPOs and Private Equity



Source: Green finance: A quantitative assessment of market trends by TheCityUK in partnership with BNP Paribas, 2022.

However, when assessing it in a general sense within the financial industry, one can see that the green finance industry is still a huge potential area for growth. The current development of this industry is only 4% of the total value of the overrating financial sector. This means there is still an enormous scope for the green finance sector to increase its market share and contribute more to the future direction of sustainable finance.

Graph 10: Global green finance and non-green finance value 2012-2021



Source: Green finance: A quantitative assessment of market trends by TheCityUK in partnership with BNP Paribas, 2022.

In this regard, there is considerable optimism that in the forthcoming years, green financial instruments will become increasingly prevalent within the financial system. This optimism is fueled by the development of a robust regulatory framework at the international level, which is poised to provide the necessary support and guidance for the proliferation of green finance. At the end of 2021, issuance in sustainable debt markets reached record levels at USD 1.6 trillion, 3 times the amount

recorded in 2019 [107]. A notable development is the significant rise of social and other sustainable financial products in addition to green debt products. While green debt issuance has been the largest source of outright capital until 2019, the sustainability themes have grown significantly since 2020. As a result, total issuance is more evenly spread across a range of sustainability themes, well beyond climate-related aspects, since 2020 compared to prior periods. While the issuance of sovereign and corporate bonds has significantly increased following the COVID-19 crisis, the sustainable bond market has emerged as a versatile source of finance. It supports both the immediate impacts and long-term recovery plans associated with the path to net-zero carbons emissions and the implementation of the Sustainable Development Goals (SDGs). It is important to say that in this regard, the green debt markets are dominated by European markets with a significant share of green debt proceeds allocated to green buildings. In particular, issuance of green debt instruments has grown substantially in the recent years. In 2021, the issuance of green debt reached a total of USD 500 billion. While bonds dominate the green debt markets, these markets also encompass loans and asset-backed securities (ABS) products. The European green debt market led the way, accounting for over 50% of the total green debt issuance in 2021. China and the United States followed, representing 19% and 16% of the total issuance, respectively[108]. The following paragraphs illustrates the main Sustainable financial instruments for Real Estate and explores the main features and trends.

7.2.1 Overview of Sustainable Financial Instruments for Real Estate

To achieve decarbonization in RE industry, significant progress is still needed. According to a 2022 report by McKinsey, an annual investment of $1.7 trillion in physical building assets is required between 2020 and 2050 to reach the net-zero threshold and combat global warming[109]. However, governments, both domestically and internationally, are increasingly unable to meet these financial demands due to insufficient resources, leading to an infrastructure gap. Therefore, it's clear that the majority of investments in the green real estate sector will need to come from the private sector. In this context, private financial entities will serve a dual role: firstly, by investing in solutions designed to address government shortcomings, such as municipal green bonds, and secondly, by directly financing private projects focused on constructing sustainable buildings. Over the past decade, innovative financial instruments have emerged within the financial system to support the transition

[107] Climate Bonds Initiative, Refinitiv, OECD calculations.
[108] Climate Bonds Initiative, Refinitiv, OECD calculations.
[109] McKinsey Global Institute (2022). The net-zero transitions: What it would cost, what it could bring. McKinsey & Company.

toward a greener real estate (RE) industry. The most prominent and widely utilized of these are outlined in the schematic table 5.

Table 5: Most used financial instruments to support the transition in real estate

Green bonds	Green lending	Green fund and trusts
Municipal GBs	Green Mortgages and Mortgages efficiency loans	Green REITs

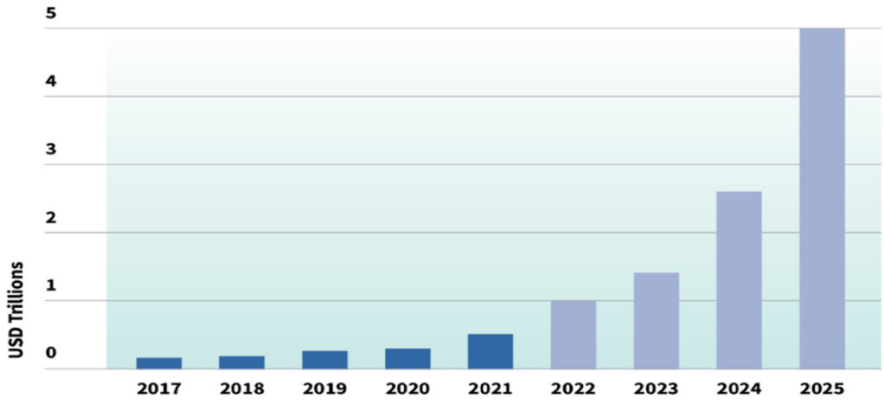
Source: Personal Elaboration.

7.2.1.1 Green Bonds

Green Bonds (GBs) are bonds specifically designed to fund projects with positive environmental impacts. They support sustainability and the transition to a net-zero emissions economy by raising funds for environmentally beneficial projects. Typically, these bonds are structured to ensure that the capital raised is directed toward green initiatives. Most green bonds are "use of proceeds" or asset-backed, meaning the funds are allocated to green projects, but the issuer's financial health guarantees the investment. The green bond market has grown significantly, showing rising interest and commitment to sustainable investing. Between 2012 and 2021, green bonds dominated the landscape of green finance, constituting a substantial 93% of the total global green finance market[110]. Notably, the issuance of green bonds has surged significantly, with the volume rising from $100 billion in 2017 to nearly $600 billion in 2021[111]. This upward trajectory is indicative of the growing recognition and adoption of green bonds as an effective tool for mobilizing capital towards environmentally friendly projects. Looking ahead, experts anticipate a continued exponential growth in the green bond market in the coming years. This projection underscores the evolving landscape of sustainable finance and the increasing emphasis on leveraging financial instruments to address environmental challenges and promote sustainable development.

[110] The City UK & BNP Paribas (2022). Green finance: A quantitative assessment of market trends. The City UK, London.
[111] Climate Bond Initiative (2022). Market data - Climate Bonds Initiative.

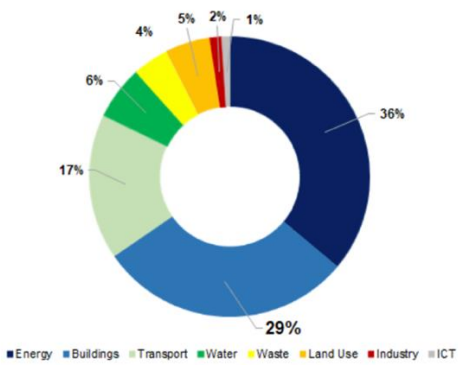
Graph 11: Green bond issuance worldwide 2017-2025 (Tn; $)



Source: Climate Bonds Initiative. (2022)

Analyzing the historical breakdown of the economic sectors towards which the proceeds of issued green bonds have been channeled reveals that the energy, buildings, and transport sectors collectively contribute a significant 81% to the total proceeds volume (CBI, 2022). Specifically, within these sectors, the share of issuances allocated to the building sector has notably increased over the past five years in absolute terms, reaching 30% of the total proceeds volume in 2021. This data highlights the crucial role of Green Bonds in financing the green transition within the real estate industry. By channeling substantial investments into green building projects, these bonds significantly drive sustainability initiatives in the built environment. The increasing funds directed towards the building sector underscore the growing importance of sustainable construction and infrastructure development in mitigating environmental impact and promoting long-term sustainability. Overall, Green Bonds make a significant contribution to environmental objectives in key sectors such as energy, buildings, and transport. As the focus on sustainability intensifies, Green Bonds are expected to continue being a key driver of green financing, accelerating the transition to a more sustainable and resilient economy.

Graph 14: Use of proceed form GBs issuance by project area in 2021(%)



Source: Climate bond initiative database.

- ***Municipal Green Bond***

Municipal Green Bonds (MGBs) form a notable subset within the realm of Green Bonds (GBs). These bonds are issued by municipalities, city governments, and states with the primary objective of financing or refinancing infrastructural projects. MGBs have emerged as a valuable tool for the public sector in addressing the infrastructure deficit and sourcing the necessary funds from the public market to support the transition towards more sustainable urban environments, often referred to as Smart Cities. By leveraging MGBs, municipal and local governments can tap into the capital markets to secure financing for a wide range of initiatives aimed at enhancing urban sustainability. These initiatives may include the development of renewable energy infrastructure, the implementation of energy-efficient transportation systems, the improvement of waste management processes, and the enhancement of green spaces, among others. The significance of MGBs lies in their ability to mobilize private capital towards projects that contribute to the creation of more livable, resilient, and environmentally friendly cities. By issuing these bonds, municipalities can access a diversified pool of investors who are increasingly interested in supporting sustainable initiatives. Furthermore, MGBs offer governments a cost-effective means of financing, as they often come with favorable terms and attract investors who prioritize environmental and social impact alongside financial returns. Overall, MGBs play a crucial role in facilitating the transition to Smart Cities by providing municipalities with the financial resources needed to invest in sustainable infrastructure and innovative urban development strategies. As cities continue to grapple with the challenges of rapid urbanization and climate change, MGBs are expected to remain a vital tool in advancing the sustainability agenda at the local level.

7.2.1.2 Green Lending and Mortgages Efficiency

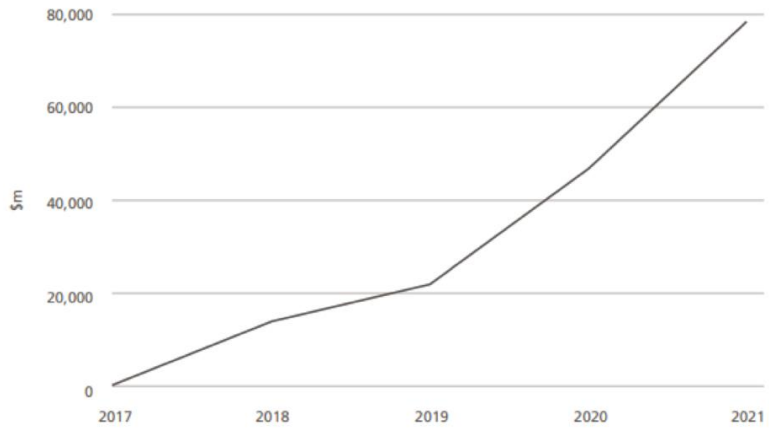
Green loans operate on principles closely aligned with those of Green Bonds (GBs) in that they both aim to raise capital for projects that meet specific environmental criteria (World Bank, 2021).

Green loans are any type of loan instrument made available exclusively to finance or re-finance, in whole or in part, new and/or existing eligible Green Projects.

However, notable differences exist between Green Bonds and green loans in their mechanics, transaction volumes, costs, and international guidelines. Green loans involve direct lending between a financial institution and a borrower, with funds specifically allocated to green-eligible projects. Conversely, Green Bonds involve issuing debt securities in capital markets, with proceeds dedicated to green initiatives. Transaction volumes and costs for green loans vary based on negotiated terms

and generally have lower transaction costs than Green Bonds, which include issuance, underwriting, and listing expenses. Additionally, Green Bonds and Green Loans are guided by different international principles and may be subject to distinct regulatory frameworks and certification standards. Despite being a relatively nascent financial instrument, green loans have experienced notable growth in recent years. At the 2022 Green Horizon Summit during COP26, it was revealed that green lending has witnessed a remarkable surge, with volumes increasing from $432 million in 2017 to a substantial $78.6 billion in 2021 (Graph 15). This impressive growth underscores the increasing recognition and adoption of green financing mechanisms as effective tools for mobilizing capital towards environmentally sustainable projects. While data on green loans may still be limited compared to Green Bonds, the upward trend in green lending volumes suggests a growing appetite among borrowers and lenders alike for financing initiatives that contribute to environmental sustainability. As the green finance market continues to evolve, green loans are poised to play a significant role in driving the transition to a more sustainable global economy.

Graph 12: Global green lending amount 2017- 2021 worldwide (M;&)



Source: Green finance: a quantitative assessment of market trends, by TheCityUk & BNP Paribas, 2022.

The LMA, together with the APLMA (*Asia Pacific Loan Market Association*) and the LSTA *(Loan Syndications and Trading Association)*, produced the GLP (*Green Loan principles*) which are a high-level framework of market standards and guidelines, providing a consistent methodology for use across the green loan market. The four components of the GLP are: Use of proceeds; Process for Project Evaluation and Selection; Management of Proceeds and Reporting. To effectively utilize proceeds in REF investments, it is crucial to first establish what constitutes an eligible 'Green Project.' Currently, there is no universally accepted definition of a Green Project within the REF investment context, as standards, regulations, and best practices are still evolving. Financial institutions typically develop their own internal standards or "eligibility criteria" within a green finance framework to

determine what qualifies as an eligible Green Project. Alternatively, they may rely on external reviews or make case-by-case decisions. These institutions often set internal technical screening criteria, sometimes referencing external certifications or standards, to identify projects eligible for funding under a green REF investment loan. LMA outlines potential categories of Green Projects in the REF investment context. These include acquiring or refinancing green buildings or portfolios of green properties, financing capital expenditures to improve energy performance and water consumption, and financing expenditures related to the financed buildings or portfolios that contribute to climate change mitigation or other environmental goals, such as retrofit works. Several standards and certifications can determine the 'greenness' of a property, though no industry-wide consensus exists on which to adopt. Commonly used standards and certifications include GRESB ratings and alignment with the EU Taxonomy at the company or fund level. For design-based certifications, Energy Performance Certificates (EPCs), BREEAM New Construction, LEED Certification, and DGNB Certification are frequently used. Within the spectrum of green lending instruments, one of the most pertinent to the net-zero transition of the real estate industry is the Green Mortgage Efficiency. This specialized financial product plays a crucial role in incentivizing sustainable homeownership by offering preferential terms to buyers who meet specific environmental criteria for their properties. Under the framework of lenders extend favorable terms to homebuyers who can demonstrate that their prospective property meets certain environmental standards. This may include newly constructed homes with predefined sustainability ratings or existing buildings where the borrower commits to investing in renovations aimed at improving environmental performance. In essence, Mortgage Efficiency is tailored specifically to properties that adhere to green building principles and contribute to environmental sustainability. The key distinguishing feature of a green mortgage lies in its emphasis on promoting green buildings and sustainable homeownership. Indeed, by providing financial incentives such as lower interest rates, reduced fees, or extended repayment periods, green mortgages encourage buyers to invest in properties that are energy-efficient, resource-efficient, and environmentally friendly. By facilitating access to financing for green homes, green mortgages play a vital role in accelerating the adoption of sustainable building practices and driving the transition towards a net-zero emissions future. Moreover, they contribute to the growth of the green real estate market by aligning financial incentives with environmental objectives, thereby fostering a more sustainable and resilient built environment. Overall, green mortgages represent a powerful tool in the arsenal of green lending instruments, offering an effective means of channeling capital towards green buildings and supporting the broader goal of achieving net-zero emissions in the real estate sector (WGBC). Green mortgages have emerged as a promising financial instrument capable of significantly enhancing energy efficiency in residential and commercial buildings. Among

various green financial tools, they stand out due to their ability to incentivize the reduction of real estate's environmental footprint. From a bank's perspective, green mortgages offer several risk-mitigating advantages. Firstly, energy-efficient buildings lead to reduced utility expenses for occupants, thereby enhancing their financial stability and increasing the likelihood of timely mortgage repayments. Additionally, green buildings are often perceived as more valuable over time, creating a "green premium" that makes them safer collateral for banks. This mitigates the risks associated with mortgage lending. In essence, green mortgages promote environmental sustainability while presenting a compelling business case for financial institutions by reducing risk exposure and fostering long-term value in real estate markets.

However, an analysis conducted by the European Banking Authority (EBA) shows a lack of comparability and fragmentation in markets for green loans in the absence of guidance, as well as a common definition and rules[112]. Credit institutions, instead of looking at specific metrics and definitions, mostly rely on their internal standards and criteria. The EU Taxonomy and related technical screening criteria, according to EBA, are used by credit institutions where possible and, in most cases, are limited to the substantial contribution criteria of the environmental objective of climate change mitigation. According to the EBA, the definition of green loans should align with current market practices and industry standards that support the EU's environmental objectives. The key element of a green loan is the use of its proceeds. Furthermore, this report highlights the necessity of integrating the EU Green Deal's policy objectives into existing metrics and standards, which is currently lacking.

7.2.1.3 Real Estate Green Funds and Trust

The transition to renewable energy and sustainable practices within the real estate sector is notably supported by both traditional debt instruments, such as green mortgages, and innovative equity instruments. These equity tools are rapidly gaining popularity among investors, providing them with novel opportunities to foster the development of a more sustainable real estate industry. The array of equity instruments includes Sustainable Real Estate Mutual Funds, Exchange-Traded Funds (ETFs), and Real Estate Investment Trusts (REITs). Each of these tools plays a pivotal role in offering retail investors varied pathways to align their investment portfolios with environmental sustainability goals. Sustainable Real Estate Mutual Funds aggregate capital from multiple investors to finance a portfolio comprising environmentally friendly real estate projects. This collective investment scheme not only pools financial resources but also spreads the associated risks, making it an attractive option for

[112] EBA, Report in response to the call for advice from the European Commission on Green Loans and Mortgages. December 2023 – EBA/REP/2023/38

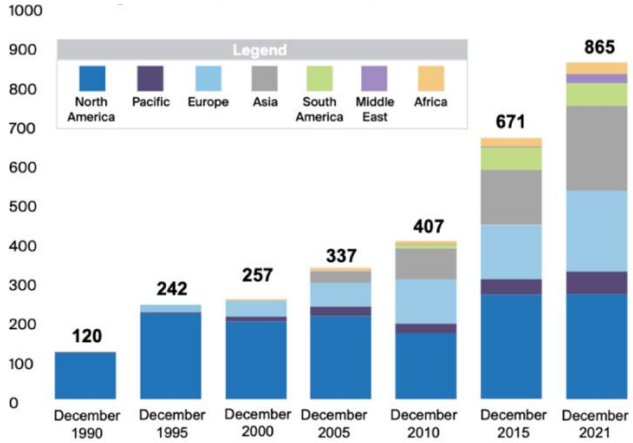
investors who are cautious yet committed to supporting sustainable initiatives. Exchange-Traded Funds (ETFs) allow investors to engage with a diversified basket of sustainable real estate assets that are publicly traded on stock exchanges. These funds provide the dual benefits of liquidity and diversification, reducing investment risk while making it easier for investors to buy or sell their holdings. ETFs are particularly appealing for their ease of access and the ability to track the performance of the sustainable real estate sector directly through market indices. Real Estate Investment Trusts (REITs) offer investors the opportunity to invest in a diversified portfolio of income-generating real estate assets that typically emphasize sustainable practices. REITs are known for their regular income streams, tax advantages, and the potential for capital appreciation, making them a favorable option for investors seeking both stability and a focus on sustainability. The increasing availability of these sustainable equity instruments underscores a significant shift in investment priorities, reflecting a broader societal move towards environmental responsibility. As the demand for responsible investment options grows, these tools are critical in empowering investors to contribute actively to the green transition of the real estate industry. This shift not only highlights the integration of environmental considerations into investment decision-making but also heralds a new era of financial innovation focused on sustainability.

- ***Green Real Estate Investment Trusts (REITs)***

Real estate investment trusts ("REITs") allow individuals to invest in large-scale, income-producing real estate. A REIT is a company that owns and typically operates income-producing real estate or related assets. Unlike other real estate companies, a REIT does not develop real estate properties to resell them. Instead, a REIT buys and develops properties primarily to operate them as part of its own investment portfolio (US Government, n.d.). In the case of Green REITs, the focus of the trust activity is on sustainable investment properties (Parker, D., 2018). These specialized REITs target environmentally friendly real estate assets, such as energy-efficient buildings, renewable energy projects, and sustainable infrastructure. By investing in Green REITs, individuals can support the growth of a more sustainable real estate industry while potentially benefiting from income generated by these environmentally conscious properties. REITs are extensively utilized financial instruments in the United States, primarily due to the numerous benefits they offer to the economy and society at large. Specifically, REITs support communities by enhancing economic growth and job creation, while also maintaining a focus on environmental stewardship and socially responsible practices towards local communities. Furthermore, REITs provide a vital channel for accessing capital, which contributes to the stability of capital markets. By allowing investors to pool funds for real estate investments, REITs facilitate the flow of capital into the real estate sector, supporting property

development, and infrastructure projects. Moreover, REITs offer investors access to low-cost, efficient, and liquid assets with unique attributes. These attributes include a distinct economic cycle, potential inflation protection, and reliable income returns. Investors can benefit from diversification and income generation through investing in REITs, while also enjoying the liquidity of these assets compared to direct real estate investments (NAREIT, 2022). In summary, REITs play a pivotal role in driving economic growth, promoting community development, and providing investors with access to diverse investment opportunities in the real estate sector, all while upholding environmental and social responsibility. From a numerical perspective, in the United States alone, Real Estate Investment Trusts (REITs) contribute to the equivalent of 2.9 million full-time jobs as of 2020, generating $197 billion in labor income. These REITs collectively own more than $4.5 trillion in gross assets across North America, encompassing approximately 535,000 properties that serve as homes to around 150 million Americans (NAREIT, 2022). The success and potential of the US-based REITs model have led to its adoption in over 40 countries worldwide (NAREIT, 2022). The proliferation of REITs globally is evidenced by the substantial increase in their numbers over the years. Specifically, the number of listed REITs has surged from 120 in 1990 to 865 by December 2021, with a combined equity market capitalization reaching $2.5 trillion (Graph 16). This remarkable growth underscores the significance of REITs as a favored investment vehicle and their substantial impact on real estate markets worldwide.

Graph 13: Number of listed REITs worldwide 1990-2021



Source: NAREIT (2022) Available at: https://www.reit.com/investing/global-real-estate-investment.

The rising popularity of Real Estate Investment Trusts (REITs) has coincided with a notable trend in recent years: an increasing number of REIT funds are actively tracking their environmental impact and directing investments towards energy-saving, waste-mitigating technology, and sustainable

building materials. This shift signifies a growing awareness and commitment within the real estate sector towards environmental sustainability (NAREIT, 2022). Sustainable practices, such as energy efficiency and waste reduction, are now receiving unprecedented attention from REITs, reflecting a broader societal emphasis on sustainability and environmental responsibility. This emerging trend suggests that Green REITs, which prioritize environmentally friendly investments and practices, may play a significant role in shaping the future of the real estate industry in terms of sustainability. By focusing on sustainable building materials, energy-saving technologies, and other environmentally conscious investments, Green REITs have the potential to not only reduce the environmental footprint of real estate operations but also generate positive social and economic impacts. As such, Green REITs are poised to become a relevant means to achieve environmental sustainability within the real estate industry in the years to come, contributing to a more sustainable built environment and addressing pressing environmental challenges.

8. KPIs and Methodologies to accelerate transition finance in the Sector

In the previous chapter, the growing importance of sustainable financial instruments is discussed, which form the basis for financing the paradigms introduced by the global sustainability agenda. Sustainable financial instruments form the foundation, and their effectiveness depends largely on clear and actionable parameters that guide their application and subsequent performance evaluation. This chapter advances the discussion by developing a focused approach on the significant role that KPIs and methodologies play in quantifying and, therefore, facilitating the transition towards sustainable real estate practices. This section shows how KPIs help turn broad, undefined goals into specific, measurable objectives, improving the clarity and accountability of real estate project management. In particular, the identification of KPIs that are capable of measuring the transition pathway is particularly relevant for credit institutions. KPIs could help avoid discrepancies between prudential and non-prudential transition plans[113]. In addition, KPIs should not just lead to an evaluation on how the company is aligning to Net Zero but also whether it is doing it consistently with EU Green Deal (EGD) objectives to maximise transition efforts by EU private and public institutions. Despite various international initiatives and contributions over the past two years focused on the credibility of transition plans, almost all of these initiatives are sector-agnostic. The recent establishment of sector-specific credibility criteria in the UK (Transition Plan Taskforce-TPT) and France (ACT Initiative) now sets the gold standard for defining key credibility attributes in the

[113] F. Schütze, F. Ballesteros et al (2024), *Enhancing Comparability and Credibility of Transition Plans and Transition Risk Assessment with Standardized Net Zero Scenarios,* Wissenchaftsplattform Sustainable Finance, Policy Brief 2/2024

preparation and implementation of climate transition plans. However, these contributions fail to address the risk of misalignment with the EGD, EU transition finance objectives, and European Industrial Transition Pathways, potentially limiting their usefulness to credit institutions subject to EBA. The outcome of this research could be beneficial not only for stakeholders in Real Estate sector, but also for EU credit institutions that lend to these companies. These institutions, which will soon be required to prepare a prudential transition plan under the forthcoming EBA Guidelines[114], face the challenging task of identifying the scope and attributes of their clients' climate transition plans. These plans are rooted in enterprise risk management practices, climate science, monitoring of technological innovations, and EU climate policy and legal sources. Specifically, the chapter intends to first analyze the need to have financial metrics and then subsequently focus on the main metrics available on the market. Finally, the objective is to analyze which KPIs, and methodologies can accelerate the transition in the sector. In particular, from the literature available on the topic it can be seen that many metrics do not focus on mitigation and do not consider the reference time horizon but rather limit themselves to "photographing" the situation. The ultimate objective is to identify which KPIs set by ACT Initiative can address the decarbonization in Real Estate and to carry out a gap analysis of the benchmarks of selected KPIs to understand how they can be improved to capture alignment with key pillars of applicable European Legislation for, EU taxonomy, Embodied Carbon Metrics, Net-Zero Industry Act (Specifically for Heat Pumps) and the European Building Directive.

This study is relevant since to have a financial transition and, therefore, to accelerate the inflow of capital into decarbonization strategies there is a need to have metrics and KPIs that focus on both adaptation and mitigation and that consider a time horizon in which these objectives must be achieved. What the dissertation wants to emphasize is that KPIs are the success mechanism of this transition; in their absence, the effectiveness of these mechanisms would be lacking and, consequently, the financial flows would not be exploited to achieve environmental benefits. In fact, KPIs in real estate transition finance are crucial because they act as a bridge between long-term sustainability objectives and the daily actions of real estate companies. These indicators are instrumental in quantifying how much specific investments contribute to the transition towards a greener and more sustainable infrastructure. For example, they measure the efficiency of resource use, the reduction of energy consumption, and the reduction of greenhouse gas emissions. Furthermore, these metrics are of extreme importance not only to comply with environmental agreements and local regulations, but also to meet the expectations of investors and consumers who are increasingly sensitive to environmental and sustainability issues. According to a Deloitte report,

[114] European Banking Authority (EBA) (2024), *Draft Guidelines on the management of ESG risks*, https://www.eba.europa.eu/publications-and-media/press-releases/eba-consults-guidelines-management-esg-risks

"*Financial environmental KPIs are essential to substantially contribute to the transition towards a circular economy and the reduction of pollution*" (Deloitte, 2022). From a financing point of view, KPIs allow companies to access new forms of capital such as green bonds or other sustainable financing instruments. In fact, investors and financial institutions often require compliance with certain sustainability standards, measured through KPIs, to grant financing. Thus, KPIs not only improve environmental and energy performance, but can also open doors to new financial opportunities. For financiers, the KPIs mean that real estate projects will become more attractive to a growing pool of investors and financiers who work according to ESG (environmental, social and governance) criteria. In fact, properties that demonstrate compliance with these KPIs are seen as investments with lower financial risk. This, in financial terms, translates into more favorable capital conditions, which means a reduced risk profile and greater future profitability of the property. Consequently, for financial institutions, such as banks, it becomes essential to have reliable metrics to improve value economy of investments and increase the resilience of the portfolio. Having financing metrics and methodologies aligned with decarbonization and SBTi objectives leads to an appreciation of real estate assets on the market and reduces the risk that these assets may become stranded or be exposed to policy shifts that can potentially lead to the property depreciating. In fact, as extensively analyzed in the chapter on drivers of changes and transition risks, the industry is globally facing the challenge of increasingly rigorous environmental legislation. Proactive properties that keep pace with changes, through KPI-driven improvements, will be less subject to obsolescence or costly future modifications to meet regulations. In other words, KPIs in the context of transition finance are not a performance indicator but rather a strategic asset that guides the real estate sector towards an irreversible path towards sustainability. By providing measurable and actionable information, KPIs allow you to focus investments on risk management and, at the same time, seek to ensure regulatory compliance and the resulting economic improvement of properties. They are the cornerstones through which financial flows could be channeled towards sustainable development goals to ensure that the real estate sector not only contributes but also thrives in the greener economy. The study of KPIs and benchmarks for Renewable Energy (RE) is derived from empirical research and a comprehensive literature[115] review, which includes both academic sources and EU soft law

[115] *Let's Discuss Climate: The essential guide to bank-client engagement*, CISL's Banking Environment Initiative (BEI) (2021), https://www.cisl.cam.ac.uk/resources/sustainable-finance-publications/lets-discuss-climate-the-essential-guide-to-bank-client-engagement. Accessed on 4 Nov. 2023. *Leadership strategies for client engagement: Advancing climate-related assessments*, The University of Cambridge Institute for Sustainability Leadership's report (2022), https://www.cisl.cam.ac.uk/resources/publications/leadership-strategies-client-engagement-advancing-climate-related-assessment. Accessed on 4 Nov. 2023. *Banking Beyond Climate Commitments: Transforming Client Engagement and Products & Services for a Net-Zero Emissions Future*, World Resource Institute (2021), https://www.wri.org/research/banking-beyond-climate-commitments. Accessed on 30 Oct. 2023. *Let's Discuss Nature with Climate Engagement Guide*, The University of Cambridge Institute for Sustainability Leadership (CISL) and members of the Banking Environment Initiative (BEI) and Investment Leaders Group (ILG) (2023), https://www.cisl.cam.ac.uk/news-and-resources/publications/lets-discuss-nature-climate-engagement-guide. Accessed on 3 Nov. 2023. *Net Zero Bondholder Stewardship Guidance*, IIGCC (2023) which lead to a definition of a multi-step approach methodology, https://139838633.fs1.hubspotusercontent-eu1.net/hubfs/139838633/Past%20resource%20uploads/IIGCC-Net-Zero-Stewardship-Guidance.pdf. Accessed on 30 Oct. 2023.

documents. This encompasses the foremost environment/climate-related bank-client engagement literature and recommendations from EU institutions. Key sources include the Commission Recommendation (EU) 2023/1425 of 27 June 2023 on facilitating finance for the transition to a sustainable economy (the **"EU Recommendation")[116],** guidelines from the European Central Bank (ECB) [117] on best practices employed by major European banks and the environmental risks linked to loan assets[118], guidelines and recommendations from the European Banking Authority (EBA) on climate and environmental risks[119], and reports from the European Supervisory Authorities (ESA) on greenwashing, which also address Sustainability Linked Loans (SLLs) [120].

As the thesis examines also the role of asset managers and banking institutions, the reviewed literature first explores the importance of commitment in enhancing alignment with the Paris Agreement. It acknowledges that merely integrating ESG factors, making commitments, using climate scenarios, disclosing ESG scores, and ESG policies are insufficient for aligning a bank's portfolio or individual customers with Paris targets. True alignment can only be achieved through active customer engagement, especially for corporate clients in high-risk industries[121].

The literature on bank-client engagement reveals that banks primarily using top-down approaches for transition risk assessment lack the necessary granularity to effectively support clients' transitions. By measuring risk at a general or aggregated level, attributing this aggregated risk to individual components, and using score-based systems to assess borrowers' transitions by proxy, financial institutions fail to accurately gauge a company's readiness to adopt and implement a credible transition plan.

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[116] Available at https://eur-lex.europa.eu/legal-content/EN/TXT/?uri=CELEX%3A32023H1425

[117] European Central Bank (2022), *Good practices for climate related and environmental risk management, Observations from the 2022 thematic review*, https://www.bankingsupervision.europa.eu/ecb/pub/pdf/ssm.thematicreviewcercompendiumgoodpractices112022~b474fb8ed0.en.pdf. Accessed on 15 Nov. 2023.

[118] European Central Bank (2022), *Walking the talk, Banks gearing up to manage risks from climate change and environmental degradation. Results of the 2022 thematic review on climate-related and environmental risks*, https://www.bankingsupervision.europa.eu/ecb/pub/pdf/ssm.thematicreviewcerreport112022~2eb322a79c.en.pdf. Accessed on 15 Nov. 2023.

[119] See in particular European Banking Authority (2022), *The Role of Environmental Risks in the Prudential Framework – Discussion Paper*, Luxembourg: Publications Office of the European Union, at https://www.eba.europa.eu/sites/default/documents/files/document_library/Publications/Discussions/2022/Discussion%20paper%20on%20the%20role%20of%20environmental%20risk%20in%20the%20prudential%20framework/1031947/Discussion%20paper%20on%20role%20of%20ESG%20risks%20in%20prudential%20framework.pdf. Accessed on 15 Nov. 2023.

[120] See: EBA Progress report on greenwashing monitoring and supervision, at https://www.eba.europa.eu/sites/default/documents/files/document_library/Publications/Reports/2023/1055934/EBA%20progress%20report%20on%20greewnwashing.pdf; Progress Report on Greenwashing, at https://www.esma.europa.eu/sites/default/files/2023-06/ESMA30-1668416927-2498_Progress_Report_ESMA_response_to_COM_RfI_on_greenwashing_risks.pdf; Advice to the European Commission on Greenwashing – Progress Report, at https://www.eiopa.europa.eu/system/files/2023-06/EIOPA%20Progress%20Report%20on%20Greenwashing.pdf. Accessed on 15 Nov. 2023.

[121] See: CISL's Banking Environment Initiative (BEI), *Let's Discuss Climate: The essential guide to bank-client engagement*, cit.; *Leadership strategies for client engagement: Advancing climate-related assessments*, The University of Cambridge Institute for Sustainability Leadership's report cit.; World Resource Institute, *Banking Beyond Climate Commitments: Transforming Client Engagement and Products & Services for a Net-Zero Emissions Future*, cit.; The University of Cambridge Institute for Sustainability Leadership (CISL) and members of the Banking Environment Initiative (BEI) and Investment Leaders Group (ILG), *Let's Discuss Nature with Climate Engagement Guide*, cit.; OECD (2023), *Mechanisms to Prevent Carbon Lock-in in Transition Finance*, Green Finance and Investment, Paris, https://read.oecd-ilibrary.org/environment/mechanisms-to-prevent-carbon-lock-in-in-transition-finance_d5c49358-en#page4.

One notable aspect is that a narrow transition risk assessment, focused primarily on carbon taxes and Emissions Trading System (ETS) implementation through a quantitative top-down approach, fails to anticipate the broader effects of changes in laws and policies. This limitation extends not only to climate mitigation but also to other environmental objectives, especially in light of the EU Green Deal policies impacting industrial processes and business models. Therefore, it is essential to monitor specific sectoral legal and policy regimes (beyond carbon taxes and ETS) on a forward-looking basis and consider their potential application to the relevant client. Additionally, evaluating the extensiveness and effectiveness of legislation affecting industrial processes and business models should be key requirements for assessing the credibility of a client's transition plan.[122]. Recommendations by EU institutions have confirmed the need to evaluate the impact and the effectiveness of transition finance in the EU and the impact on borrowers' business models by focusing on policy-driven aspects and to expand the scope of bank's due diligence exercises to cover environmental risks in a systematic and analytical manner. Coalition frameworks[123] provide an important point of reference to identify new decarbonisation approaches that banking institutions can review to evaluate clients' mitigation actions. Then will follow an analysis of the main financial metrics proposed by ACT in the real estate sector, trying to analyze critical issues and points for improvement. Subsequently, the intent is to analyze the potential gap between actual KPIs and EU policy objectives, proposing KPIs to better align the RE sector towards decarbonization by 2050.

8.1. The needs for transition finance metrics

Before analyzing the KPIs in detail, it is important to have an overview of why metrics for transition finance have become increasingly fundamental. In particular, the scale of investments required to finance the transition is enormous; estimates range from 3.51 to 6.7 TN US dollars in additional

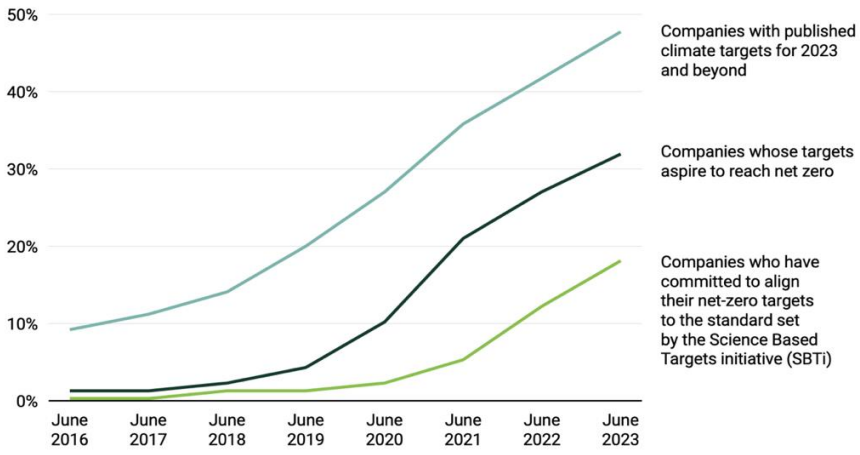
[122] This is confirmed by research by S&P Global Ratings on financial materiality, which states that to date, the financial impact of ESG factors is most often realized through four main drivers, which are not exhaustive or mutually exclusive, but interact with each other:
"– *The introduction of new or tighter policies or regulations usually directly influences the economics of businesses and the financial situation of entities in a sector.*
– *Increased public awareness of environmental and societal changes can trigger changes in stakeholder demand for more sustainable products, services, and relations.*
– *Legal actions can also suddenly result in the materialization of a financial impact for most entities in a sector.*
– *The widespread adoption of reliable and standardized accounting methods for quantifying and disclosing the impact of ESG can help uncover and determine financial materiality*" in ESG Research – Materiality Mapping Providing insight into the relative materiality of ESG factors, Standard & Poor's Financial Services LLC, https://www.spglobal.com/_assets/documents/ratings/research/101560738.pdf. Accessed on 15 Nov. 2023.
[123] According to P. A. Sabatier, advocacy coalitions are people from a variety of positions (e.g. interest group leaders) who share a particular belief system (including problem perceptions): see Sabatier P. A. (1988), *An Advocacy Coalition Framework of Policy Change and the Role of Policy-Oriented Learning Therein*, in *Policy Change and Policy-Oriented Learning: Exploring an Advocacy Coalition Framework,* n. 21, pp. 129-168.

annual investments to make the transition[124]. This scale is beyond the capabilities of governments alone; therefore, in recent years, private sector financial institutions have allocated capital to support the transition. In turn, this has created a need for structures to direct capital into green projects, measure the efforts of financial institutions and ensure that the amount of capital pledged is of sufficient scale. It is important to understand how, from a logical point of view, financial institutions have gradually integrated specific KPIs into their investment decisions to finance the green transition. The first step of financial institutions and banks was to set objectives in line with the definitions provided by the taxonomy and "sustainable finance". The taxonomy is essential to define how and to what extent an activity can be defined as sustainable and consequently define the exact amount of financing needed for green activities. However, the sustainable finance objectives defined by the taxonomy alone are not sufficient to measure the climate action needed as a whole. First, by focusing exclusively on financing "green" projects, there is a risk of not explicitly limiting financial support to "brown" activities, such as high-emitting operations such as coal-fired power plants (CFPPs). Instead, having metrics that lead to incentivizing the outflow of capital to non-green projects would have the effect of increasing the cost of capital for these projects and simultaneously incentivizing the inflow to green projects. Furthermore, sustainable finance objectives that only look at the taxonomy risk measuring exclusively the volume of financing without considering the impact of the financing and lacking a sufficient and coherent definition. Furthermore, information on the impact of lending to companies with ambitious transition plans is often unavailable, making it difficult for various stakeholders to evaluate such efforts. Certainly, the metrics and objectives that focus on "financed emissions" represented a notable step forward in aligning the transition to scientific paths aimed at limiting global warming. This momentum has been spurred primarily by developments in carbon accounting standards, such as those established by the Partnership for Carbon Accounting Financials for Financial Institutions (PCAF), derived from the Global Greenhouse Gas (GHG) Emissions Accounting and Reporting Standard. Furthermore, these metrics and standards have been further promoted by groups such as the Task Force on Climate-related Financial Disclosures (TCFD), established by the G20 and the Financial Stability Board (FSB). From a transition finance perspective, these metrics have allowed financial institutions to calculate the total CO2 equivalent emissions with the consequent implication of having made the institutions partly responsible for the emissions themselves (PCAF, 2020)[125]. As a result, financial institutions, including NZBA members, have since set targets to reduce their funded emissions over time in line with science-based modeling published

[124] Energy Transitions Commission. Financing the Transition: How to Make the Money Flow for a Net-Zero Economy. March 2023.
[125] Partnership for Carbon Accounting Financials (PCAF). (2020). *The Global GHG Accounting and Reporting Standard for the Financial Industry*. Retrieved from https://carbonaccountingfinancials.com/standard.

by bodies such as the IEA[126]. Emissions reduction targets enrich sustainable finance goals, encompassing all activities supported by a bank in a given sector, including transition efforts, moving transition financing from a niche activity to a core one. This has significantly increased the allocation of resources towards the zero-emissions transition. However, it is critical to recognize that emissions reduction targets focus primarily on decreasing emissions financed by the bank, and do not necessarily reflect the amount of financing directly allocated to emissions reduction activities. For example, a bank or financial institution could reach its reduction target by simply stopping financing high-emitting customers, without increasing its support for climate mitigation efforts. This highlights a significant gap, as a crucial role of financial institutions in the transition to net zero emissions is to ensure that adequate financing is available for activities that support the transition, considering both financial and non-financial risks. Consequently, at the same time as the objectives of sustainable finance and emissions reduction, the need for complementary metrics and objectives linked to the support of financial institutions for companies in transition towards sustainability has clearly emerged. Leading companies across all sectors recognize the moral imperative and business benefit of a transition and, as a result, are establishing decarbonization goals and plans. It is therefore necessary to have adequate metrics and KPIs to support the transition and mitigation of climate change.

Graph 14: Upward trend of companies setting increasingly stringent climate targets.



Source: MSCI. The MSCI Net-Zero Tracker, July 2023

Many metrics available on the market are not detailed enough to capture the full complexity with which financial institutions must approach transition financing. Most KPIs highlight an absence of a long-term strategy for the transition, focusing only on the analysis of the current state. This approach results in a failure to fully implement the transition process. For example, financing companies that

[126] International Energy Agency (IEA). (2021). *Net Zero by 2050: A Roadmap for the Global Energy Sector*.

are currently carbon intensive but have credible transition plans could lead to increased emissions in the bank's portfolio in the short term, creating the impression that the bank is not progressing in line with its reduction targets. of emissions. This issue is of particular importance for banks and strategic equity investors. Banks' corporate banking divisions maintain long-lasting relationships with large corporate clients, providing advice and guiding the flow of financing to specific client projects, rather than simply providing general financing. Having credible KPIs that consider the transition process gives financial institutions a platform for customer engagement and influence and consequently accelerate the transition. In particular, it is essential to have metrics that clearly show the extent of financing provided to companies in transition and that are able to provide forward-looking and reliable indications on the amount of decarbonization supported.

In this regard, it is important to have KPIs based on both fundamental qualitative principles of credibility and quantitative measures that address critical issues of the transition. First, the integration of fundamental qualitative principles of credibility, adapted to sectoral peculiarities and aligned with European policies such as the Energy Performance of Buildings Directive (EPBD) and the EU Taxonomy, ensures that KPIs are specific to the context and comply with regulatory standards. In the case of Real Estate, it is essential that the KPIs are aligned with the regulatory standards set by the EU regarding the policies analyzed previously. Furthermore, looking at qualitative principles offer a holistic view of a company's transition plans, allowing an assessment of the ambition, feasibility and coherence of those plans. However, qualitative KPIs are not sufficient to accelerate the transition and have credible plans. It is therefore necessary to develop quantitative KPIs in order to avoid green washing and set ambitious and credible objectives, in line with European legislation. Indeed, detailed and comprehensive measurements are key to capturing the full complexity of transition financing. Quantitative KPIs provide objective data to accurately measure progress, including not only the reduction of emissions but also the support provided to companies on their sustainability journey. Many existing KPIs simply evaluate the current state, often without a forward-looking perspective. By incorporating quantitative KPIs, financial institutions can better understand a company's transition trajectory, offering insights into how current efforts contribute to long-term decarbonization goals. The forward-looking insights provided by these metrics help assess whether companies are on track to achieve their decarbonization goals and whether the financial support awarded is adequate and appropriately directed. In addition, quantitative KPIs balance the need to reduce emissions with the imperative to support transition efforts. This is critical to avoid short-term misinterpretations where financial institutions may appear to be falling behind emissions reduction targets due to increased financing of carbon-intensive companies with credible transition plans. Many existing metrics are

purely retrospective. The financing metrics needed for a transition must broaden this vision by providing a future-oriented perspective.

The following paragraph intends to provide an overview of the main financial KPIs commonly used by the market in the Real Estate sector. The starting point is to analyze Assessing Low Transition (ACT) and then highlight any critical issues. This section intends to establish the foundations for the conclusion of the thesis work, highlighting KPIs designed to accelerate the transition process in the sector.

8.2. KPIs and Target

As already highlighted at the beginning of this thesis, the real estate sector is among the main responsible for CO2 emissions and, consequently, occupies an important position in the fight against climate change. For this reason, I believe it is essential to focus on some specific metrics related to the carbon intensity of this sector to see if are adequate to align the sector toward EU policies goals. However, the complexity of the construction industry in the economy makes it complex to fully understand its reality. Indeed, the sector encompasses a wide variety of activities, such as real estate development, construction work and building management, each managed by different companies. Consequently, an accurate assessment of emissions in the building sector requires an approach that considers the entire life cycle of buildings, integrating all components of the supply chain. In fact, emissions related to buildings come from different phases of their life cycle. These include the production, transformation and transport of materials, all essential phases that precede the construction itself. During construction, further emissions are released following operations carried out directly on site. Once completed, the building continues to generate emissions, mainly due to the energy consumption required for its operation. Finally, when a building reaches the end of its useful life, interventions such as renovations, demolitions and the disposal of residual materials further contribute to its environmental impact. Each step in this process has a significant impact on the environment, making it critical to consider these emissions in a comprehensive assessment of the environmental impact of buildings. Particularly significant in terms of environmental impact is the use phase of the property itself which can represent up to 93% of the total emissions over the life of an existing building[127]. However, for the purpose of this research, the focus is on the activity, outlined by the EU taxonomy, related to the Acquisition and Ownership being a crucial activity for asset manager and banks.

[127] Base Carbone, ADEME.

This chapter intends to start from some metrics developed by Assessing Low Carbon Transition (ACT) and then carry the discussion forward. ACT Initiative defines a workable quantitative approach applicable to several criteria identified in the literature review[128]. It identifies several KPIs for transition plan credibility which are critical to deal with carbon lock-in risk, retirement of high-emitting corporate assets, R&D on low-carbon assets and technologies.

These KPIs represent a great contribution to the literature, highlighting an effort to decarbonize the sector. In particular, these metrics were developed with basic principles that demonstrate the solidity of the methodology adopted. Specifically, metrics are relevant to the extent that all information relating to the core business and stakeholders has been selected. Furthermore, the data necessary for the evaluation are verified or verifiable and maintain consistency, being comparable over time. It is also fundamental that KPIs have a long-term orientation: this allows the performance of a company to be assessed over the long term, while providing significant insights into short and medium-term results, in line with long-term objectives. Table 5 summarizes the reference KPIs and the related data necessary to calculate them. Subsequently follows the ratio of each KPIs and the specific calculation methodologies.

A notable example of sectoral quantitative KPIs is those set out by ACT Initiative for the Real Estate Sector below:

Table 6: Main KPIs and Data Requirements

	KPIs	***Data Requirements***
Targets	**R1: Alignment of owned buildings reduction targets**	Current internal targets set on carbon performance ($KgeCO_2/m^{2)}$; Breakdown of floor areas per business segment and country
	R2: Alignment of buildings managed (use phase) reduction targets	
	R3: Alignment of new buildings integrated (Use phase) reduction targets	
	R4: Alignment of new buildings Integrated (materials) reduction targets	
	R5: Time Horizon of Targets	Current internal targets set on carbon performance (kgeCO2/m2)

[128] Accelerate Climate Transition (2024), https://actinitiative.org/fr/act-methodologies/.

	R6: Historic Target Ambition and Company Performance	Past internal targets set on carbon performance (kgeCO2/m2); Average carbon intensity of company's own building in the past 5 years
Material Investment	**R7: Trend in past emissions intensity for buildings managed**	Average carbon intensity of building managed in the past 5 years; Breakdown of floor areas per business segment and country
	R8: Emission lock-in	
	R9: Trend in future emissions intensity for buildings managed	
Management Indicators	R10: Oversight of climate change issues	Environmental policy and details regarding governance
	R11: Climate change oversight capability	
	R12: Low-Carbon transition plan	
	R13: Climate Change Management Incentives	Management incentives
	R14: Climate Change scenario testing	Scenario testing
Supplier engagement indicators	R15: Strategy To Influence suppliers to reduce their GHG emissions	List of environmental/CSR contract clauses in purchasing
	R16: Activities to influence suppliers to reduce their GHG emissions	List of initiatives implemented to influence suppliers to reduce their GHG emissions
Clients Engagement indicators	R17: Strategy to influence suppliers to reduce their GHG emissions	Client policy
	R18: Activities to influence customer to reduce their GHG emissions	List of initiatives implemented to influence client behavior to reduce their GHG emissions
Policy Engagement Indicators	R19: Company policy on engagement with trade associations	Company policy on engagement with trade associations
	R20: Trade associations supported do not have climate-negative activities or positions	Company policy on engagement with trade associations

	R21: Position on significant climate policies	Position of the company on significant climate policies (public statements, etc.)

Source: Personal Elaboration based on KPIs, and Target retrieved from *Assessing Low Carbon Transition (ACT).*

The objective of this research is to analyze which KPIs are most relevant to EU policy objectives and identify any issues or criticalities they may present. As previously mentioned, while qualitative metrics are essential, it is impossible to develop a credible transition plan without quantitative KPIs that effectively consider decarbonization efforts. Moreover, having quantitative KPIs helps avoid greenwashing. Therefore, the following paragraph will focus solely on analyzing quantitative metrics and aims to shed light on potential shortcomings.
For what concern the EPBD, Heat Pumps, EU Taxonomy and Embodied Carbon metrics the most relevant KPIs are:

- *R2: Alignment of buildings managed (use phase) reduction targets:*

This KPI is a paramount important since it focuses on reducing emissions during the operational phase of buildings. This is directly linked to improving energy performance and efficiency, which is a core objective of the EPBD. Additionally, by ensuring that buildings are managed to reduce emissions, asset managers and banks can ensure compliance with EPBD standards and reduce operational costs and increase the resilience of their portfolio. Indeed, this KPI is crucial because show the company's commitment to reducing emissions. This commitment is a key part of their internal planning for transitioning to lower emissions and it is crucial for asset managers and banks to assess the company's long-term plans and, consequently, the credibility of such plans.
Furthermore, this KPIs could be relevant also for the Heat Pumps since it promotes efficient heating and cooling solutions, such as heat pumps, which are critical for reducing operational emissions.

- *R3: Alignment of new buildings integrated (use phase) reduction targets:*

Furthermore, *R3* is extremely important in ensuring that new buildings meet high energy performance standards from the outset is crucial for compliance with EPBD, which mandates nearly zero-energy buildings (NZEB) for new constructions. This indicator evaluates the company's emission reduction targets concerning the energy consumption emissions released during the operational phase of newly

acquired buildings. It calculates the difference between the company's reduction target and the established decarbonization pathway as a percentage. This percentage represents the company's commitment gap, indicating how closely the company's targets align with broader decarbonization goals. In order to meet high energy performance standards, the Heat Pumps, as a key technology is key. Indeed, this KPI could potentially supports the adoption of low-emission technologies in new buildings, which is vital for meeting future regulatory requirements and achieving sustainability objectives. Additionally, this metric is crucial for the EU Taxonomy, ensuring that new buildings meet stringent emission reduction targets and align with the sustainable construction criteria outlined in the EU Taxonomy. This alignment is important for attracting sustainable investment and financing.

- *R4: Alignment of new buildings integrated (use materials) reduction targets:*

This indicator measures how well a company's goals for reducing emissions from materials used in newly acquired buildings align with standard decarbonization pathways. It calculates the difference between the company's emission reduction target and the expected decarbonization standard as a percentage. Specifically, this percentage is referred to as the company's commitment gap, indicating how much more the company needs to do to align with recommended emission reduction levels. This KPI is relevant for different reasons, firstly because the Materials represent a significant part of a new building's lifetime that is 45% to 75% of the total emissions[129]. Secondly, the Real Estate firms have more information about recent buildings acquired in the property portfolio (materials, new regulations and standards). This KPI is thus extremely relevant for Embodied carbon since it directly addresses emissions from materials used in construction, which is crucial for measuring and reducing embodied carbon.

- *R7: Trend in past emissions intensity for buildings managed*

This KPI measures the historical performance in reducing energy-related emissions, which aligns with the EPBD's goal of continuous improvement in energy performance. By calculating the difference between the growth rate in emissions intensity over the past five years and the target growth rate in the company's decarbonization pathway, this KPI helps firms understand how close they are to their planned emission reduction trajectory. The "Company Benchmark Pathway" (CBBM-5y) is defined as the 'Buildings managed specific decarbonization pathway.' The assessment focuses on

[129] French Ministries of Ecological Transition and of Territorial Cohesion, E+C- methodology, experiment, label and observatory. http://www.batiment-energiecarbone.fr/

examining the differences between these two pathways in the reporting year, with the outcome indicating the magnitude of the action gap. To assign a score to this indicator, the size of the action gap will be compared to the maximum action gap, which is defined by the business-as-usual pathway (BAUBM). BAUBM is defined as an unchanging (horizontal) intensity pathway, whereby the emissions intensity is not reduced at all over the 5 years period leading to the reporting year.

$$Buildings\ managed\ emissions\ action\ gap = \frac{A_{BM} - CB_{BM}}{BAU_{BM} - CB_{BM}}$$

$$Score = 1 - Buildings\ managed\ emissions\ action\ gap$$

The score for this indicator is determined by subtracting the action gap from 1, and it is expressed as a percentage. In this context, the action gap is calculated as the difference between the Company Action Pathway (ABM) and the Company Benchmark Pathway (CBBM).

- *R8: Emission lock-in:*

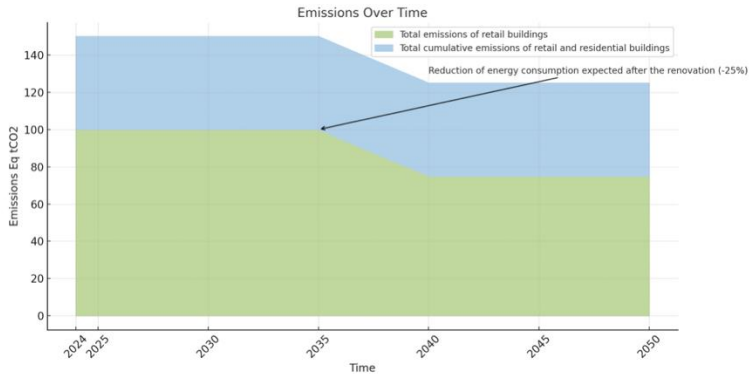
This indicator measures the total emissions projected from the company's current property portfolio from the reporting year up to 2050, considering any planned renovations that are expected to reduce energy consumption. Since embodied carbon refers to the total greenhouse gas emissions associated with the production, transport, and installation of building materials, as well as those emissions locked in during the construction phase, this KPI is crucial for understanding and managing embodied carbon. The projected emissions are then compared to an emissions budget that reflects the company's goals for reducing emissions intensity. This budget is derived from the company's decarbonization pathway and the anticipated trends in energy generation within the sector at a country or regional level. Essentially, this indicator evaluates how well the company's future emissions from its existing assets align with its long-term decarbonization objectives, considering improvements in energy efficiency and broader sectoral energy trends.

This KPI is calculated by comparing the amount of greenhouse gas emissions emitted from the buildings of an organization in a reporting year, denoted as "LG (t)", with a given emissions target or "budget", for the reporting year, denoted as "BG (t)". The comparison is thereafter done from the reporting year to the year 2050. These are the emissions in the form of locked emissions, for each of such building types that the company manages, and which essentially cannot be avoided until the next renovation of the building comes. All such characteristics for each renovation of the renovation type for the respective building type of the company that it manages are considered. Therefore, the

emission levels calculated account for all the emissions that will be released from the building until it is next renovated. The locked-in emissions for each renovation of a certain energy-saving renovation are calculated as the difference between the total dumped gases at the renovation time and the total expected dumped gases due to the energy-saving renovation.

In the case where no emissions savings are registered from the renovation, the default reduction of 25% of the current emissions will apply. In cases where no renovations are planned, it is assumed that locked-in emissions are equal to registered emissions in the reporting year.

For instance, a Company x plans a renovation in 2035 which will reduce total emissions of 25% and no renovation is planned for residential buildings. The company's locked-in emissions are presented in the following chart:



In particular, LG (t) is calculated as the company's locked-in carbon commitments up until a chosen time period, t. This calculation involves finding the area under the company's future locked-in emissions curve. The emissions curve itself is derived from the company's intensity pathway, which is determined by multiplying the emission intensity by the floor area.

$$L_G(t) = \int_{\text{the reporting year}}^{t} F_G * CA_G$$

While, instead BG (t) is calculated as the company's carbon budget up until a chosen time period t. This calculation involves finding the area under the absolute emissions reduction curve. This emissions reduction curve is derived from the company benchmark pathway (CBG), which is determined by multiplying the emission intensity by the floor area.

Consequently, the locked-in ration (r_{LB}) is calculated as following:

$$r_{LB}(t) = \frac{L_G(t)}{B_G(t)}$$

This ration is important because analyze the company's locked-in emissions alongside science-based budgets allows for the examination of the potential cost of inaction, including the likelihood of stranded assets. Additionally, examining absolute emissions and recent and short-term emissions intensity trends provides a comprehensive view of the company's emissions performance over time, covering past, present, and future.

- *R9: Trend in future emission intensity for buildings managed:*

Assessing forecasted emissions intensity is crucial for future planning and energy performance improvements, in line with EPBD requirements. This KPI helps set realistic yet ambitious targets for energy efficiency, ensuring that managed buildings continue to improve their energy performance over time. Additionally, by determining future emissions, asset managers and banks can plan investments and renovations that align with EPBD standards, ensuring ongoing compliance and enhancing the long-term sustainability of their building portfolios.

The indicator will show the gap between company performance and the decarbonization pathway in 5 years following the reporting year, to be expressed in percentage terms, and it shall be expressed as the company's 'action gap'. The evaluation is based on the difference between the company action pathway (ABM) and the company benchmark (CBBM) for a period of up to five years from the reporting year. Company action pathway (ABM) is the emission intensity for the existing building of a company through time, assuming the property portfolio is at a constant state. The company benchmark (CBBM) is the evaluated company building managed specific decarbonization pathway. This evaluation is done between the difference in these pathways five years after the reporting year. Pathways are set in kg CO2/m2 (intensity measure). Such difference is the action gap. Recent emissions intensity performance reflects the company's progress towards or away from the future emissions intensity needed for the sector to decarbonize in line with a low-carbon scenario. This indicator provides the most valuable information regarding the company's actual efforts toward decarbonization. Along with recent emissions intensity and absolute emissions, this measure contributes to a comprehensive view of the company's emissions performance over time, encompassing the past, present, and future.

$$Future\ emissions\ action\ gap = \frac{A_{BM} - CB_{BM}}{BAU_{BM} - CB_{BM}}$$

$$Score = 1 - Future\ emissions\ action\ gap$$

To assign a score to this indicator, the size of the action gap will be compared to the maximum action gap, which is defined by the business-as-usual pathway (BAUBM). BAUBM is characterized as an unchanging (horizontal) intensity pathway, where the emissions intensity remains constant and does not decrease over a period following the reporting year. This KPI provides the most valuable information regarding the company's actual efforts toward decarbonization. Along with recent emissions intensity and absolute emissions, this measure contributes to a comprehensive view of the company's emissions performance over time, encompassing the past, present, and future.

8.3. Evaluation and Recommendations for Enhancing the ACT Initiative's KPIs to Align with Latest EU Climate Legislation and Standards

A review of the ACT Initiative's KPIs indicates that while its quantitative approach is robust and potentially the most comprehensive quantitative-based standard available for transition plans, there are significant areas for improvement. The underlying benchmarks and scope of the KPIs do not sufficiently engage with the latest EU climate legislation. Specifically, they fail to align with the Climate EU Law and have not been updated to reflect the recent European Net-Zero Industry Act (NZIA), EPBD, EU Taxonomy and Metrics for embodied carbon. The Climate EU Law, which enshrines the 2050 climate neutrality target and the 2030 emissions reduction goal of at least 55%, is a cornerstone of European climate policy. However, the current ACT KPIs do not fully incorporate these legally binding targets, which may result in transition plans that fall short of meeting mandated climate objectives. Additionally, the benchmarks used in the ACT KPIs are outdated and do not reflect the latest sectoral decarbonization trends and innovations outlined in the European Green Deal. This misalignment can lead to a gap in achieving the EGD's ambitious goals. Furthermore, although these KPIs consider energy efficiency, they do not sufficiently reflect the level of ambition set by the EPBD. This oversight could lead to transition plans that fail to adequately address decarbonization or incorporate key enabling technologies essential for achieving it. For example, the Net Zero Industry Act aims to scale up the manufacturing of clean technologies within the EU, particularly focusing on sustainable construction practices and energy-efficient building systems. However, the ACT KPIs do not reflect the specific targets and pathways outlined in this legislation. Specifically for analysis purposes, it is important to note that no KPI details the level of heat pump penetration.

This disconnect means that transition plans might not fully leverage the industrial policy frameworks and incentives designed to accelerate the adoption of green building technologies and energy-efficient

systems. To enhance the relevance and effectiveness of the ACT KPIs for the real estate sector, it is recommended to update the benchmarks and scope to integrate the targets set by the Climate EU Law. By incorporating these updates, the ACT Initiative's KPIs can provide a more comprehensive and current framework for assessing and guiding real estate transition plans, ensuring alignment with the latest EU climate legislation and industrial pathways.

Firstly, the metrics related to decarbonization and energy efficiency (especially the one that require current internal targets set on carbon performance (KgeCO2/m2) and breakdown of floor areas per business segment and country) need to be adjusted to align with the EU Climate Law's target of 1.5°C, rather than well below 2°C. Indeed, the benchmark used by ACT in this regard is to not exceed a threshold of 2°C global warming compared to pre-industrial temperatures. I believe that to increase the level of ambition, the benchmark should be set at 1.5°C.

Additionally, for R2 and R3, to ensure the reduction of operational emissions, is important that the benchmark of the minimum energy performance standards consider Directive (EU) 2018/2001[130]. Furthermore, while R2 and R3 represent solid metrics for reducing emissions during the use phase of buildings, no emphasis is placed on the use of key technologies that are essential for the decarbonization of buildings. These KPIs should guarantee a higher use of Heat Pumps than that established by the NZIA. In fact, NZIA is decidedly unambitious, predicting a production capacity target of 31 GW by 2030, while a conservative growth scenario would lead to 47 GW by 2030. In particular, it is important that R2 and R3 consider how much reduction in energy derived from Heat Pumps on the total efficiency. Specifically, R2 and R3 when calculating the gap between the expected reduction and the actual reduction should take into consideration how much of this reduction is due to the use of heat pumps. In this regard, it is important to consider that, according to EHPA, approximately 16% of the energy needs of residential and commercial buildings in Europe are currently met by heat pumps[131]. A credible KPI should set a medium to long term target of at least 25-30%. Additionally, for an asset manager and a bank, understanding the proportion of assets in their portfolio covered by heat pumps is essential. The Irish government has set a target of having approximately 600,000 residential properties equipped with heat pumps by 2030, out of a total of 1.9

[130] Directive (EU) 2018/2001 of the European Parliament and of the Council of 11 December 2018 on the promotion of the use of energy from renewable sources. Official Journal of the European Union, L 328, 21 December 2018, p. 82–209.
[131] European Commission. (2023, June 21). Residential heating: Heat pumps would knock down energy consumption and emissions. European Commission. https://joint-research-centre.ec.europa.eu/jrc-news-and-updates/residential-heating-heat-pumps-would-knock-down-energy-consumption-and-emissions-2023-06-21_en

million properties, achieving a percentage of 31.6%[132]. An asset manager might aim to achieve a similar or higher percentage in their portfolio by 2030.

Additionally, when considering the emission reduction target in line with the EPBD, it could be relevant evaluate the EPC rating of buildings. As of 2023, approximately 25% of buildings in England have an EPC rating of A or B, indicating significant potential for improvement in energy performance[133]. Although precise and updated data are not currently available for Europe, a useful KPI for assessing the commitment gap could be consider 25% as the initial reference percentage of new buildings achieving a high EPC rating. This can be calculated as follows: (Number of buildings with EPC A or B / Total number of buildings) * 100. Given that around 25% of buildings had an A or B rating in 2023, it is feasible to aim for 75% by 2030, which translates to an annual improvement rate of 17%[134]. Furthermore, a KPI that considers the energy certificate would also be aligned with the Taxonomy in terms of the substantial contribution criteria (New building EPC A).

For R8, which specifically addresses emissions in the form of locked emissions, I suggest incorporating the most credible metrics available for embodied carbon into the calculations. Specifically, when calculating the carbon budget and total projected emissions, i would consider the reduction targets established by RE 2020. These targets stipulate a reduction from *640 kg CO2-eq/m^2/year in 2022 to 415 kg CO2-eq/m^2/year* by 2031 for single housing, and from 7*40 kg CO2-eq/m^2/year to 490 kg CO2-eq/m^2/year* for collective housing. Using these targets as benchmarks for calculating emission lock-in can establish a clear and credible trajectory towards substantial carbon mitigation[135]. In addition, these targets could potentially also be used for the KPI R4 (*use materials*) as a reference for materials with a lower CO2 impact.

Moreover, I believe that given the importance of the Circular Economy, R4 should not only consider the CO2 emissions from the use of materials but also their recycling rate. Drawing inspiration from the Sustainability-linked bond principal registry[136], R4 could also consider the average recyclability percentage of construction materials. The formula could be:

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[132] G. Maroulis, Ireland: summary, 2019, URL: http://www.res-legal.eu/search-by-country/ireland/summary/c/ireland/s/res-hc/sum/148/lpid/147/; Climate action plan 2019, 2019, URL: https://www.dccae.gov.ie/en-ie/energy/ consultations/Documents/42/consultations/Draft%20NECP%20Ireland.pdf.

[133] UK Government. (2023). Energy Performance of Building Certificates in England and Wales: October to December 2023.

[134] The formula used to calculate the annual growth rate is $P(t) = P_0(1+r)^t$, where P(t) is the final percentage of buildings with EPC A or B (75%); P_0 is the initial percentage of buildings with EPC A or B (25%) and r is the annual growth rate and t is the number of years between 2023 to 2030. The calculation shows an annual growth of approximately of 17%.

[135] European Commission. (2021). *Revised thermal regulation of Règlementation Environmentale (RE2020).*

[136] Sustainability-Linked Bonds Working Group. (2023). *Illustrative KPIs registry: June 2023*.

Average recyclability of construction materials (%) = $\left(\frac{\sum(M_i \times R_i)}{\sum M_i}\right)$

Where M_i is the weight of material *i* used in new constructions and R_i represent the Recyclability percentage of material *i*.

Furthermore, despite R9 is a solid and robust KPI to assess the actual effort toward decarbonization, it could benefit from a more precise standard set by the EPBD. Specifically, the European directive stipulates that member states must establish minimum energy performance standards for non-residential buildings, ensuring that these buildings do not exceed a maximum energy performance threshold expressed in kWh/ (m2.a). In this direction, ACT could refine KPIs considering quantitative benchmarks such as thermal transmittance values or U-values (for external walls, roofs, or windows) or thresholds for primary energy consumption for both residential and non-residential buildings. Drawing inspiration from one of the most ambitious standards available, RE 2020, it could be important to consider the following thermal transmittance values (U-values) to enhance building energy efficiency. For external walls, the maximum U-value should be ≤ 0.22 W/(m²K), a critical parameter for minimizing heat loss and improving overall energy efficiency. Similarly, for roofs, the maximum U-value should be ≤ 0.18 W/(m²K), essential for maintaining a comfortable indoor environment and reducing the energy required for heating and cooling. Additionally, the standard sets a maximum primary energy consumption for new residential buildings at 50 kWh/m²/year. These standards could be incorporated into the ACT's KPIs to promote more energy-efficient and sustainable building practices.

Additionally, I noted that the metrics could consider social aspects related to the affordability and accessibility of housing, also in compliance with the EU taxonomy. In fact, in line with the European Union's Just Transition goal, a KPI from the ICMA's Illustrative Registry of KPIs could be applied to real estate companies, asset managers, and banks. This KPI is the *"Number of disadvantaged individuals/communities served by operations, projects, and/or investments (as a percentage of the total or in absolute terms)."* Additionally, the implementation of these metrics should adhere to the minimum safeguards to ensure that no significant harm is done to any environmental objectives and that fundamental social rights are respected.

9. Conclusions

This thesis has examined the real estate sector through the perspective of financial transition, focusing on its significant contribution to greenhouse gas (GHG) emissions and its critical role in the global economy and financial stability. The overarching goal was to underscore the importance of credible transition plans and the integration of quantitative Key Performance Indicators (KPIs) that align with EU climate regulations.

Throughout the research, it became evident that the real estate sector is intricately linked to macroeconomic stability. Fluctuations within the financial sector have a profound impact on real estate, and vice versa, creating a dynamic interplay that can amplify the risks associated with climate change and the transition to a greener economy. Understanding these risks is essential for developing robust strategies that ensure the sector's stability and sustainability. Key drivers of change, such as demographic shifts, digitalization, advancements in technology, hybrid work models, and environmental sustainability, were explored to illustrate their financial relevance and transformative impact on the real estate sector. These drivers not only shape the current landscape but also point to future trends that must be considered in transition planning.

Chapter 4 serves as a cornerstone of the thesis, focusing on key European policies that significantly affect the real estate sector. Policies like the EU Taxonomy, the EPBD Directive, and metrics for embodied carbon set the standards and objectives that influence financial and investment decisions. This chapter is critical, as the ultimate goal is to assess whether the available KPIs in the market are effectively aligned with EU climate regulations.

Furthermore, Physical and transition risks were also highlighted as major challenges that the real estate sector must address. These risks have significant economic and financial implications, affecting key variables and requiring comprehensive risk management strategies. The thesis underscored the need for KPIs that not only assess current performance but also anticipate and mitigate future risks.

A central theme of the thesis was the concept of transition finance and the credibility of transition plans. The study emphasizes that the quality of transition plans depends on their credibility characteristics, defined in accordance with both sector-agnostic and specific standards, and the commitment of asset managers and banks in effectively pursuing transition governance. However, the lack of quantitative KPIs capable of harmonizing the assessment of the credibility of transition plans could endanger the transition itself and give rise to greenwashing. This would impact the

reliability of the prudential transition plans of EU credit institutions, which should not be based solely on the "financed emissions" parameter, but also on their ability to contribute to the transition of the real economy in line with the EBA and CRR3.

To avoid greenwashing and ensure credible transition plans, it is therefore necessary to develop KPIs that reflect both qualitative and quantitative aspects of transition policies. The key issues for the credibility of transition plans, which will determine the ability of real estate companies to effectively decarbonize, concern their ability to reduce the risk of carbon lock-in in their assets and to ensure a gradual and managed phase-out of high-emission assets, in line with the objectives of the European Green Deal (EGD). These objectives should be captured by quantitative KPIs that can be updated based on the evolution of EU policies, thus ensuring that the sector progresses faster than the EU sectoral pathways towards Net Zero. The research evaluated the KPIs proposed by ACT and found them robust yet somewhat lacking in alignment with specific European legislative standards. In fact, the benchmarks used could align more directly with the standards of the Climate Law, ensuring decarbonization of the sector. Having quantitative KPIs that reflect and incorporate the standards required by European regulations also allows banks and asset managers to increase the resilience of their portfolios and reduce the exposure of their assets to both physical and transition risks.

Finally, the thesis proposes metrics and standards to be incorporated into those proposed by ACT to reflect a more concrete commitment to European policies. Among other things, it proposes to update the reference parameters to reflect a 1.5°C goal, emphasize the main decarbonization technologies, including Heat Pumps, and incorporate parameters for the recyclability of embodied carbon and materials. Furthermore, the integration of social aspects related to economic affordability and housing accessibility, in line with the goal of a just transition in the EU, can further increase the relevance and effectiveness of the proposed KPIs. This comprehensive approach ensures that real estate transition plans meet the current EU climate goals and promote sustainable development in the sector. This approach can also be followed for other hard-to-decarbonize sectors and could encourage further research on the subject.

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