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REPORT

Green Real Estate Financing Market Report 2024

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A Joint Publication by Aalto University, RMIT University, and Australian Catholic University

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Executive Summary

This report is designed to guide and inform practitioners and academics on the rapidly evolving landscape of green real estate financing, which increasingly influences property market dynamics, funding availability, and asset risks. We shed light on the intricacies of green real estate financing, examining various products, the frameworks in which they sit and their usage patterns. Additionally, we explore developments in the secondary green finance markets and securitisations within the real estate sector. Integrating the latest market trends with recent academic research, a comprehensive review of green financing's relevance for real estate, finance professionals and scholars is presented. Furthermore, this report provides foundational knowledge and insights for academics and real estate practitioners alike, enabling them to explore avenues for further research and practical applications of green real estate financing.

Our report reveals a few key themes:

1) While the current green real estate landscape remains fragmented, featuring diverse green metrics, frameworks, and debt products, there is a notable trend towards greater standardisation and global alignment.

2) We observe a shift in policy focus from a property-specific energy efficiency metric to a total emissions focus, including embodied emissions from construction. This shift is evident both in policy literature and voluntary green finance frameworks.

3) Similarly, the targets for deep green performance are moving from low-carbon to carbon neutral and even further to carbon-positive.

4) Climate change adaptation is becoming increasingly relevant to the real estate sector as property assets face physical risks such as floods, hurricanes and fires due to a changing climate. The assessment of physical risks in real estate has significant implications for financing, insurance, and asset values.

5) The discussion in the real estate sector relating to green finance is shifting from the 'greenium' to 'brown discounts', emphasising the advantages of green financing instruments, including lower default rates.

6) Since green bonds are accessible only to a limited number of issuers due to investment size constraints, scaling up green mortgages and green loans —typically featuring debt-to-asset ratios of 30-80%— is essential for real estate decarbonisation efforts. Ireland is paving the way for rapid green mortgage uptake.

7) Regardless of country- and region-specific features in real estate practices and regulation, achieving standardisation and global data availability is imperative for scaling green mortgages and loans that lag compared to green bonds. This expansion would also facilitate the development of green residential securitisation, which relies on the asset-level data from green mortgages.

8) Sovereign green bonds issued by AAA-rated countries may attract more investors to green finance markets as many international investors only invest in AAA–rated products, especially those related to state-owned property.

9) Green residential securitisation could further unlock the private capital needed for decarbonising the residential stock by combining smaller projects into investable green finance products. Substantial building renovation is essential to achieve net zero by 2050, with transition finance playing a critical role in supporting this transformation.

10) Finally, in order to reduce real estate related carbon emissions there is a need for coordinated action across various stakeholders in the industry. This report presents a lens for understanding these multiple motivations.

Acknowledgements

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Contents

List of Abbreviations

CBI	Climate Bonds Initiative
DNSH	Do No Significant Harm
EEM	Energy-Efficient Mortgage
EPBD	Energy Performance of Buildings Directive
EPC	Energy Performance Certificate
EuGBS	European Green Bond Standard
GBP	Green Bond Principles
GBRS	Green Building Rating System
ICMA	International Capital Markets Association
IEA	International Energy Agency
LMA	Loan Market Association
NDC	Nationally Determined Contribution
NZEB	Nearly Zero-Emissions Building
PED	Primary Energy Demand
WLCA	Whole-Life Carbon Assessment
ZEB	Zero Emissions Building

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1. Introduction

This report aims to help practitioners and academics navigate the rapidly changing landscape of green finance, specifically providing clarity and insights into green real estate financing. It provides tools to understand how green real estate financing is used (products, frameworks) and how it affects real estate and finance practitioners and scholars by integrating the latest market dynamics with recent academic research. For academics, this report aims to provide the current foundations in green real estate financing and open avenues for further research. We raise discussion about 1. What the decarbonisation needs in the real estate sector are 2. What green finance in the real estate sector entails 3. Who the stakeholders and their motivations are and 4. What tools are required to understand green real estate financing.

This introduction responds to a series of questions designed to provide a comprehensive understanding of the key themes relating to the interaction of green financing and the real estate sector.

What does green finance include, and how does it relate to climate finance?

The term green finance is often used vaguely. This report clearly distinguishes between green finance, climate finance, and sustainable finance based on the broad definitions of the United Nations Environment Programme (UNEP, 2016). As depicted in Figure 1 below, green finance is a synonym for environmental finance, encompassing climate-related and other ecological issues. According to UNEP (2016), green finance distinguishes itself from sustainable finance in that it excludes other types of sustainability, such as social, economic and governance. Although these definitions are not always clear-cut, they provide information about the objectives and boundaries of each area of sustainability, thus enabling a more effective comparison of different kinds of financial instruments. This report covers real estate financing from the environmental sustainability perspective comprising climate change mitigation, defined as actions to reduce or prevent greenhouse gas emissions from human activities; climate change adaptation, defined as actions to adjust to the climate change already in the pipeline; and other environmental matters. Green finance covers climate and low-carbon finance, which initially received the most focus.

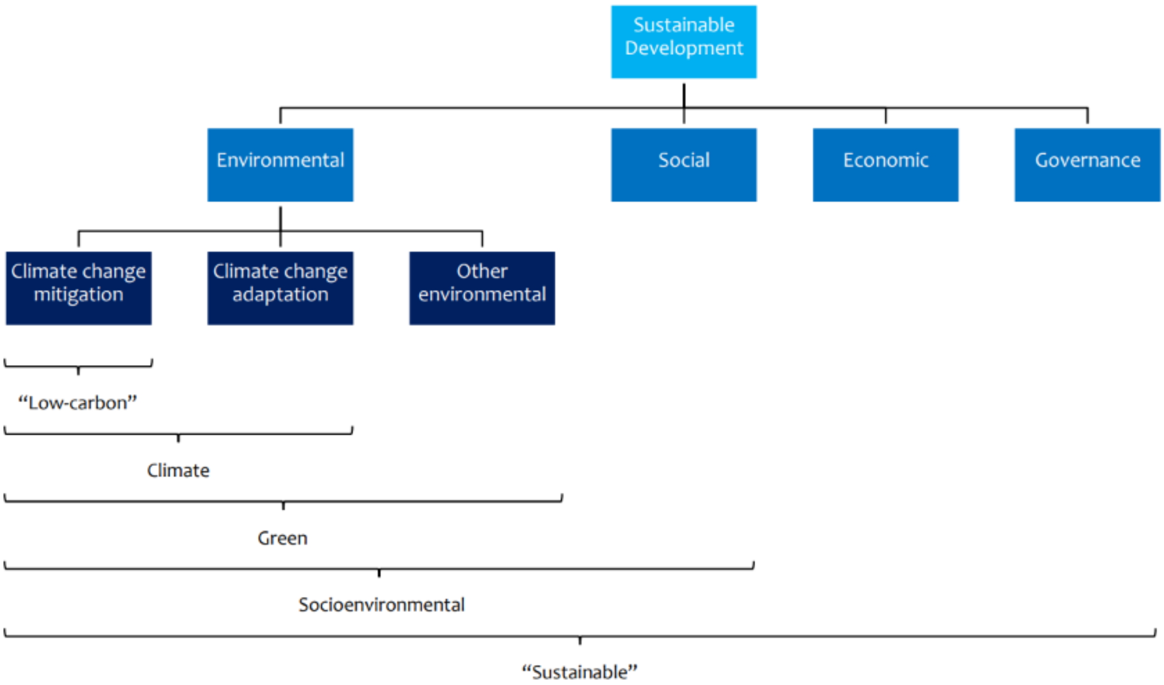

Figure 1. Broad definitions and concepts of sustainable finance. Adopted from UNEP (2016).

Why is the real estate sector so significant in achieving zero carbon?

The real estate sector is remarkable regarding economic, societal, and environmental relevance. It accounts for around 60% of the world's wealth (Savills, 2023), 37 % of global energy-related carbon dioxide emissions, and 36% of the world's final energy consumption (United Nations Environment Programme, 2021). Reaching global climate targets requires the real estate sector to make significant new investments to increase energy efficiency, incorporate renewable energy sources, and implement other green technologies to reduce carbon emissions. About 60 % of buildings estimated to exist in 2050 have not been built yet, and around 20 % of existing buildings must be renovated to zero-carbon ready by 2030 (United Nations Environment Programme, 2024). Although global investments in buildings' energy efficiency increased by around 14 % from 2021 to USD 285 billion in 2022, rising borrowing costs and economic instability in 2023 halted the progress. In 2022, global inflation was recorded at approximately 8.8%. Moderating somewhat to 6.9% in 2023 and expected to stabilise in 2025 at 4.4%. Central banks worldwide have responded by increasing interest rates to manage these inflationary pressures, leading to a challenging economic environment characterised by rising borrowing costs and concerns over potential recessions (IMF 2024). Indeed, investments in climate adaptation activities and infrastructure are notably needed to support resilience in the global economic outlook (IMF 2024).

Where are we now in terms of decarbonising the real estate sector?

Although global investments in buildings' energy efficiency increased by around 14 % from 2021 to USD 285 billion in 2022, rising borrowing costs and economic instability in 2023 halted the progress. In 2022, global inflation was recorded at approximately 8.8%. Moderating somewhat to 6.9% in 2023 and expected to stabilise in 2025 at 4.4%. Central banks worldwide have responded by increasing interest rates to manage these inflationary pressures, leading to a challenging economic environment characterised by rising borrowing costs and concerns over potential recessions (IMF 2024). Indeed, investments in climate adaptation activities and infrastructure are notably needed to support resilience in the global economic outlook (IMF 2024). While these investments might initially add to inflationary pressures, they can also lead to improved overall productivity. Economies can reduce long-term operational costs and enhance economic stability by focusing on energy-efficient and sustainable capital projects, such as green infrastructure. This dual approach mitigates the immediate impact of inflation and contributes to a more sustainable and resilient economic future.

Yet, in 2022, energy efficiency investments and the construction of sustainable buildings represented less than 5 % of total global building sector investments. To put the scale of the real estate sector's investment challenge into context, transitioning to an entirely renewable-based system would require cumulative investments worth EUR 67 trillion by 2050 on a global scale (Ram et al., 2019). In summary, substantial and coordinated investments in green real estate are required to achieve the zero-carbon transition.

What are the direct benefits of green real estate investments?

Green real estate investments, such as renewable energy transitions and energy-efficient refurbishments, have gained significant attention in the past fifteen years. These investments contribute to real estate decarbonisation and enhance property values by reducing operating costs and attracting higher sales premiums and occupancy rates. Many reviews since 2010 have shown that green buildings enjoy greater market demand, willingness to pay, decreased property costs, higher rental values, and increased property values than conventional buildings (Darko et al., 2017; Falkenbach et al., 2010; Olubunmi et al., 2016). Green building certificates have been shown to provide cash flow and property value benefits for commercial buildings (Leskinen et al., 2020). In Australia, Lee et al. (2022) confirm a strong positive connection between green buildings and financial performance, which was strengthened further after introducing a mandatory energy efficiency disclosure program. In addition to the benefits directly related to green buildings, recent studies show that many green debt products used to finance green buildings provide tangible benefits for the building owner, the financier, or the green debt product investors in secondary markets. These benefits and incentives include a greenium[1], lower loan default rates[2], and higher demand[3].

Is ESG criteria affecting investment decisions?

Institutional investors increasingly integrate environmental, Social, and Governance (ESG) criteria into investment decisions. This trend is driven by a growing recognition of the long-term benefits of sustainable investments, including risk mitigation, regulatory compliance, and alignment with societal values. The market demand for green real

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[1] The term "greenium" (or green premium) refers to the premium or additional cost that investors are willing to pay for green bonds or sustainable investments compared to traditional ones.

[2] Lower default rates in green loans, see, e.g., Energy Efficient Mortgages Action Plan, (2019), pp. 6–9; Guin & Korhonen, (2020); Kaza et al., (2014).

[3] Higher demand for green bonds, see, e.g., Bhutta et al., (2022).

estate investments is thus established. These decisions involve incorporating ESG criteria into evaluating, acquiring, managing, and developing real estate assets. Geopolitical events, such as Russia's invasion of Ukraine in 2022, have further underscored the importance of energy efficiency and renewable uptake in buildings. Recently, the spotlight has shifted to how these green real estate investments are financed. Given the high leverage in real estate investments, loan-to-value ranges from as high as 90 % for residential consumers to up to 70 % for stable commercial assets and 30-40 % for opportunistic commercial asset classes (Financial Times, 2023). Both financial and non-financial considerations are crucial in investment decision-making and real estate outcomes.

It is observed that banks offer less funding for environmentally non-performing properties primarily due to the means through which the physical climate interacts with real estate assets and how changing climate may result in 'stranded assets'[2] or assets that lose value in the face of transition to a low-carbon economy (Caldecott et al., 2021). For example, this risk is currently reflected in commercial properties that do not meet environmental standards already find fewer funding options in certain markets. This decrease in financing options for non-environmental assets adds to real estate owners' stranded asset risks -the risk that an asset will become devalued unless vast sums are invested in green renovation required by local regulations. Banks are already risk mitigating away from non-environmentally performing buildings to minimise future stranded asset risks. In addition, the existing assets on banks' books will require additional retrofit investments to avoid devaluations and write-downs driven by market demand and regulatory changes.

Green financing mechanisms typically have specific incentives to encourage green investments, such as preferable interest rates due to the 'greenium', tax benefits, subsidies, and better loan terms. These lower interest rates are often a result of the "greenium," where higher bond prices and lower bond yields for green products translate to more favorable borrowing costs for green projects. While green real estate financing initially promised lower interest, the evidence has been inconsistent. Yet, research has identified other benefits for green real estate financing instruments ranging from lower default and arrears rates to higher new-issue coverage. For banks, greener financed properties also signal fewer financed emissions and contribute to greener mortgage books with fewer climate risks.

How is green finance related to risk mitigation?

Financial institutions must understand what they finance and what climate risks are involved. However, as the green real estate finance landscape has evolved rapidly, keeping up with how to define greenness and what indicators to use as green proxies is a challenging task. Moreover, climate change also calls for adaptation in the building stock due to increasing extreme events such as droughts, floods, wildfires and rising sea levels. These climate change adaptation strategies are highly local and also require significant financing, from both private and public institutions. Overall, there are clear indications that the environmental performance of assets is becoming an essential factor in property finance, with implications for both the funding availability and the strategies for managing climate-related risks.

Is growth in green financing markets driven by purely regulatory contexts or changing market dynamics?

In recent years, green finance markets have rapidly developed into a USD 4.18 trillion market with multiple debt products, frameworks, and definitions of green. 2023 marked the second year in a row when global banks underwriting bonds and providing loans for green projects than they earned financing oil, gas, and goal activities (Bloomberg, 2024a). With its substantial environmental impacts, real estate has constituted one of the primary green finance submarkets.

Regulatory developments shaping the green real estate financing markets include the EU Taxonomy regulations in the EU, green bond schemes in China, and the Inflation Reduction Act in the US. Moreover, the global IFRS S1 General Requirements for Disclosure of Sustainability-related Financial Information and IFRS S2 Climate-related Disclosures (IFRS, 2024a, 2024b) also impose reporting and disclosure of sustainable investments for financial entities. In addition to the regulatory push, there is an increasing market demand for low-carbon and resilient real estate investments aligned with net-zero trajectories due to lower risks. In fact, the IFRS also acknowledges the risks and opportunities with sustainable investments (IFRS, 2024b). The theory of the firm suggests that businesses will invest in green buildings if the expected benefits (e.g., lower energy costs, increased property value, and improved marketability and demand) outweigh the investment costs. On the other hand, the future consumer demand for green real estate can also be shaped by market supply, as can be the case with innovation in general (e.g., Apple iPhones and other electronic devices). Hence, supply-side factors could influence consumer demand, becoming a market creator for green loans.

How can we define sustainable real estate in green financing?

Other critical terms in green real estate financing relate to how environmentally friendly buildings are termed, defined and classified. Such categorisation has various interpretations across the industry. While most of the terms initially centred around energy, the terms adopted by institutions and governments have now started transitioning towards zero emissions – signalling a clear leap in scope and target setting, aligning with the Paris 2015 objectives. Table 1 below summarises these terms and provides their most accepted definitions.

Table 1. Varying definitions for environmentally sustainable buildings.

Term	Definition	Market (if applied in policy)	Source
Energy-efficient building	A building with a high degree of energy efficiency in its fabric and building services that consume energy (e.g., heating, cooling, cooking, lightning, ventilation, hot water, appliances).		(United Nations Environment Programme, 2022)
Nearly zero-energy building	A building that has a very high energy performance, where the nearly zero or very low amount of energy required is covered to a very significant extent by energy from renewable sources, including energy from renewable sources produced on-site or nearby.	EU, 2010: Target for all new buildings by end of 2020, all public buildings by 2018.	EPBD 2010, 2010/31/EU
Net-zero operational energy buildings	Buildings that, over the course of a year, offset their energy consumption through the generation of renewable energy.		GlobalABC, IEA, UNEP, 2020
Zero-energy building	An energy-efficient building where, on a source energy basis, the actual annual delivered energy is less than or equal to the on-site renewable exported energy.	US Department of Energy, 2015	(IPEEC, 2018)
Zero energy (and carbon) ready buildings	Buildings that have an energy efficient thermal shell and appliances, have sufficiently low energy use and have the relevant set-up so they are 'ready' to achieve net zero energy (and carbon) usage, if they are combined with renewable or decarbonised energy systems on-site or offsite.	Australia, 2018	(Commonwealth of Australia, 2018)
Low-carbon building	Building that is energy efficient and is supplied by low-carbon energy. Some building services equipment may not be decabonisable without being replaced (e.g., fossil gas boilers)		United Nations Environment Programme, 2022)
Nearly-zero carbon building	A building that is energy-efficient and may have some available zero-emission energy supply (onsite or offsite) but that does not offset 100 % of the building's energy demand.		United Nations Environment Programme, 2022)
Net-zero carbon building	A building that is energy efficient and relies on zero-emission energy sources that meet the energy demand over the course of a year (or other established timeline, e.g., a month)		United Nations Environment Programme, 2022)
Zero-carbon building	A building that is energy efficient and has its energy demand completely met through zero emission energy generated either onsite or offsite		United Nations Environment Programme, 2022)
Zero-emission building	Building with very low energy demand, zero on-site carbon emissions from fossil fuels, and zero or very low amount of operational greenhouse gas emissions.	EU target for all new buildings from 2030 and existing buildings from 2050.	EU's Revised EPBD (EU/2024/1275)
Carbon negative building	An energy-efficient building that generates renewable energy onsite that not only fully covers the building's own energy demand, but also produces excess renewable energy which is fed back to the grid and can be used for other offsite purposes.		United Nations Environment Programme, 2022)
Whole lifecycle, net zero-carbon building	A zero-carbon building with the additional requirement that the embodied emissions associated with the material used for the construction are themselves net zero, either through decarbonisation or offsetting		IEA 2022
Whole-life, net-zero carbon emissions buildings	Buildings that offset not only their operational carbon emissions but also the carbon emissions embodied in the materials used for their construction.		United Nations Environment Programme, 2022)

How are the sustainable building definitions shifting?

Figure 2 below visually presents the varying ambition levels across the definitions, particularly regarding the loads addressed and the boundaries set for energy and emissions. At present, there's a noticeable upward trend in ambition level. Previously, the definitions were primarily energy-centric, but we are now shifting towards using emissions (or carbon) as the primary metrics. Additionally, there's a concurrent transition from focusing solely on operational emissions to including the embodied emissions from building construction.

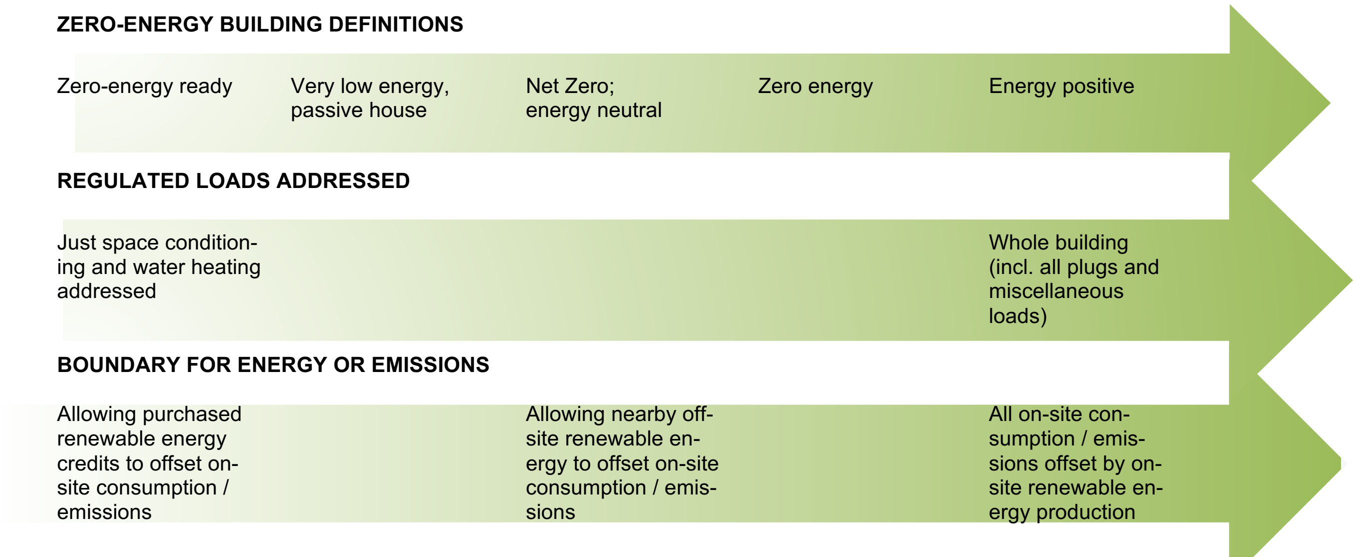

Figure 2. Ambition levels of different zero-energy building definitions. Adapted from DCCEEW (2022).

How much decarbonisation does the real estate sector require?

As illustrated in Figure 3 below, buildings were responsible for around 34 % of global energy demand in 2022 and a 36 % share of global energy and process emissions (IEA, 2023a).

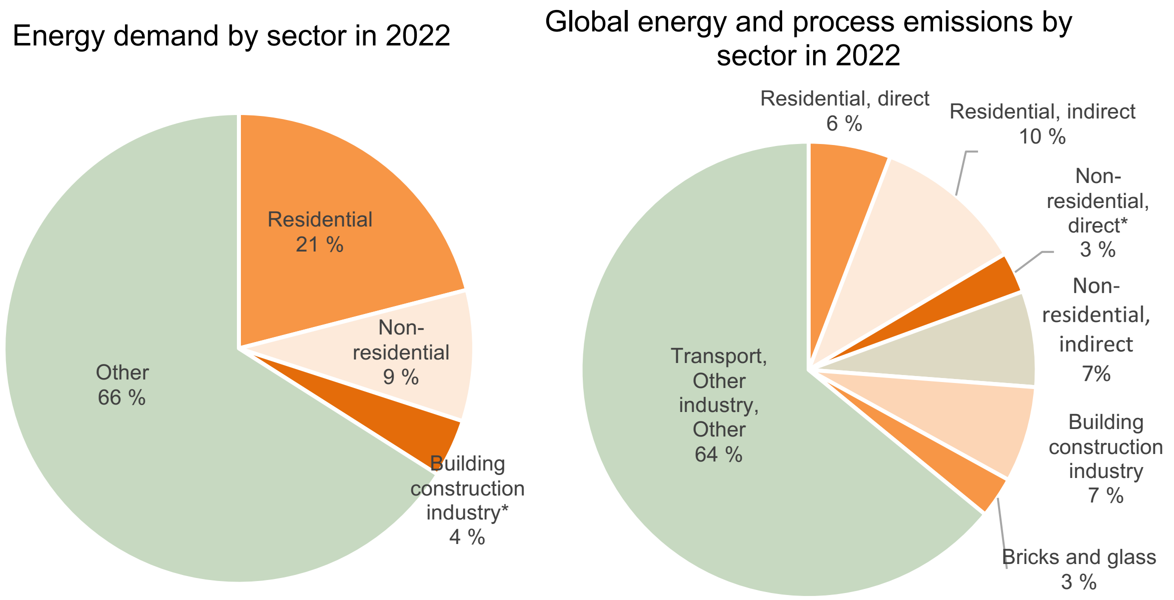

Figure 3. Energy demand, global energy, and process emissions in 2022. Adapted from IEA (2023a).

What are embodied emissions, and what's their impact?

To achieve net zero by 2050, the construction of new buildings and renovation of existing residential buildings need significant changes, and both operational and embodied emissions – whole lifecycle emissions - require urgent attention. Operational emissions are the carbon emissions from a building's space and water heating, lighting, cooling, equipment, and appliances. In contrast, embodied emissions refer to the emissions from manufacturing and processing building materials (Ibn-Mohammed et al., 2013). Röck et al. (2020) have shown that while around 20-25 % of a typical building's total lifetime greenhouse gas emissions come from embodied emissions, this figure can rise to 45-50 % for very energy-efficient buildings. In some extreme cases, the embodied emissions can even make up more than 90 % of a building's total emissions. (Röck et al., 2020). Figure 4 below illustrates the building's lifecycle energy components.

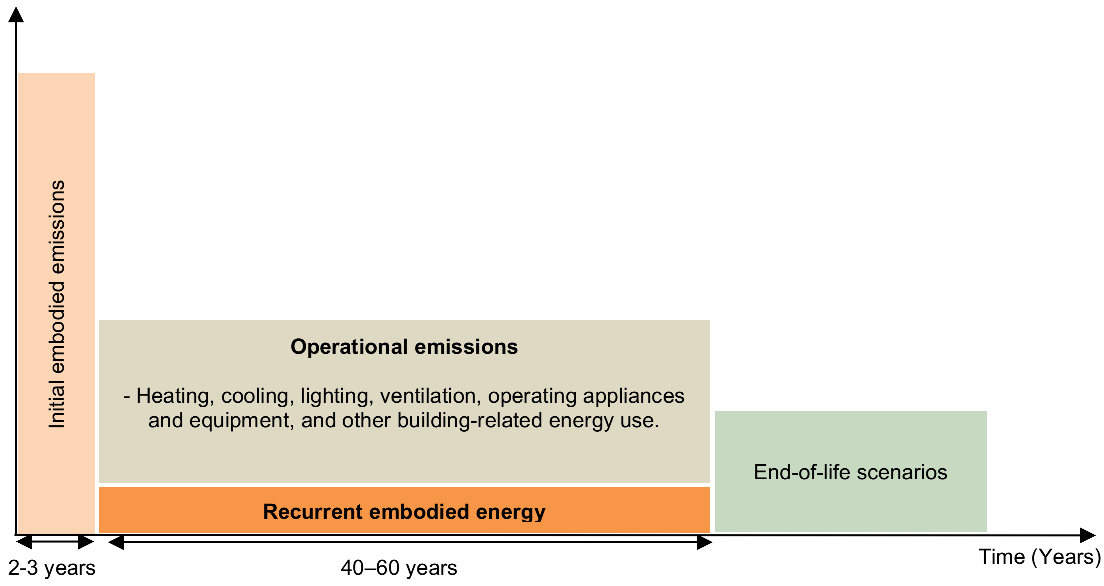

Figure 4: Lifecycle energy components of buildings. Adapted from Ibn-Mohammed et al. (2013).

How can we reduce operational and embodied emissions in the real estate sector?

Reducing operational emissions from existing buildings calls for changes to space heating, water heating, residential appliances, cooling, cooking, and lighting. In practice, on-site photovoltaics and heat pumps must be installed. Cutting down embodied emissions during the building design stage considers the type and shape of the building and its multiple uses. This also includes design features that enable buildings to be adjusted and adapted to meet changing user needs and repurpose unused buildings, which helps avoid using materials and land contributing to greenhouse gas emissions. However, achieving buildings with low embodied emissions may incur additional upfront costs to enable long-term benefits and reduce the risk of stranded assets over time. The willingness to bear these costs will depend on the risk and return profile of various stakeholders at different stages of the property supply chain. Additionally, building codes worldwide are being updated to include limits on embodied carbon, ensuring that new constructions meet stringent environmental standards. Ensuring that these upfront investments translate into long-term savings and environmental benefits is crucial for encouraging the widespread adoption of low-emission building practices.

When constructing buildings, mitigation interventions include low-emission construction materials, a highly efficient building envelope and integration of renewable energy solutions. Once the building is in use, using highly efficient appliances and equipment, optimising the use of the building, and powering it with low-emission energy sources are key mitigation strategies. Finally, at the end of the building's life, recycling and re-using construction materials are essential emission reduction strategies. (IPCC, 2023)

How do global floor area growth and buildings' long-time spans affect decarbonisation?

In most regions, historical energy efficiency improvements have been negated by floor area per capita growth (IPCC, 2023). Furthermore, the global floor area is expected to increase by around 15 % by 2030 – equivalent to North America's entire built floor area today (IEA, 2023b). For the building sector to remain on track, global operational emissions must decrease by 50 % from their 2022 level by 2030 (International Energy Agency, 2023; IPCC, 2023). Simultaneously, embodied emissions require significant attention. Embodied steel emissions must fall 25% and 20 % for cement by 2030. The risk is that buildings' long 50- —to 100-year lifespans potentially cement a future dominated by emission-intensive structures susceptible to environmental risks (International Energy Agency et al., 2023).

What are the real estate sector's emission reduction targets?

To align industry with global decarbonisation goals, such as the Paris Agreement, all new buildings need to be net zero from 2030, a substantial increase from less than 5% of new buildings today (International Energy Agency et al. 2023). Renovating[4] and retrofitting[5] current housing stock is concurrently paramount, as, for instance, about 75 % of the European building stock is energy inefficient, meaning that they do not meet Europe's requirements for building energy efficiency. Yet almost 80 % is estimated to be still in use in 2050 (Braune et al., 2021). In IEA's Net Zero Energy Scenario, the global average retrofit rate will reach only 2.5% by 2030 and remain at that level until 2050, leading to about half of existing buildings being retrofitted and becoming zero-carbon ready by 2040 (International Energy Agency, 2023). This contributes to an average annual investment requirement of USD 700 billion, of which 80 % is projected to be in retrofits and heating, followed by efficient appliances (IEA, 2020). The Intergovernmental Panel on Climate Change (IPCC) analysis suggests that by 2050, as much as 61% (equivalent to 8.2 GtCO2) of worldwide building emissions could be reduced. This potential reduction is attributed to various policies. Policies that reduce the demand for energy and materials, known as sufficiency policies, could contribute to 10% of this potential. Energy efficiency policies could contribute 42%, while renewable energy policies could contribute 9%. Most of the mitigation potential for new buildings is found in developing countries. Conversely, in developed countries, the most significant potential for emission reduction lies in refurbishing existing buildings (IPCC, 2023).

What's covered in the rest of this report?

This report is structured as follows: Section 2 explores the decarbonisation needs of the real estate sector from the diverse real estate sector stakeholders, including, policymakers, investors, owners, and financial institutions. Section 3 overviews the current green real estate financing instruments and their market outlooks and frameworks. Section 4 details the most used metrics and KPIs to define 'greenness' in the real estate context. Section 5 delves into the green real estate financing instruments beyond

[4] Renovation refers to returning the building and its systems to their original condition, addressing the forces of physical obsolescence and then taking it one step onward by integrating changes to physical building parameters (Che Husin et al., 2019).

[5] Retrofitting refers to a process of replacing and systems and technology in existing building to address its technological or environmental obsolescence (Che Husin et al., 2019).

greenium as confirmed by various research studies. Finally, Section 6 summarises the report and presents key conclusions.

2. Real Estate Sector's Decarbonisation

Implementing strategies and policies to reduce embodied and operational building emissions in the real estate sector aligned with the Paris Agreement objectives requires knowledge sharing and coordination between diverse actors. These actors include government bodies (regulatory, national and local), private sector entities (developers, engineers, architects, planners), non-governmental organisations (financial institutions, industry associations, technology providers) and the general public. This section focuses on motivations for these diverse actors to move towards decarbonisation strategies. It examines the incentives from multiple perspectives: 1) real estate owners and investors, 2) financiers and insurers of the real estate sector, 3) capital markets, and 4) governments.

2.1 Real Estate Owners and Investors

Climate change poses serious physical and transition risks for real estate owners. These physical risks include property damage, mortgage default, house valuation risks, and market responses to climate migration flows (UNEP FI, 2023). Transition risks include declining market attractiveness that reduces demand, asymmetric market shocks, dramatic shifts in competitive advantages, and asset and market valuation risks. Risks to owners and investors also involve increased regulation and increased financial reporting and disclosure obligations (especially for listed REITS on securities exchanges due to IFRS reporting requirements), which can bring additional costs and risks to reputation and market positioning due to inaction or delayed action (UNEP FI, 2023). A 2021 survey on real estate transition risks highlighted that 94,1% of respondents regarded climate change and sustainability as a substantial board-level discussion topic. This focus is driven by tightening regulatory frameworks on efficiency and GHG emissions, concerns about stranded asset risks, and other transition risks such as increased carbon pricing and growing reporting requirements (CRREM, 2021).

SNAPSHOT 1: Physical and Transition Risks in Real Estate

Overview

The physical effects of climate change are intensifying. The eight years since the Paris Agreement conclusion in 2015 have been the hottest measured. Rising temperatures fuel new climate extremes, with heatwaves, storms, drought, wildfires, and flooding becoming more common, damaging and deadly. Buildings within many coastal cities and settlements are already experiencing severe effects from rising sea levels and climate change variability (IPCC, 2023).

Key features

- The transition risks for the real estate sector include increasing regulation, reporting and disclosure requirements (e.g., via IFRS S1 and especially S2 for listed vehicles like REITs), and policy pressure, cost of indirect emissions, shifting market preferences, change in investor sentiment and reputational risks of inaction (UNEP FI, 2023).
- Physical risks of climate change for the real estate sector include rising sea levels and coastal flooding, inland flooding, extreme storms, wildfires, subsidence, and heat and water stress (UNEP FI, 2023).
- The investments to decarbonise the real estate sector should not only mitigate the impacts of climate change, but also help the sector to adapt to shifting climate conditions.
- This calls for highly location-specific adaptation strategies to improve the real estate sector's resilience.
- Evidence from US and Australia suggests local lenders tend to securitise mortgages with higher levels of physical climate risks, signaling either a risk transfer from local lenders to securitisation markets or the securitisation markets not fully incorporating climate risks assessments (Keenan & Bradt, 2020; McCarthy & Reid, 2024).
- Recent Domain 2024 report (has suggested that up to 50% of property in Australia will be at risk due to climate related incidents including bush fire, flooding and costal erosion, putting at risk over $4 trillion dollars of real estate. This will also drive-up insurance costs as well as impacting property values.

Impact

- Physical and transition risks threaten real estate asset cashflows and future asset values (UNEP FI, 2023).
- Climate risks have already started affecting property insurance availability and pricing, with rising insurance premiums for vulnerable properties (UNEP FI, 2023).

Source: (Domain, 2024; ECBC, 2023; IPCC, 2023; UNEP FI, 2023).

For real estate owners and investors, decarbonising investments can provide complementary benefits. These include energy efficiency improvements and on-site renewable energy sources, reducing energy costs and boosting asset's future desirability. This can be achieved through increased rental income and decreased operating expenses and vacancies (Leskinen et al., 2020). Furthermore, energy and emissions are starting to impact funding availability. More environmentally friendly assets have more financing options than those not aligned with net-zero targets. This trend is already evidenced in some commercial real estate markets.

SNAPSHOT 2: User Cost of Real Estate

Overview

The user cost of real estate, often used in the context of housing economics, refers to the total cost of owning a property per period (typically a year). It includes both explicit costs (such as mortgage interest, property taxes, maintenance, and depreciation) and implicit costs (such as the opportunity cost of capital).

The user cost of housing can be represented by the following equation:

$UC=(r+m+\delta-\pi)\cdot P$

Where:

UC = User cost of housing

r = Real interest rate (nominal interest rate adjusted for inflation)

m= Property tax rate

δ= Depreciation rate (physical wear and tear of the property)

π = Expected capital gain or appreciation rate of the property

P= Current price of the property

$UC=(r+m+\delta+\text{maintenance cost rate}+\text{insurance cost rate}-\pi)\cdot P$

Key features

Green finance can reduce long-term costs and enhance property values by influencing these various cost components. For example, investing in energy-efficient building systems can lower maintenance and operational costs, while sustainable building materials can reduce depreceitation rates. Additionally, properties with green certifications often command higher market values and benefit from tax incenties, thereby enhancing overall property value.

Impact

Decarbonization can reduce long-term user costs through lower maintenance, , depreciation, insurance, and operational expenses while enhancing property value and benefiting from tax incentives.

Source: Fox & Tulip (2014).

Do all real estate owners have equal climate risk management opportunities?

Regulations, such as the Minimum Energy Efficiency Standard in the UK, setting a minimum energy class for domestic private rented properties (UK Government, 2023), will further divide the real estate markets between green, thriving, and brown, underperforming assets. These developments may exacerbate inequality issues in the consumer residential markets. After all, managing climate change mitigation and transition risks usually requires significant, one-time investments. These often reduce operational costs over time and enhance the asset's resilience. However, individuals with lower incomes may be unable to afford these investments, potentially leading to higher energy bills and a state of energy poverty.

In 2019, the Institutional Investor Group on Climate Change (IIGCC) laid out critical recommendations for the boards and management of listed real estate companies. They called for robust governance frameworks to effectively manage physical and transition risks impacting property assets and portfolios. IIGCC also advocated for strategic, science-based decisions to reduce greenhouse gas emissions, aligned with a commitment to net-zero emissions.

The IIGCC emphasised integrating climate risks into overall real estate-related risk management. This helps monitor how these risks affect company operations and the value of the property portfolios. They also recommend developing a framework to track and reduce material emissions (scope 1, 2, and 3) and energy use across entire buildings. Finally, the IIGCC urged listed property companies to align their public policy and lobbying efforts with their commitments and the implementation of the Paris Agreement goals. (IIGCC, 2019). IIGCC recommendations for real estate investors have recently expanded to incorporate the whole-life carbon aspects, accounting for embodied and operational emissions (IIGCC, 2023). Capturing this carbon-related real estate asset information is the first step to capturing its market value. The IFRS S1 and S2 reporting and disclosure requirements also affect eporting entities, especially large institutional REITs (IFRS, 2024a, 2024b).

How can climate-related real estate risks be managed?

One example of a tool developed to capture and measure climate-related real estate asset risks is the EU-driven Carbon Risk Real Estate Monitor (CRREM), as illustrated in Figure 5 below. CRREM is a tool for commercial real estate companies to measure climate change risks and the viability of retrofitting their assets. The tool aims to help real estate owners mitigate stranded asset risks by setting science-based carbon reduction pathways and empirically quantifying the different scenarios and their impact on investor properties, portfolios, and companies. The CRREM tool sets location-based benchmarks for operational decarbonisation to comply with the Paris Conference (COP21) climate targets of limiting global warming to 1.5°C. Currently, pathways are available for 44 countries in three versions for EU, US, and Asia Pacific for various commercial property types ranging from retail high street and offices to leisure & recreation. Overall, the CRREM initiative signals how climate change and energy efficiency investments impact commercial real estate strategies (CRREM, 2024).

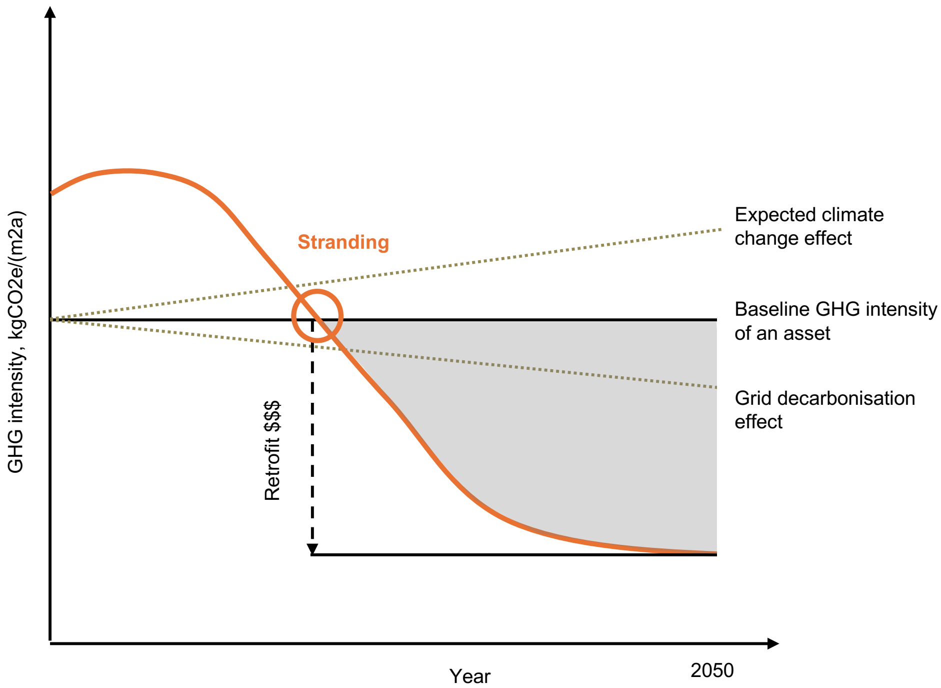

Figure 5. CRREM building progress vs. net-zero and asset stranding. Adapted from CRREM (2023).

How does access to information affect real estate risk management?

There may be asymmetry in access to information related to risk assessment in the real estate sector. Larger investment companies can often access detailed flood zone modelling and other risk data, which are typically unavailable or costly for individual homeowners, depending on location. This disparity means that risks are managed differently depending on the size of the investor or real estate portfolio. Homeowners or buyers may need more comprehensive information and awareness to pay attention to the risk of climate-related events like floods and storms. This could result in insufficient investment in protective measures or the selection of properties in high-risk areas.

2.2 Real Estate Lenders' Perspective

> "What will happen to the 30-year mortgage – a key building block of finance – if lenders can't estimate the impact of climate risk over such a long timeline, and if there is no viable market for flood or fire insurance in impacted areas?"
> Larry Fink (2020), Blackrock CEO, in his 2020 Letter to CEOs

What is the significance of mortgages and property loans for banks?

Mortgages and property loans represent a significant share of most bank assets. These debt instruments also expose lenders to climate risks related to the assets they finance, as the borrowers typically pledge a piece of real estate as collateral for the loan to purchase the property. From a bank perspective, the climate risks of mortgages are significant as typically mortgages have maturities of as long as 30 years – a timeline where physical risks could materialise (Duan & Li, 2024). Moreover, real estate is locked into its geographic location, predisposing the asset to the local physical climate risks[6]. These physical and transition risks include property damage, mortgage foreclosure risks, climate migration, and declining market attractiveness that may have significant credit, market, liquidity, reputational, and operational implications (UNEP FI, 2023).

How are climate risks already affecting bank real estate lending practices?

Banks are already making changes to reduce risk exposure and re-assess their lending policies. For example, US banks require more significant down payments (from traditional 20 % up to 40 %) and offer shorter loan terms for homes residing in coastal areas (Flavelle, 2020). Additionally, US banks are increasingly getting these mortgages off their books by selling them to government-backed buyers like Fannie Mae through securitisation (Keenan & Bradt, 2020), which can also lead to additional 'hidden' risks as the true credit risk with bundled mortgages can be difficult to ascertain. Duan & Li (2024) found evidence that lending institutions in the US are already taking climate risks into account when originating mortgages: loan officers approve fewer mortgage applications and originate lower amounts of loans in abnormally warm weather, with the effect being more substantial among US counties heavily exposed to rising sea-level risks, during periods of heightened public climate change attention, and for loans originated by minor lenders.

How are regulations impacting real estate lenders?

Additionally, regulations including additional reporting and disclosure obligations introduced by IFRS for reporting entities, impact real estate lenders. For example, in Australia, the prudential regulator called for banks to use quality data in their climate vulnerability assessments to understand how, e.g., flood and fire risks impact their mortgage books at the level of individual blocks rather than postcodes (James Eyres, 2023). Moreover, in the EU, banks must disclose their alignment with the EU Taxonomy regulations as the so-called green asset ratio (GAR). GAR shows the proportion of environmentally sustainable assets contributing substantially to climate change mitigation or adaptation objectives or enabling other activities under the EU taxonomy.

[6] For example, in Australia, the physical risks are significant, with an estimated 50% of Australian real estate at risk due to bushfires, flooding and costal erosion valued at over $4 trillion dollars of property at risk. (Domain, 2024)

SNAPSHOT 2: Property Insurance & Climate Change

Overview

Property insurance is a significant risk mitigation tool in the real estate sector. Climate change has now started impacting property insurance availability and pricing, dividing the property markets even further: climate-resilient assets may not be affected, but those in high-risk areas may struggle to get insurance due to increased severity of climate-related natural disasters and the resulting property damage. Bloomberg estimates a 360 % rise in insured losses from natural disasters in the past 30 years.

Key features

- As property insurers face higher costs due to more disasters, homeowners face higher property insurance costs.
    - For example, the average property insurance costs increased by 50 % from 2019 to 2023 in the US and are expected to hit a record high in 2024.
    - In Australia, insurance premiums rose by 28 % in a year in 2023, with a steeper increase of 50 % for high-risk properties, such as those in flood-prone areas.
    - The German Insurance industry has warned that home insurance premiums may double in the coming decade.
- Especially high-risk areas see significant changes, as some insurers have started reducing their exposure in these areas. Insurers may not issue new insurance policies and sometimes decline to renew existing.
    - For example, in Florida's flood-risk zones insurance premiums will approach USD 12.000, whereas the US average is expected to hit USD 2.522 a year.
    - In California, US, many insurance companies have stopped selling new home insurance policies altogether.
- The average US homeowner receiving an insurance non-renewal automatically loses a double-digit percentrage of home value (First Street Foundation).
- "Climate insurance bubble" refers to overvalued and possibly worthless houses lacking adequate insurance coverage against increased natural disaster risks.

Impact

- Intensifying weather disasters, rising reinsurance rates and high home repair fees will likely contribute to even higher future property insurance costs.
- Insurance non-renewals in high-risk areas are likely to decrease property values significantly.

Sources: Actuaries Institute (2023); Bloomberg (2024c, 2024d); First Street Foundation (2023); Gesamtverband der Versicherer (2023).

2.3 Capital Market Perspective on Sustainability

Capital market investors contribute to the demand for green real estate financing instruments and provide an essential source of capital for decarbonisation. Section 3 details the current green real estate financing instruments, while this subchapter describes the capital market's overall sentiment toward sustainability integration and decarbonisation.

How do sustainability-themed funds rank against their non-green competitors?

The total number of sustainability-themed funds worldwide increased in 2022, although the growth rate slowed from 2021 (UNCTAD, 2023). Overall, sustainability funds continued to be more attractive to investors than traditional funds in 2022 (UNCTAD, 2023). The value of the global sustainable fund market fell from its high of USD 2.7 trillion in 2021 to 2.5 trillion in 2022. Despite the decline in the sustainable fund market valuation, its net inflows were positive, in contrast to the net outflows from traditional fund markets. UNCTAD (2023) considers this to signal that investors view sustainable finance as a longer-term strategy and are convinced by the business case for sustainable sectors.

What is the institutional investor's role in decarbonisation?

Institutional investors, such as public pension and sovereign wealth funds, are crucial in financing sustainable energy investments. The capital-intensive and long-term nature of renewables investments align well with the maturity profiles of pension fund liabilities and meet the sovereign demand for infrastructure investments. According to UNCTAD's monitoring, more institutional investors report their climate actions, including investments in sustainable energy and divestments from fossil fuels. Similarly, the number of stock exchanges requiring sustainability reporting increased in 2022. (UNCTAD, 2023)

How has sustainability integration developed in the capital markets?

Overall, UNCTAD divides sustainability integration in capital markets into three distinct phases: 1) the pioneering phase with niche activities from the 1990s to 2005, 2) the mainstreaming era from 2005 to the adoption of the SDGs and the Paris Agreement in 2015, and 3) the standardisation and increasing codification from 2015 onwards, as Figure 6 below illustrates.

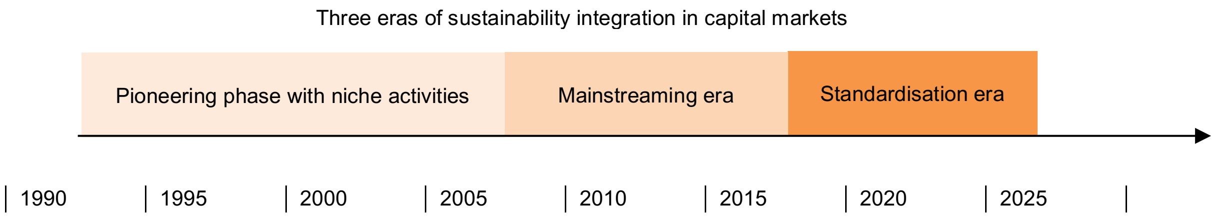

Figure 6: Three eras of sustainable finance. Adapted from UNCTAD (2023).

After 2015, many large capital market players, such as exchanges, fund issuers, and institutional investors, realised the materiality of sustainability risks and opportunities. The current era is characterised by increasing standardisation and codification. The next step requires rapid education and support for investors and other market players, especially in developing countries (UNCTAD, 2023).

2.4 Governments & Real Estate Decarbonisation

Governments have a pivotal role in decarbonising real estate. Governments establish their own climate change mitigation targets, usually expressed as nationally determined contributions, and enforce regulations to instigate the necessary changes. Recent government regulations have shifted the sustainable finance markets from a voluntary to a mandatory governance architecture (UNCTAD, 2023). By the end of 2022, 35 developed and developing economies and country groupings, representing 93 % of global GDP, had implemented 388 measures dedicated to sustainable finance. At least 50 were introduced in 2022, with more than 50 in development (UNCTAD, 2023).

How do governments express their climate mitigation plans?

Governments express their climate mitigation plans under Nationally Determined Contributions (NDCs), which should be updated and strengthened every five years. As of December 2023, 194 countries and the European Union have submitted NDCs to the United Nations Framework on Climate Change (UNFCCC) repository. Yet, overall, more improvements need to be made in the details of buildings-related actions and a clear reference to measuring the planned achievements, as shown in Figure 7 below.

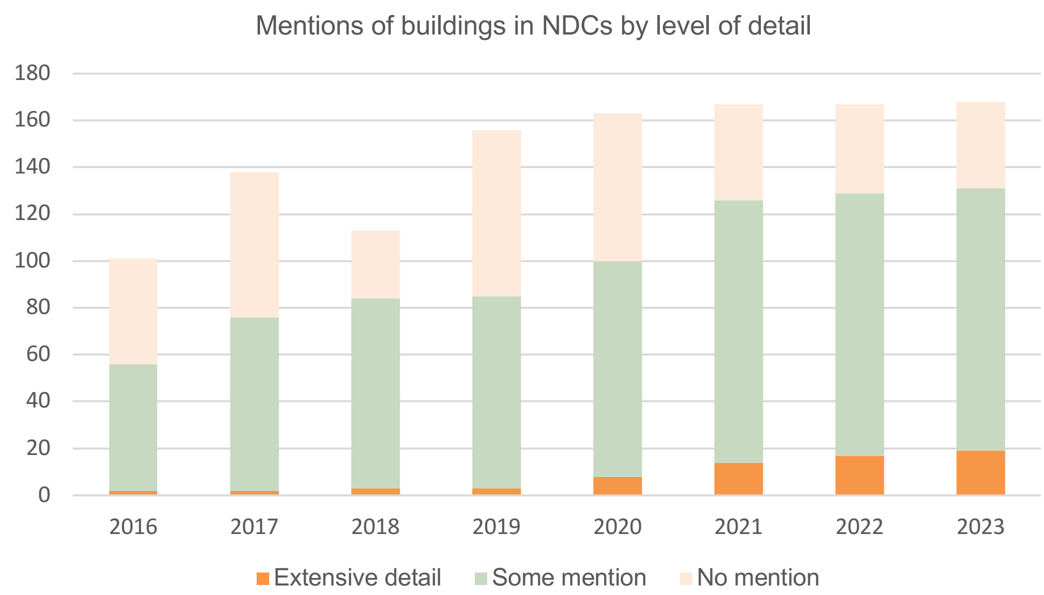

Figure 7. Mentions of buildings in NDCs with the level of detail. Data from GlobalABC (2024).

SNAPSHOT 3: COP 28 Renewables Pledge

Overview

The COP28 climate action announcements include over 74 emission reduction initiatives. While voluntary pledges can be a valuable tool to increase climate action, they have thus far provided mixed results. Climate Action Tracker's analysis however highlights the pledge to triple renewable capacity and double energy efficiency as a praiseworthy global target – that needs to be transformed into concrete implementation.

Key features

- The pledge aims to tripling global installed renewable energy capacity to 11,000 GWH by 2030 and doubling energy efficiency improvements from around 2 % to 4 % in the same timeframe.
- As of May 2024, the pledge has been signed by 133 governments, including almost all OECD members.
- Signatories commit to contributing to the global target, not necessarily to tripling renewables and doubling energy efficiency at the country level.
- Major players, such as China, which holds about 34 % of global renewables capacity, have not signed the pledge. However, China is expected to triple its renewables capacity regardless, though it may not achieve the efficiency doubling.
- Other non-signatories include India and Indonesia.
- While there seems to be a greater appetite for triple renewables than double energy efficiency, both are essential to meeting the emissions efficiency targets.
- Greater focus is needed on doubling the energy efficiency improvements, which will more complicated than tripling renewables.
- The pledge incorporates the principle of energy efficiency as the "first fuel" at the core of policymaking, planning, and significant investment decisions.

Impact

- If fully implemented, the pledge would close the presently estimated 2030 emission gap between current policies and the 1.5ºC target by 30-35 %.

Sources: Climate Action Tracker et al. (2023); COP28 (2024).

What does the policy and regulatory landscape consist of?

UNCTAD divides the current sustainable policy and regulation architecture into seven areas: national strategy, national framework and guidelines, taxonomy, product standards, sustainability disclosures, sector-specific regulations, and carbon pricing. The policymaking priority is improving market clarity and credibility and decreasing greenwashing concerns, primarily achieved through national sustainable finance taxonomies and standards and greater sustainability disclosure requirements.

How does the EU's sustainable finance approach differ from the US and China?

The EU, China, and the US have taken two different stances on sustainable finance regulation. The EU has primarily adopted a regulatory approach, prioritising establishing a comprehensive sustainable finance regulatory framework, which has been used as a benchmark in other countries. China and the US have thus far adopted a hybrid approach, highlighting both regulation and integration of climate and sustainable development dimensions into industrial policies. The US 2022 Inflation Reduction Act has focused on green investments. (UNCTAD, 2023)

What is the EU Taxonomy, and how is it paving the way for other governments?

The EU taxonomy, which entered into force on 1 June 2020, is the European Union's legislative effort to support sustainable investment by classifying environmentally sustainable activities, helping investors navigate the transition to a low-carbon economy. The EU Taxonomy creates a shared language for investors, green bond issuers, corporations and policymakers using specific technical screening criteria for six environmental objectives. To be classified as green or environmentally sustainable, an activity must significantly contribute to at least one of EU Taxonomy objectives while not significantly harming the other five and meeting "minimum social safeguards". The building and real estate sector is one of the first sectors governed by the EU Taxonomy. (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 (Text with EEA Relevance), 2020)

The EU Taxonomy has two explicitly climate-related environmental objectives: climate change mitigation and adaptation, which apply to many construction and real estate activities, e.g., from acquisition and ownership to construction, demolition, and renovation of buildings. EU-taxonomy's other objectives include water, circular economy, pollution prevention and biodiversity. Yet, currently, only circular economy targets apply to the construction of new buildings, demolition of buildings, maintenance of roads and motorways, renovation of existing buildings and use of concrete in civil engineering. The remaining three other EU Taxonomy objectives (water, pollution prevention, and biodiversity) do not currently apply to construction and real estate activities. (European Commission, 2022)

Other regions and countries have started following the EU's lead by developing their own green taxonomies. For example, Canada and South Africa's green taxonomies are primarily based on the EU Taxonomy, whereas other green taxonomies, such as Indonesia and Singapore, prioritise their local contexts. Overall, by the end of 2022, over twenty green taxonomies were published or being developed. (The SustainAbility Institute by ERM, 2022).

SNAPSHOT 4: Central Banks and Climate Change

Overview

Over 100 central banks and financial supervisors are part of the "Network for Greening the Financial System" network, which aims to manage climate change risks and mobilise mainstream finance to support the transition toward a sustainable economy. Climate risks can impact the financial system through physical risks and transition risks, affecting three key areas: financial stability (e.g., bank soundness and overall financial system risks), macroeconomic variables (e.g., growth and inflation), and monetary policy. The increasing frequency and severity of physical risks may increase losses for banks and insurers. Transition risks arising from potentially costly climate policies to decarbonise the economy can potentially result in higher loan losses for financial institutions.

Key features

- Regulators aim is to encourage banks to incorporate climate risks in their strategies and risk management.
- Supervisors' climate stress tests help identify the primary sectors and geographies generating transition and physical risks for banks' assets and aim to quantify their exposure to these risks.
- Currently, regulators are not imposing higher capital requirements on banks for long-term climate risks, but they are intensifying pressures on bank management to understand and manage these risks actively. However, there are potential future prudential implications arising from climate risks.
- Climate risk and the net-zero transition are also likely to directly affect monetary policy as weakened financial systems due to asset losses could impair the effectiveness of monetary policy. Weakened asset values for banks via their collaterisation processes and systems could lead to increased stress for banks and other financial institutions due to bad and doubtful debts.
- The transition to a hotter planet or a greener economy is expected to lead to significant structural changes that can alter the neutral interest rate, affecting labour productivity and capital accumulation due to increased physical risks.
- Frequent and severe physical risks, along with the swift transition to net-zero emissions, are likely to cause volatility in output and inflation, challenging central banks' abilities to maintain price stability.

Impact

- Integrating climate considerations into central banks' asset portfolios and collateral eligibility criteria will further incentivise investors to purchase sustainable assets.

Source: ECBC (2023, pp. 56–58).

3. Current Green Real Estate Finance Instruments

The green real estate financing market encompasses various instruments, including green mortgages, green loans, green bonds, green covered bonds, green mortgage-backed securities, and green building funds. Each instrument serves different purposes and targets distinct market segments, from individual homeowners to large corporations and institutional investors. The total labelled finance market amounts to around USD 7.2 trillion in overall issuance, encompassing green bonds (USD 3 trillion), sustainability-linked loans (USD 1.5 trillion), green loans, sustainability bonds, and social bonds (each representing USD 700-800 billion), and sustainability-linked bonds (USD 280 billion) (Bloomberg, 2024b), as Figure 8 illustrates.

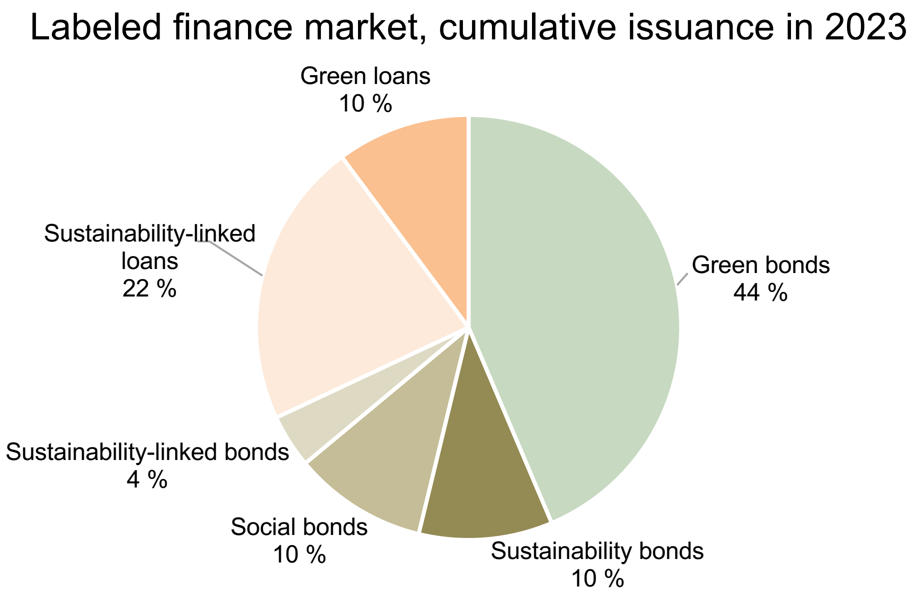

Figure 8. Sustainable finance market, cumulative issuance in 2023. Data from Bloomberg (2024).

Who issues green bonds?

Figure 9 below shows that non-financial and financial corporations have issued most green bonds, with Chinese banks dominating the issuance in 2023. Sovereigns were responsible for 14 % of cumulative sustainable bond issuance in 2023. (Climate Bonds Initiative, 2024a)

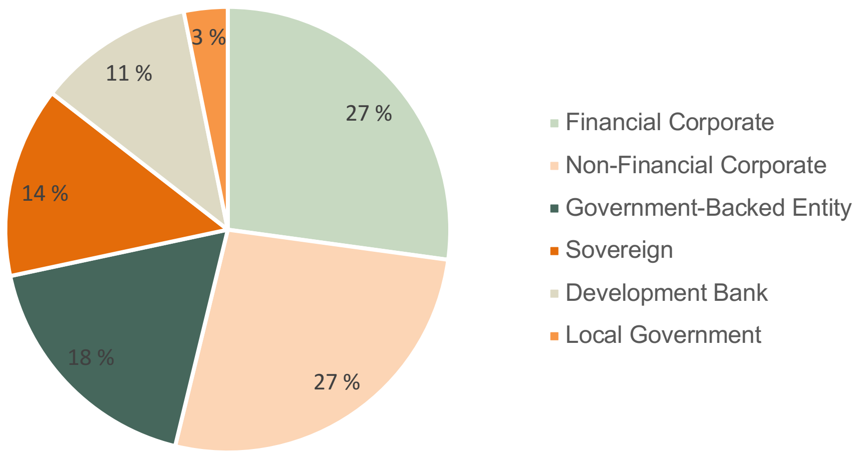

Figure 9. Issuers of cumulative green bonds. Data from Climate Bonds Initiative (2024).

The sovereign issuers (i.e., national governments) are important in the green finance markets. Especially the countries with AAA credit ratings (e.g., Australia, Sweden, Finland) with lower default rates and legal green finance frameworks, as they introduce a layer of regulatory credibility and robustness to the green finance markets. This welcome market development compliments private green bonds that primarily depend on private contracts between two or more counterparties with some assurance from the green finance standards and IFRS Sustainability Standards S1 and S2 for reporting and disclosures. Overall, sovereign green bonds issued by low default sovereigns may attract more investors to green finance markets as many international investors are mandated to only invest in AAA-rated financial products. The statutory legal frameworks of sovereign green bond issuers, combined with their AAA credit ratings, increase the pool of resources, which may unlock further development and innovation within private green financial markets.

When examining green bond issuance by region, we note that Europe remains the largest issuer. However, as Figure 10 below shows, Asia-Pacific is catching up.

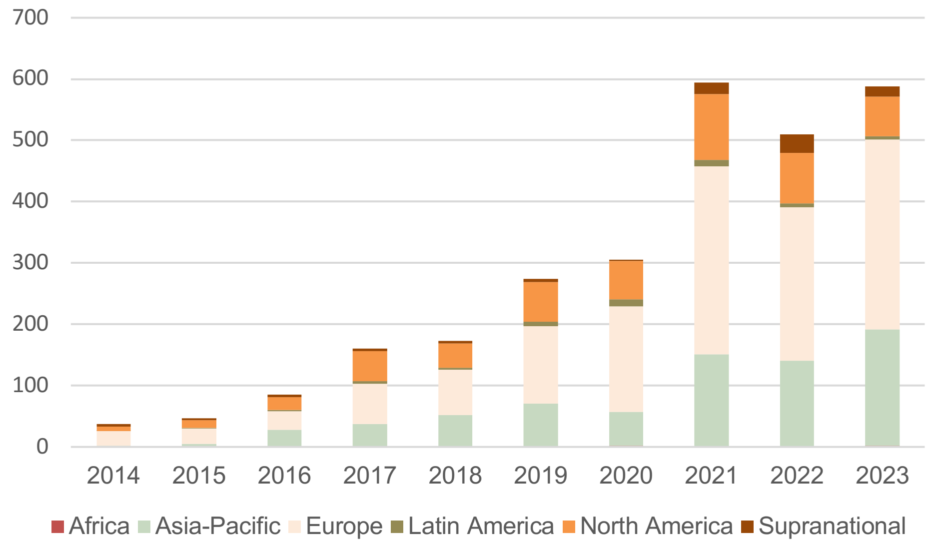

Figure 10. Green bond issuance in USD billions by region from 2014 to 2023. Data from CBI (2024).

What is the difference between sustainable and sustainability-linked products?

Interestingly, the sustainable finance markets are becoming more starkly divided between instruments with explicit use of proceeds and those tied to the borrower's ESG targets: Sustainability instruments, such as green and social bonds, saw issuance picked up in 2023, whereas sustainability-linked instruments that don't have a precisely defined use of proceeds but are tied to the issuer's environmental performance saw only 40 % yearly issuance of the 2021 highs. As the linked sustainability instruments have fallen dramatically, the annual green finance issuance declined in 2022 and 2023. (Bloomberg, 2024b) As this report is dedicated to green real estate financing, we are primarily excluding the green-linked and sustainability-linked instruments as they refer to the corporation's sustainability and low-carbon actions are not directly linked to real estate as such.

How is the green real estate financing submarket developing?

The green real estate debt market, a broader green debt sector segment, experienced a more rapid expansion than any other green debt market until 2021 (OECD, 2022). In 2021, approximately 30 % of green debt finance proceeds were allocated to buildings (OECD, 2022). Green bonds represent the most substantial market segment, with cumulative issuance reaching 3 trillion in 2023 (Bloomberg, 2024b). In 2022, USD 487.1 billion was issued, with around 25% allocated to buildings. However, the share of buildings in total issuance decreased to 18 % in 2023, indicating a shift in the allocation of green bond proceeds. While green bonds have extensive data available, other instruments like green mortgages and green mortgage-backed securities lack systematic global data.

What do the green real estate financing markets organised?

Green real estate financing markets can be categorised into wholesale and retail markets. The green retail financing market involves banks and other financial institutions financing individuals, retail customers, and small and medium companies' green real estate investments via green mortgages and loans. In contrast, the wholesale green debt market includes wholesale funding markets where large investors or institutional lenders provide debt to financiers or large borrowers, such as real estate developers, pension funds or other large corporate clients. There can be an interaction between wholesale and retail green markets where green loans and mortgages in retail markets can be repackaged to create new financial products, such as asset-backed securities, green-covered bonds and green mortgaged-backed securities for wholesale markets. Similarly, some large institutions can issue green bonds to the wholesale markets. Once these green debt securities have been issued on the primary wholesale capital markets, they can then be exchanged between investors on secondary capital markets. Figure 11 below illustrates the differences between retail, primary, and secondary wholesale markets in green real estate financing. Notably, all green real estate debt products rely on asset-level sustainability data.

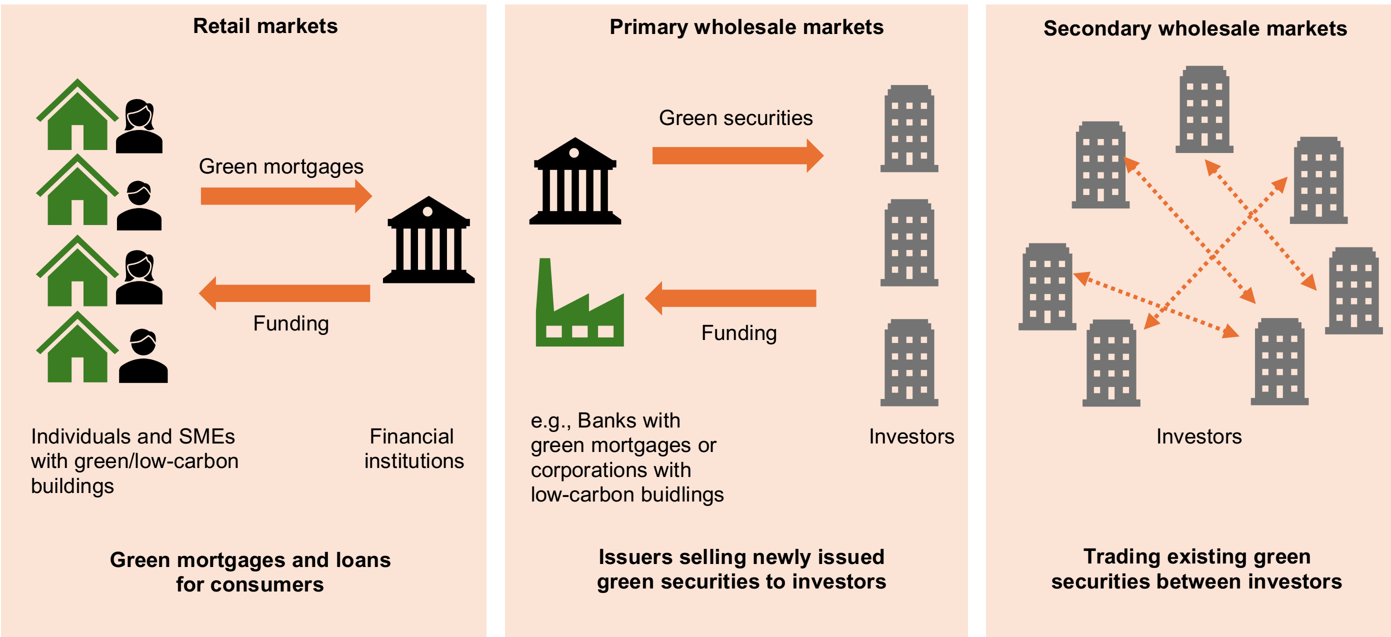

Figure 11: Green real estate financing markets: retail, primary and secondary wholesale.

Table 2 details the real estate sector's most often used green debt instruments, with yearly issuance and typical issuers, borrowers, and investors. The remaining chapter then describes these primary green real estate finance instruments, overviewing their submarkets and primary green finance frameworks.

Table 2. Primary green financing instruments in the real estate sector.

	Definition	Market size	Yearly Issuance	Typical financier/ investor	Typical borrower
Green mortgages	Financial arrangements given on preferential treatments by banks or mortgage lenders to homeowners when they purchase or renovate buildings meeting certain ecological requirements, e.g., green building standards (Akomea-Frimpong et al., 2022). Can be classified into energy-efficient mortgage loans and green building certification mortgage loans (OECD, 2022).	No systematic data on the size of markets available (OECD, 2021)	-	Retail banks, mortgage lenders	Homeowners
Green loans	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. Green loans are based on 'use of proceeds' (UoP), with borrowing proceeds transparently earmarked for eligible 'green' assets. Green loans include green corporate loans and green consumer loans. In the building sector, the latter can consist of loans for rooftop solar panels, batteries and water tanks. (Climate Bonds Initiative, 2020).	In China, green loans represented 12.7 % of China's total loan balance (J. Zhang et al., 2024)		Retail banks, financial institutions	Corporations, homeowners
Green bonds	Any type of bond instrument where the proceeds are exclusively applied to the finance or re-finance of projects with clear environmental benefits (Climate Bonds Initiative, 2024a)	Cumulative issuance of USD 2.830tn (Climate Bonds Initiative, 2024a)	487.1 USD billion in 2022, of which around 25 % was for buildings; in 2023, buildings' share decreased to 18 % of total issuance (Climate Bonds Initiative, 2023)	Institutional investors, investment managers, governments, corporate investors	Financial corporations, non-financial corporations, government-backed entities sovereign, development banks
Green covered bonds	Debt instruments secured by a cover pool of mortgage loans (property as collateral) to which investors have a preferential claim in the event of default, where the covered bond includes the issuer's formal commitment to use an amount equivalent to the proceeds of that same covered bond to (re)finance loans in clearly defined green criteria, based on their issuer's sustainable bond framework which an independent external assessment has verified. (ECBC, 2023)	Cumulative issuance EUR 69.44 billion between 2019 and Q1 2023 (ECBC, 2023)	EUR 24.0 bn in 2022	Bank or mortgage institution	
Green mortgage-backed securities (MBS)	A MBS that uses green mortgage loans are underlying assets, providing issuers and investors additional risk management tools and options to increase investment portfolio diversification. Issued, e.g., in the US, UK, France, the Netherlands, China, Australia (OECD, 2022)		0.3 % in the US, 1.5% in China, 7% in Europe (OECD, 2022)	Government sponsored enterprises, municipalities	

3.1 Green Real Estate Bonds

Bonds are straightforward debt instruments governments, municipalities, or corporations use to raise capital. Investors buying bonds lend money to the bond issuer in exchange for periodic interest payments and the bond's face value return at maturity. Green bonds are like regular bonds, but the bond proceeds are exclusively applied to finance or re-finance projects with clear environmental benefits (Climate Bonds Initiative, 2024a).

Green bonds initially promised – and in many cases also delivered, a green premium ("greenium"). Yet, the current literature on greeniums has been somewhat inconclusive, with no overall definitive conclusion confirmed. A recent European Securities and Markets Authority (ESMA) research on greenium could not confirm a systematic greenium for green bonds as of March 2023, even if ESG bonds benefitted from statistically significant pricing in the past driven by their issuer-level ESG credentials (ESMA, 2023).

Cortellini & Panetta's (2021) review shows that 40 % of past research in the primary markets has found evidence for the greenium. Still, the share for controversial and contrary evidence was 40 % and 20 %, respectively. In the secondary markets, 63 % of past studies have confirmed evidence for the greenium (Cortellini & Panetta, 2021). In the cases where the studies have confirmed the greenium, the identified greenium varies significantly from around -63 basis points (bps) to around -0.9, as shown in Table 3 below. To put the greenium finding in perspective, we can compare this to credit default swap rates representing country default risks of 13.08 bps for Australia, 37.33 bps for the US, and 60.23 bps for China. This means that the greenium ranging from -0.9 to 63 basis points can significantly impact borrowing costs, potentially making it cheaper than the country risks for some nations.

What do we know about the greenium in green real estate bonds?

When it comes to the greenium of green real estate bonds, research is scarce. European Public Real Estate Association estimated the greenium on green bonds issued by European listed property companies and confirmed a greenium of -8.3 bps for green bonds issued between 2020 and 2022 (EPRA, 2024). Interestingly, the EPRA research noted a decreasing trend for greenium over time for European issuers. Furthermore, no statistically significant evidence for greenium was found as of September 2023, aligning with ESMA's (2023) research explained above. On the other hand, the decreasing greenium trend may be explained by the low liquidity observed in many fixed-income markets in 2022-2023 (EPRA, 2024).

What are the broader benefits of green bonds?

Overall, even if research relating to the presence of greenium lacks concensus, there is agreement that green bonds attract other benefits. For example, many studies have found that company stock prices respond positively to corporate issuers' green bond announcements (Baulkaran, 2019; Flammer, 2020, 2021; Tang & Zhang, 2020; Zhou & Cui, 2019), indicating that investors perceive green bonds as adding value. Green bond issuance also helps broaden the investor base and attract new investors (Flammer, 2021; Tang & Zhang, 2020). For publicly listed green bond issuers, first-time issuers see a 1.95% increase in stock liquidity and a 7.9% increase in institutional ownership. In contrast, green bonds are generally more liquid than brown bonds globally (Tang & Zhang, 2020). In fact, 70 % of issuers report higher demand for green bonds than plain vanilla bonds, as revealed by a global survey of green bond issuers covering 29 % of all green bonds issued since 2007 (Bhutta et al., 2022).

Additionally, green bond issuance has been linked with increased long-term environmental and financial performance (Flammer, 2020). Sangiorgi & Schopohl (2023) surveyed global green bond issuers representing 29 % of total green bond issuances and found that reputational benefits, market signalling power and climate change mitigation are the main motives for green bond issuance. These benefits justify the higher green bond issuance costs that include e.g., additional certification, verification, and compliance costs (Sangiorgi & Schopohl, 2023). Table 4 lists studies identifying evidence for green bond benefits beyond greenium, as discussed above.

Table 3. Recent green bond benefits in academic literature, published from 2019 onwards.

GREENIUM **Quantified Benefit**	**Country**	**Methodology**	**References**
Mean greenium of around -1.1 bps, yet varies significantly	Global	Global data from -14 to 2019	(Lau et al., 2022)
Greenium of around -4 bps around whole European green bond market	Europe	Linear regression methodology with 3851 green and conventional bonds from 2007 to 2021	(Sergei & Alesya, 2022)
A yield bond spread of -8 and -14 bps on the secondary market	Global	OLS regression, data from 2007-2019 with 466 samples	(Immel et al., 2022)
Significant greenium of - 22 bps for non-financial corporations, but not for financial institutions	Global	Global data on 1397 green bonds during 2007-2018	(Fatica et al., 2021)
The existence of greenium, on average -1 to -9 bps, within 56 % of primary and 70 % of secondary market studies	Global	Literature review	(MacAskill et al., 2021)
Average greenium of – 15 to -20 bps both on primary and secondary markets	Global	Regression analysis with propensity scoring and coarsened exact matching, with all available green bonds data from 2007 to October 2019, and conventional bond data of same issuers	(Löffler et al., 2021)
Credit spread of -34 bps between green bond yield and treasury security of comparable maturity	China	Multivariate and univariate analysis with data from 2016-2019, with 159 samples	(Wang et al., 2020)
For publicly-listed green bond issuers, green bonds have a - 6.94 bps yield spread compared to corporate bonds issued by similar firms on primary markets. Yet, if compared with non-green bonds of the same issuer in the same year, no significant pricing exists.	Global (28 countries)	Panel regressions with 132 unique public issuers from 2007-2017	(Tang & Zhang, 2020)
A small negative premium of -4 bps in daily traded market yields on secondary markets	The US	Municipal green bonds, panel regression model	(Partridge & Medda, 2020)
A small negative premium of -2 bps in the entire sample on secondary markets	Global	Fixed effect panel regression, data from 2013 to 2017	(Zerbib, 2019)
A small negative and significant premia of 1) -4,7 bps and 2) -2,2 bps	Global	Intra-curve method at the security level, 2) matching method at the asset level, data from the secondary markets	(Slimane et al., 2020)
Greenium of - 63 bps compared with comparable corporate bonds	Global	Panel data regression with hybrid model over 2016-2017.	(Nanayakkara & Colombage, 2019)
Institutional green bonds have a negative premium, ranging from 0.9 to 1.87 bps. Yet, negative greenium identified in private green bonds.		Regression analysis of 89 green – brown bond pairings on secondary markets	(Bachelet et al., 2019)
A statistically significant premium of around 18 bsp for the whole market, for corporate issuers -21 basis points	Europe	Propensity score matching approach with 121 green bonds issued between 2013 and 2017	(Gianfrate & Peri, 2019)

SNAPSHOT 5: Factors Influencing Green Bond Pricing

Overview

Studies from sources like the Climate Bonds Initiative highlight that green bonds generally achieve tighter spreads at issuance compared to conventional bonds, reflecting the greenium. However, this premium can vary depending on market conditions, issuer reputation, and the specific characteristics of the bond. High demand from ESG-focused investors, regulatory incentives, and reputational benefits typically lead to more favourable pricing for green bonds. The EIB's Climate Awareness Bonds showcases how these factors play out in practice, highlighting the importance of transparency, investor confidence, and market development in achieving better pricing for green bonds.

Key features

- Green bonds are typically priced with considerations like conventional bonds but with additional factors related to their environmental benefits and the growing demand for sustainable investments.
- Greenium reflects the premium investors are willing to pay for the environmental benefits and alignment with sustainability goals.
    - Evidence from EIB: The primary market pricing of EIB's Climate Awareness Bonds (CABs) has shown instances of greenium, ranging from 5 to 10 basis points lower than equivalent conventional bonds.
- Green Bond Yield: Suppose EIB's green bond has a yield of 1.5%.
- Conventional Bond Yield: A similar conventional bond issued by EIB might have a yield of 1.7%.
- Greenium: The difference between the yields (1.7% - 1.5% = 0.2%) represents the greenium. Investors accept a lower yield on the green bond due to its environmental benefits and alignment with their sustainability goals.

Impact

- Comparative Analysis on EIB's Climate Awareness Bonds: The evaluation of EIB's CABs indicates that while there is evidence of greenium, it is not yet systematic across all issuances. The secondary green bond market often provides enhanced stability and lower volatility, justifying lower yields within the primary green bond market.

Source: EIB (2021).

Table 4. Green bond benefits beyond greenium in research from 2019 onwards.

Quantified Benefit	Country	Methodology	References
POSITIVE STOCK MARKET REACTIONS			
70% of issuers state that the level of demand for green bonds is higher than the demand for previously issued plain vanilla bonds	Global	Survey of green bond issuers covering 29 % of all green bonds issued since 2007.	(Bhutta et al., 2022)
Cumulative abnormal return of 0.49 % for green bonds, with the returns being higher for certified bonds and first-time green bond issuers	Global	Matching methodology with corporate green bonds from 2013 to 2018	Flammer, 2021
For publicly-listed green bond issuers, a statistically and economically significant 1.4 % abnormal return for the 21-day even window around green bond issuance announcements. Larger returns for first-time issuers.	28 countries	Panel regressions with 132 unique public issuers from 2007-2017	(Tang & Zhang, 2020)
The stock price responds positively to green bond issuance announcements, with 2-day cumulative abnormal returns of 0.67%, 0.8 % for certified green bonds and 0.4% for non-certified.		Public corporate and government bonds issued between 2007-2018	(Flammer, 2020)
A positive relation between green bond issuance and stock price	China	144 green bonds	(Zhou & Cui, 2019)
Green bond issuance announcements elicit mean 21-day cumulative abnormal returns of 1.48 %.		Sample of 54-self-labelled green bonds by corporate listed firms	(Baulkaran, 2019)
For publicly-listed green bond issuers, a 1.95 % increase in stock liquidity improvement for first-time issuers. For repeat issuers, it's 0.34 % less.	28 countries	Panel regressions with with 132 unique public issuers from 2007-2017	(Tang & Zhang, 2020)
Green bonds are generally (around 5 bps) more liquid than their brown counterparts	Global	Regression analysis of 89 green – brown bond pairings on secondary markets	
For publicly-listed green bond issuers, a 7.9 % increase in institutional ownership of the green bond issuers	28 countries	Panel regressions with 132 unique public issuers from 2007-2017	(Tang & Zhang, 2020)
LONG-TERM IMPROVEMENTS			
Quantified Benefit	**Country**	**Methodology**	**References**
Issuers of certified green bonds experience long-term improvements in financial performance (measured by an increase in ROA and ROE) and environmental performance (decrease in CO_2 emissions) and increase in environmental ratings.	Global	217 green bonds issued between 2007 and 2018	(Flammer, 2020)
Positive influence on corporate profitability, operational performance, and innovation capacity.	China	144 green bonds	(Zhou & Cui, 2019)

What are the current green bond issuance challenges?

Despite the advantages of green bonds, they continue to face considerable hurdles. The vague definition of 'green' complicates certification and fuels suspicions of greenwashing (Lau et al., 2022). Despite rapid developments in this area, the need for universal rules and standardisation continues to be an issue. Sangiorgi & Schopohl's (2023) survey on global green bond issuers representing 29 % of total green bond issuances shows that insufficient market evolvement, lack of awareness and suitable green projects represent the most significant entry barriers to green bond markets. Flammer (2020) notes that the current certification of green bonds is binary (i.e., certified vs. non-certified). In contrast, bonds likely differ in their environmental impacts. Flammer (2020) proposes a tiered rating system (e.g., triple-A for more substantial environmental effects) similar to the models used by credit rating agencies to improve informativeness and expand the depth of the green bond market.

3.1.1 Green Real Estate Bond Market Outlook

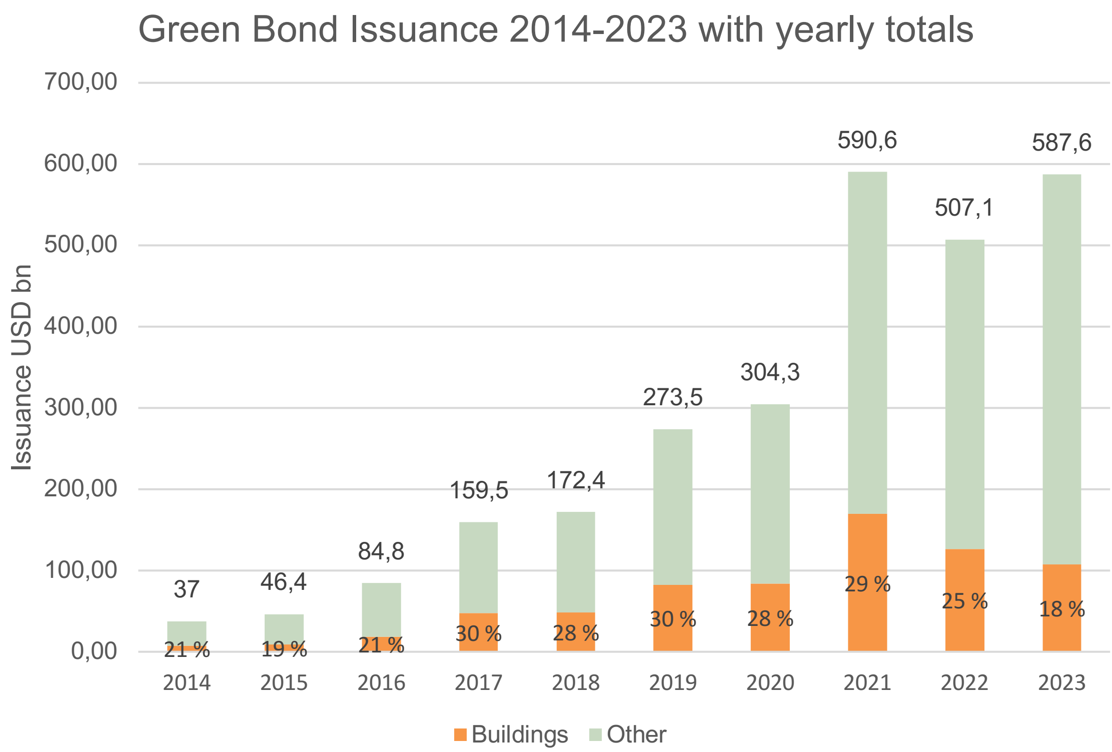

Figure 12. Green bond issuance 2014-2023 with buildings' share. Data from CBI (2024).

Figure 12 above shows that green bond issuance grew quickly from 2014 to 2021. However, in 2022, the Russian invasion of Ukraine disrupted global capital markets, causing the first-ever yearly decline in green bond issuance. By 2023, issuance began to recover, yet it did not reach the record levels set in 2021. Buildings' share of use of green bond proceeds has varied between 18% and 30%. Buildings have attracted 25 % of the global cumulative green bond issuance proceeds (Climate Bonds Initiative, 2024d). Green bond funding for low-carbon buildings peaked in 2021, after which it reduced in 2022 and 2023, as shown in Figure 12.

SNAPSHOT 6: Green Covered Bonds in the EU

Overview

Covered bonds, primarily focusing on housing and commercial real estate, have developed into a significant segment of privately issued bonds on Europe's capital markets over the past 25 years with total volume of over EUR 3 trillion. They provide banks a cost-effective way to fund long-term mortgage loans and provide investors good quality credit exposure. Green covered bonds, first issued in 2015, have seen a surge in issuance in 2021 and 2022, driven by political and regulatory developments in Europe. In 2023, green covered bond issuance represented around 3.5 % of total covered bond issuance.

Key features

- Green covered bonds are usually for mortgages financing energy-efficient buildings.
- The green covered bond market has adopted ICMA's Green Bond Principles (GBP) where the issuer determines the green eligibility, limiting comparability.
- The EU's Taxonomy regulation and the related voluntary EU Green Bond Standard will form an essential future reference point for investors.
- By mid-2023, 68 issuers across 18 jurisdictions had issuer green covered bonds, with German, Norwegian, Danish and French issuers leading.
- Green covered bonds tend to broaden the investor base, but greenium remains modest (1.5bp in 2023) and, in some cases, nonexistent.
- Since 2019, green covered bonds have had a lower average new issue premium (NIP) than conventional covered bonds, averaging a 1.3 bps difference between 2018 and May 2023
- Green covered bonds also exhibit a better coverage ratio, with an average 0.63 increase compared to non-green covered bonds between 2018 and May 2023, indicating larger order books and lower execution uncertainty.
- Issuing green bonds involves extra costs for the issuer, such as ESG reporting and maintaining green bond frameworks. Investors will only cover these costs only if the green bond offers sufficient returns.
- Many investors focus mainly on the issuer's ESG credentials rather than the specific bond's credentials. Therefore, the greenium is primarily issuer-driven and not market-wide.

Impact

- Sustainable covered bonds aim to contribute to the UN's sustainable development goals (SDGs).
- Issuers with more substantial EU-taxonomy alignment could achieve more attractive pricing for their standard bonds.

Source: ECBC (2023).

3.1.2 Green Bond Frameworks

Until recently, private initiatives have primarily shaped the green debt frameworks. **The Green Bond Principles (GBP)** by the International Capital Markets Association (ICMA) and **Climate Bond Standard (CBS)** by the Climate Bond Initiative (CBI) have been the leading global green bond frameworks. CBI maintains a green bond database categorising green bonds into three categories: CBS-certified green bonds (the highest standard), CBI-aligned (next highest standard), and CBI-non-aligned green bonds (self-labelled green bonds not meeting CBI-screening requirements) (Climate Bonds Initiative, 2022). Most issued green bonds fall into the second category, CBI-aligned green bonds. As shown in Figure 5, ICMA's Green Bond Principles are the primary standards the green bond market applies, followed by the EU Taxonomy. As of January 2024, around 10 % of all issued green bonds of USD 2.884tn have been certified by Climate Bond Standard (Climate Bonds Initiative, 2024b, 2024c). The Climate Bond Standard certification fee is 1/10th of the basis point of the bond issuance amount, with a minimum fee of USD 2.000 in developed countries, whereas using Green Bond Principles has no direct fee other than the required third-party verifications.

What are the most popular green bond standards and frameworks?

Certified green real estate bonds represent a minor share of the overall green real estate bond market, yet it is the share for which the most transparent public data exist. The first Climate Bond Certified green bonds for low-carbon buildings were issued in 2015.

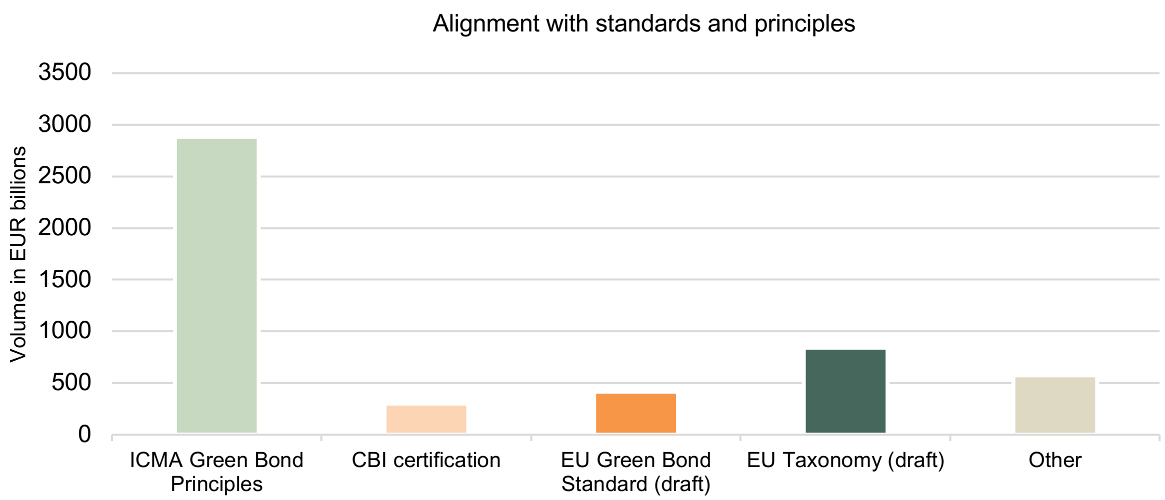

Figure 13. Green bond market's alignment with standards and principles. Data from LGXHub (2024).

The CBI data show that the US, the Netherlands, and Australia have issued most certified bonds for low-carbon buildings. Approximately 66 % of these bonds are directed towards residential projects, 25 % to commercial buildings, and around 9 % to building upgrades. The average issuance amount for certified low-carbon building bonds is approximately USD 544.88 million, with a tenor of 16.07 years. (CBI, 2024b)

ICMA's Green Bond Principles (GBP) is a voluntary process with guidelines defining a procedure for project selection, allocation of funds, high-level guidance, and green and low-carbon building criteria. They allow many core indicators for energy performance, carbon performance, water efficiency and savings, waste management, and types of certifications (if applicable) to be used for green and low-carbon building projects. GBP recognises green buildings that meet regional, national, or internationally recognised standards or certifications for environmental performance and leaves the green definitions for the issuer to define.

On the contrary, CBI's **Climate Bond Standards (CBS)** set forth specific requirements and sector-specific eligibility criteria. For new residential buildings where more than half of the floor area is used or suitable for dwelling purposes, the Climate Bond Standards updated in December 2023, align with the 1.5°C degree scenario, the Paris Agreement, and the EU Taxonomy (Climate Bonds Standards, 2023). The CBS's new buildings criteria use location-and building-specific emission intensity metric [kg CO2e/m2] trajectories as upper limits to the emission intensity, becoming more stringent year-on-year (Climate Bonds Standards, 2023). CBS creates the emission intensity trajectories by using the city's top 15 % emission intensity efficient residential buildings as a baseline and then drawing a linear line to zero emissions in 2050, as shown in the example in Figure 14 below.

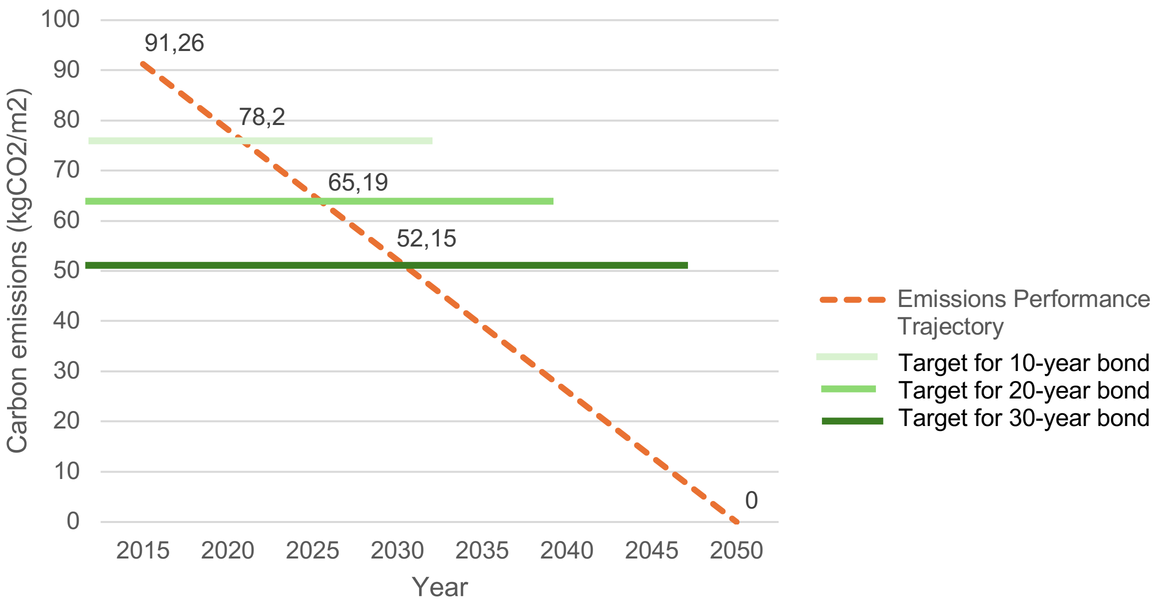

Figure 14. Low-carbon building criteria trajectory in Climate Bond Standards. Adapted from CBI (2024).

How does the strictest private green bond certification define eligibility?

To qualify, the building or portfolio must prove it stays below this limit throughout the bond term. Moreover, new residential buildings constructed after December 2023 must be fully electric (no fossil fuels), must enable 100% electrified parking (when parking is included within a building), and their whole life carbon assessment must be reported and accounted for (Climate Bonds Standards, 2023). Additionally, the New Buildings must report on the Whole Life Carbon Assessment and account for and report on GHG Protocol Scope 3 emissions (Climate Bonds Standards 2023). CBS-approved proxies, such as approved local building codes, can still be used for city buildings until CBS has published a trajectory for the location.

On the other hand, existing buildings currently use relative performance thresholds by comparing the emission improvement against business-as-usual cases, but an update is expected to the requirements in 2024. Currently, 5-year-old bonds must yield a 30 % improvement in emissions performance against the business-as-usual benchmark, whereas a 30-year-old bond must reach a 50% improvement. Figure 15 summarises the CBS certification pathways for residential buildings.

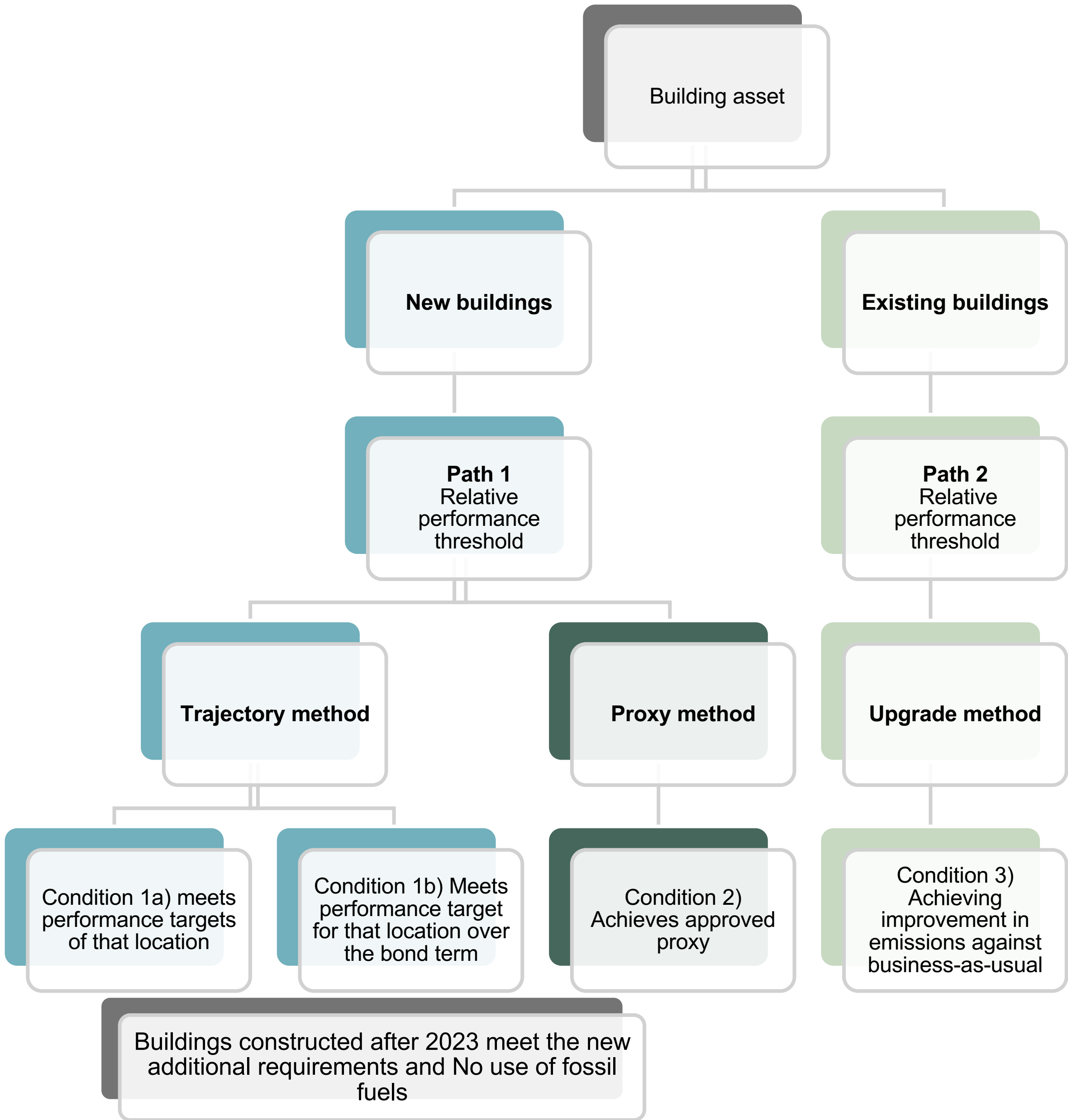

Figure 15. Residential building certification in Climate Bond Standards. Adapted from CBI (2023).

What is the EU's role in public green bond initiatives?

Public initiatives have only recently started setting foot in the green debt standards and frameworks. The voluntary **EU Green Bond Standard** (EUGBS) adopted on 30

November 2023 aims to become the Gold Standard for green bond issuance and provides a legal enforceability framework (Curtis et al., 2023). The EuGBs must be reviewed by external reviewers registered with and supervised by the European Securities Market Authority and adhere to strict disclosure rules. The EUGBS also has the power to issue monetary fines for non-compliance by the national competent authorities for up to 0.5% of the issuer's turnover. The EUGBS is based on the EU Taxonomy that sets strict technical screening criteria for, e.g., new construction, ownership and acquisition of buildings, and building renovations. Even if fulfilling the EU Taxonomy criteria and the EU GBS is voluntary in Europe, European financial undertakings must report their taxonomy alignment as Green Asset Ratio and non-financial undertakings as shares from their turnover, operating expenses and capital expenses (European Commission, 2020).

How is Australia's governmental green bond framework structured?

The **Australian Government Green Bond Framework**, published in December 2023 and aligned with ICMA's Green Bond Principles, outlines how the Australian Government will issue green bonds. Making energy efficiency upgrades more accessible to homeowners and tenants and green buildings are critical objectives of the Australian Government to tackle with green loans (Commonwealth of Australia, 2023). The Australian Green Bond Framework represents the legal framework that the Australian Government will partly rely on to achieve its outcomes for climate change and environmental priorities, designed to transition Australian society to net zero by 2050. The Framework provides for 'eligible green expenditures', which must align with one or more of the Australian Government's three key goals: climate change mitigation, adaptation and improved environmental outcomes (AOFM 2023).

Notably, the Australian Government's Sustainable Finance Strategy recognises the critical role the private sector can play in financing the transition to net zero (Sustainable Finance Strategy 2023). The Strategy includes several key proposals that are designed to deliver three central policy pillars that are designed to:- (1) improve transparency on climate and sustainability reporting, (2) enhance financial system capabilities, and (3) provide Australian Government leadership and engagement. One of the central aims of the Australian Government Strategy is to help mobilise private sector capital to finance and support the transition to net zero. A further aim of the Strategy is to ensure Australian businesses can access green funding and green capital to pursue opportunities that are both supportive and positively aligned to sustainability outcomes.

SNAPSHOT 7: Green Bonds in Australia

Overview

The Australian Green Bond market originated in 2014, when two green bonds negotiated privately between counterparties. The green bond market within Australia has continued to develop since its modest origins and now has a market value approaching $AUD15 billion. The green bond market will continue to grow and scale up with the recent announcement by the Commonwealth Government of its sovereign green bond issue, expected to take place in 2024.

Key features

- The Australian green bond market comprises professionals including corporates, Australian banks, State treasuries, and 'kangaroo issuers' which include non-resident organisations that issue green bonds denominated in Australian dollars.
- The green bond market within Australia has more domestic issuers relative to overseas due to the active participation of State treasuries, large Australian banks, and the corporate sector.
- Green loans continue to be securitised and used as collateral for green asset backed securities and residential mortgage-backed securities (RMBS), with volumes increasing from less than AUD100 million in 2016 to circa AUD1.5 billion in 2023-2024.

Impact

- Between 2014-2023, Australian green bonds have 'use of proceeds' earmarked for:
    - development and delivery of green friendly transport, including electric vehicles;
    - transition to energy efficient and renewable energy projects;
    - development and construction of new green friendly buildings within the Australian built environment.
- Green loans and green mortgages have also been offered by some Australian banks including non-bank financial institutions (NBFIs) to finance the transition towards environmentally friendly residential development.
- With the imminent issue of the Commonwealth sovereign green bond the market for green bonds will continue to expand both in size and scale.
- Commonwealth government via its inaugural sovereign green bond issue in 2024 is committed to supporting climate change adaptation programs, designed to manage the physical impacts of climate change and to build overall climate resilience.

Source: AOFM (2024); RBA (2023).

How are China's green bond frameworks structured and aligned globally?

Chinese Green Bond Framework The official establishment of China's green bond market is attributed to the introduction of three critical national regulatory documents between 2015 and 2016, collectively forming the foundation of China's green bond framework (H. Zhang, 2020). From its inception, the Chinese green bond market has been predominantly led by the government, distinguishing it from many other jurisdictions (Lin & Hong, 2022). The vital regulatory documents include the People's Bank of China (PBoC) Announcement No. 39 (published in 2015), the National Development and Reform Commission (NDRC) Guidelines on Green Bond Issuance (published in 2015), and the China Securities Regulatory Commission (CSRC) Guiding Opinions for Supporting Green Bonds (published in 2017) (Zhang, 2020).

Announcement No. 39 lays down the fundamental eligibility criteria for green bonds, including a detailed list of eligible green projects, referred to as the Green Bond Endorsed Project Catalogue (H. Zhang, 2020). The catalogue, commonly called the 'Chinese green bond taxonomy,' received its latest update in 2021 (CBI 2021), enhancing its conformity with international standards. One significant update was to exclude projects related to fossil energy (Lin & Hong, 2022). AOFM 2024 Where the Green Bond Endorsed Project Catalogue is aimed at financial entities, the Guidelines on Green Bond Issuance by NDRC are mainly directed at corporate bonds (Berensmann, 2017). The Guiding Opinions of the CSRC, on the other hand, steer the issuance and trading of green corporate bonds on the stock exchange (Lin & Hong, 2022). In addition to the three regulatory documents, several other guidelines have been published by different Chinese authorities since 2015, referencing the Green Bond Endorsed Project Catalogue, such as the Guidelines on Green Debt Financing Tools for Non-Financial Enterprises by the National Association of Financial Market Institutional Investors (NAFMII) (H. Zhang, 2020).

In July 2022, the China Green Bond Standard Committee, a cooperation among PBoC, CSRC, NAFMII and private sector institutions, published *China's Green Bond Principles* to harmonise the different green bond regulations in China and increase alignment with ICMA's GBP, especially regarding the requirement to allocate 100% of UoP to green projects. Similar to the ICMA GBP, the China GBP does not constitute a legal document but serves as a self-regulatory framework. It mandates that Chinese issuers adhere to the Green Bond Endorsed Project Catalogue. Foreign issuers can refer to international taxonomies such as the EU Taxonomy. (ICMA, 2022)

SNAPSHOT 8: China's Green Bond Market

Overview

China's 30/60 decarbonisation goal aims to reach carbon peak before 2030 and carbon neutrality before 2060, and green finance is an important tool to support this transition. In 2023 for the second consecutive year, China supplied the largest volume of green bonds by CBI's Climate Bonds definitions. By the end of 2022, cumulative (self-) labelled green bond volumes from China reached USD 489 billion. However, only around 63 % of China's green bond issuance in 2023 aligns with Climate Bond Initiative's definitions for green bonds, i.e., the debt meets Climate Bonds Use of Proceeds and other Climate Bonds Green Bond requirements. Yet, labelled green bonds only represented 1.5 % of China's overall onshore debt market in 2022.

Key features

- In 2023, energy and transport dominated Chinese green bond issuance, with buildings receiving a minor share.
- Typically, Chinese green bonds use external reviewers (second-party opinions) to confirm alignment of the issuer's Green Bond Framework with the ICMA Green Bond Principles.
- Due to the multitude of SPO providers and the approaches used, second-party reviews are not comparable across issuers or sectors and do not guard against greenwashing as sufficiently.
- China's economy relies on carbon-intensive sectors that require addressing in China's carbon neutrality objectives. China's central bank is expected to put forward sector-specific transition finance standards also for construction areas.
- Whereas China's green bond issuer base broadened in 2022, with debut issuers accounting for 56 % of bonds issued, in 2023 the market was dominated by repeat issuers accounting for 84 % of the 2023 issuance.
- In 2023, over 80% of Chinese green bonds come from state-owned enterprises, with Beijing remaining the leading region in green bond issuance.
- China's Green Bond Principles, released in July 2022, require adapting an 100% Use of Proceeds approach and has helped the China's green bond market align with the international market, increasing quality and credibility.

Impact

- China is expected to continue world leadership in sustainable finance issuance to help reach its carbon neutrality goals and contribute to the goals of the Paris Agreement.

Source: CBI (2023, 2024a).

3.2 Green loans and mortgages

Whereas governments, municipalities, or corporations typically issue bonds, loans are usually issued by financial institutions and banks to individuals, businesses, or governments. Similarly, while bonds are often traded on secondary markets, loans are typically held by the original lender, sold to other private investors, or pooled and issued as securities, making them less liquid than bonds. On the other hand, green loans are any loan instruments made available exclusively to finance or re-finance, in whole or in part, new and/or existing eligible green projects. The potential financial incentives credit institutions may provide under green mortgages and loan agreements include preferential rates (greenium), longer maturity, and maximum available loan amount relative to the property (EBA, 2023b). In some cases, banks provide green loans with lower issuance costs. Some countries have introduced public schemes to support sustainable lending, ranging from public guarantees and subsidies (e.g., Belgium, Estonia, Germany, Greece), preferential pricing conditions (e.g., France), and tax reliefs (EBA, 2023b), often facilitated via public banks or public authorities.

What are the advantages of green loans and mortgages?

Energy-efficient and green mortgages offer significant financial advantages, including lower default rates and reduced interest expenses. Research across multiple countries, such as Belgium, Italy, and the Netherlands, consistently shows that energy-efficient properties have substantially lower default risks, as summarised in Table 5 below. Additionally, in the US, green mortgages for LEED-certified buildings benefit from lower interest spreads, resulting in annual savings for property owners. For credit institutions, an EBA 2023 survey indicates that the primary benefits of originating green stem from meeting sustainability targets, improving investor and borrower reputation, helping with regulatory requirements (such as the EU Taxonomy disclosure requirements, and minimising climate-change-related transition risks.

While bank lending remains the primary source of external finance for households and SMEs, tools supporting their access to green loans are still limited. The European Commission has identified that the challenges stem from a need for standardised financial products, regulatory guidance, high upfront costs, and limited institution and borrower awareness. Moreover, low-income households are mainly excluded from markets that finance energy-efficient buildings (EBA, 2023b).

Table 5. Benefits linked to green mortgages and green real estate loans.

Energy-efficient mort-gages	Lower default rates	A negative and highly significant correlation between a building's Energy Efficiency and lower default risk; the odds of defaulting on a renovation loan about 2.64 times higher if the borrower does not improve the building's energy efficiency.	Bel-gium	Logistic regression model, with 42.055 loan-level observations. Loan- and borrower-specific dif-ferences accounted for in the model.	(Energy Effi-cient Mortgages Action Plan, 2019, pp. 6–9)
	Lower default rates	Overall mortgage default risk is lower in re-gions where governmental support for en-ergy efficiency renovations is relatively higher	Italy	Logistic regression model using loan data between 2015-2018 and energy-efficiency investment data from 2018 reports.	(Energy Effi-cient Mortgages Action Plan, 2019, pp. 10–13)
	Lower default rates	Default risk on a mortgage is about 5.39 greater if the borrower's property has EPC C rating or worse; energy efficiency is asso-ciated with a lower mortgage default proba-bility	The Neth-er-lands	Logistic regression model using Dutch energy label and mortgage data & Cox regression	(Billio et al., 2022; Energy Efficient Mort-gages Action Plan, 2019, pp. 14–21)
	Lower default and prepay-ment rates	ENERGY STAR label associated with sub-stantial and significant reduction of default and prepayment risks, with default risks 1/3 and prepayment risks ¼ lower than in the control groups. The higher the energy effi-ciency, the lower the mortgage and prepay-ment risks.	The US	Multinomial logit model using data of Energy Star & non-Energy Star -fi-nanced mortgages, n=71062	(Kaza et al., 2014)
	Lower default and arrears risks	EPC classes of A, B and C have lower share of mortgages in arrears compared to mortgages with higher EPC classes.	The UK	Logistic regression model, with more than 1.8 million mortgages	(Guin & Korho-nen, 2020)
Green mort-gages	Lower interest expenses (Greenium)	Mortgages collaterized with LEED certified buildings receive 39 to 41 bp lower mort-gage spreads (implying USD 200,000-345.000 lower annual mortgage interest payments); 'Gold' and 'Platinum' labelled buildings achieve 66-68 bp reduction in mortgage spreads	The US	Regression model with 5596 US commercial buildings, data from 2006 to 2015	(Eichholtz et al., 2019)

SNAPSHOT 9: From Green Premium to Brown Discount

Overview

Initially, the green investment market focused on "greenium" – the premium investors pay for green bonds or sustainable investments over traditional ones. However, recent evidence highlights a shift, particularly in commercial real estate markets, towards "brown discounts." These discounts are financial penalties applied to unsustainable buildings. Empirical findings indicate that brown discounts may become a more significant long-term trend than green premiums.

Key features

- Only a small share of existing buildings align with the Paris Agreement objectives, so the brown discount substantially threatens the global building stock.
  - For example, around 97 % of today's commercial buildings are not on track to achieve zero emissions.
- European data suggests a shrinking pool of buyers for commercial properties with poor net-zero projections (JLL, 2020).
- JLL estimates the brown discounts to be significantly larger than greeniums.
- A 2022 RICS Sustainability Survey involving 4000 professionals revealed that nearly 50 % of global respondents observed a brown discount in rents and prices compared to green buildings. The brown discount was especially evident in the European markets. Conversely, 30 % noted that even without brown discounts, green buildings still receive rent or price premiums (greenium).
- Brown discounts linked to energy ratings have been identified in many residential markets:
  - The lowest-rated properties in European residential markets (EPC classes G & F) showed brown discounts (McCord et al., 2020).
  - In Barcelona, the brown discount in building listing prices was only related to the cheapest apartments with the most basic features and apartments in low-income areas. (Marmolejo-Duarte & Chen, 2019).

Impact

- The real estate industry must not only focus on sustainability value creation (green premium) but also on preserving property values (avoiding a brown discount) and ensuring asset resilience.
- Reducing emissions following the Paris Agreement and managing the brown discount risks requires retrofitting most assets.

Source: Fortune (2021); Hoss & Luppi (2024); JLL (2022); McCord et al. (2020); RICS, (2022); Wilkinson & Sayce (2020).

3.2.1 Green Loans and Mortgages Market Outlook

Initiated as early as 2005 by major US banks like Wells Fargo and Bank of America, the green loan market has grown exponentially. However, its exact size is unclear due to a lack of disclosure requirements, except in China, where banks have been mandated to disclose their green loan policy since 2007 (Gilchrist et al., 2021). In Europe, credit institutions' green loans and advantages are estimated to be, on average, 4.5 % of their total loans (EBA, 2023b). Similarly, the share of green loans to households is estimated to account for 11 % of the total household loans (EBA, 2023a), primarily for purchasing a property. Renovation is the second green mortgage purpose, whereas purchase and renovation receive a smaller share in Europe (EBA, 2023b). The International Finance Corporation at the World Bank Group proposes a bottom-up approach to estimate and track green loan markets. The International Finance Corporation (IFC) found that 41% of green loans, totalling around USD 165 billion in 2014, were allocated to the real estate sector, with the most significant amount of green loans found in the United States, followed by the United Kingdom, Australia, France, Japan and China (Gilchrist et al., 2021).

In China, green loans constituted 12.7 % of the total loan balance, up from 8.3 % in 2021 and 10.3 % in 2022. This continual increase is partly due to policy initiatives. Banks are required to report green loan data to the PBOC, and these metrics were incorporated into performance evaluations, incentivising banks to issue more green loans. Various Chinese regions have set localised policy goals for green loans. (J. Zhang et al., 2024).

EBA's 2023 survey results signal that European credit institutions expect green loans to grow in 2024-2025. Banks' Green Asset Ratio disclosure requirements and the EPBD recast will encourage credit institutions to significantly increase their lending to residential renovation.

SNAPSHOT 10: Green Mortgages in Ireland

Overview

Green mortgages, despite only being introduced in 2019, accounted for almost 30 % of mortgage originations in Ireland in 2022. Majority of Irish mortgage lenders offer green mortgages. These mortgages directly contribute to Ireland's Climate Action Plan 2023 which targets reducing building emissions by 40 % by 2030. This reduction is primarily expected to be achieved through the retrofitting 500,000 homes to B2 standard, as per the Irish energy performance certificate scheme (the Building Energy Rating) labelling system that ranges from A (most efficient) to G (lowest) (Government of Ireland, 2023).

Key features

- Irish green mortgages are directly linked to Building Energy Rating labelling, with most banks requiring a minimum of B3.
- Green mortgages are available to consumers who are buying, building, or retrofitting.
- Typically, green mortgages in Ireland offer consumers a 30-bps financial benefit that persists over the loan term.
- For Irish banks, the gradual decarbonisation of the mortgage book lowers energy-related risks. Efficiency improvements also improve banks' collateral positions.
- Green mortgage borrowers have higher income, larger mortgages and by higher value properties in Ireland.
- Green mortgage share of new properties (42 %) is lower than expected as all homes built since 2019 must be A2 rated and thus would automatically qualify.

Impact

- Green mortgages directly contribute to Ireland's Climate Plan 2023.
- However, lower green mortgage uptake among low-income borrowers in Ireland is noteworthy.

Source: Lambert et al. (2023).

3.2.2 Green Loan and Mortgages Frameworks

Currently, there are no widely used common standards nor labels exclusively applicable togreen loans (EBA, 2023b). The Loan Market Association's (LMA) **Green Loans** Principles **(GLP)** and **Energy Efficient Mortgages Label** are the leading frameworks for green loans. Like GBPs, the Green Loan Principles (GLPs) provide a high-level framework of market guidelines but do not provide definite criteria for Green Projects. Instead, GLPs define green buildings as buildings that 'meet regional, national, or internationally recognised standards or certifications for environmental performance' and allow using many standards and certifications as indicators (LMA, 2020b, 2020a). The GLP consists of the following elements: 1. Use of proceeds, outlining how the borrowed funds are allocated to specific green projects, 2. Project evaluation and selection process, disclosing how the project aligns with taxonomies and which standards or certifications are used when identifying projects, 3. Management of proceeds, ensuring that the loan proceeds are allocated purely to green projects, and 4. Reporting describing how the green loan's environmental impact is tracked and monitored (usually annual reports). (LMA, 2020b, 2020a).

Energy-Efficient Mortgages Label (EEML) is a European label for identifying energy-efficient mortgages in lending institutions' portfolios intended to finance the purchase, construction, or renovation of residential and commercial buildings, focusing on building energy performance that meets or exceeds relevant market best practice standards in line with the current EU requirements and/or an improvement in the energy performance of at least 30 %, evidenced by a recent Energy Performance Certificate (EPC) rating or score. The EEML aims to become the global benchmark for energy-efficient mortgages. The EEML provides information on the portfolios of energy-efficient loans as assets to be included in green-covered bonds and green securitisations, achieved through a Harmonized Disclosure Template, a standardised Excel-based form (Energy Efficient Mortgage Label, 2023).

Climate Bond Standards can also be used to label green corporate loans. Moreover, the Climate Bonds Standard's Sector Criteria can also be used to determine green consumer loans (e.g., mortgages) even if CBS certification is unavailable for consumer loans (Climate Bonds Initiative, 2020).

What about governmental green mortgage initiatives?

The European Banking Authority (EBA) proposed a voluntary EU definition for green loans based on the EU Taxonomy. It developed a voluntary **EU Green loan label** to incentivise green loan uptake in December 2023. The EBA's proposal aims to ensure that banks and other financial institutions maintain data on the sustainability of their property portfolios. The standard definition would level the playing field for credit institutions and enhance consumer protection while preserving the banking sector's ability to innovate with green product offerings. The EBA also recommends that sustainability features of the property, such as the Energy Performance Certificate (EPC) rating, be included in pre-contractual information provided to borrowers. However, it acknowledges that access to EPC databases is not uniform across EU Member States.
Furthermore, the EBA suggests that green mortgages should be included in the competence and knowledge standards for staff advising on mortgages. This could increase professional knowledge and make sustainability an active discussion during the mortgage sales. Despite these efforts, the European Central Bank (ECB) has expressed concern that some European banks are not doing enough to manage climate risks. The EBA's proposal for a voluntary definition of green loans and mortgages could be a significant step towards engaging both climate laggards and exemplars.

How do banks define green loans in practice?

In practice, an EBA study of European credit institutions reveals that most banks utilise these industry standards to develop their internal criteria, which they then employ to define their green loans (EBA, 2023b). The low share of EU Taxonomy leveraging here likely stems from EU Taxonomy's recent introduction and the usability challenges. A consistent pattern emerges among institutions defining green lending and granting green loans: they identify sustainable lending areas, establish criteria linked to the UN SDGs and EU Taxonomy (if applicable), set environmental targets, apply exclusion criteria, select eligible projects, connect green lending with green funding instruments, manage proceeds, report on allocation and impact, and seek second-party opinions on their green finance frameworks (EBA, 2023b). Energy efficiency and EPC are the primary benchmarks for green loans in Europe, according to EBA's 2023 survey.

What is holding back green mortgage developments in banks?

EU's sustainable finance advisory body, Platform on Sustainable Finance, has identified several significant bank reporting barriers on green mortgages. For example, as most bank lending is to retail customers, a bank must conduct its alignment and green asset ratio estimations as the data has not been collected from customers yet and is not automatically collected. There are also inconsistencies with international standards outside the EU and the UK. Moreover, significant challenges relate to performing and verifying Do No Significant Harm (DNSH) assessments for activities regarding constructing new buildings and acquiring and owning real estate. Information on construction and demolition waste and building components and materials is currently unavailable for new building construction. The future expectation is to include this information in the loan contract or make the information easily obtainable from an external verifier. Table 6 below illustrates these challenges.

Table 6. EU Taxonomy's DNSH mortgage challenges. Data from Platform on Sustainable Finance (2022).

Criteria	How to verify?	Provided by?	Issue	Feasibility
Adaptation: Physical risks (flooding, sea level…)	Map location with risk maps	External providers	No market standards for all risks	Medium
Water (commercial buildings)	Audits	None	Missing local regulation	Low
Circular economy: Recycle 70 % of non-hazardous demolition waste	Audits	None	Missing local regulation	Low
Pollution prevention: materials used	Audits	None	Missing local regulation	Low
Biodiversity: not constructed on arable land, greenfield, forest	Registration Number of building ground	Local governments	Not readily available throughout the EU	Low

3.3 Green Real Estate Securitisations

Securitisations differ from traditional loans and bonds by pooling several types of financial assets, such as mortgages or loans, to create new securities that can be sold to investors. Unlike loans, which are agreements between lenders and borrowers, and bonds, which represent a single entity's debt, securitisations distribute the risks and returns among multiple investors through diverse financial instruments. Typical real estate securitisations include bundling mortgages into mortgage-backed securities (MBS), allowing investors to gain exposure to the real estate market through the collective cash flows derived from homeowner payments. Green real estate securitisation usually involves bundling green mortgages into green mortgage-backed securities, allowing investors to contribute to financing environmentally friendly development.

What are the benefits of green real estate securities?

Green securitisations offer significant financial benefits, including lower default rates and reduced interest rates for borrowers, as summarised in Table 7 below. In the US commercial MBS market, LEED and ENERGY STAR-certified buildings have a 34 % lower default risk (An & Pivo, 2020). Lower energy consumption further reduces commercial mortgage defaults. Green programs for MBS provide lower interest rates and higher loan-to-value ratios than traditional MBS (Devine & McCollum, 2022). For real estate investment trusts (REITs), doubling the share of environmentally certified buildings can lower corporate bond spreads by 21 to 74 basis points, underscoring the value of greenness in the securitisation markets (Eichholtz et al., 2019).

Table 7. Benefits linked to green real estate securitisations.

Lower default rates	LEED and ENERGY STAR certified buildings carry 34 % less default risk, all else equal, in the Commercial mortgage-backed security market	The US	A hazard model	(An & Pivo, 2020)
Lower default rates	Lower building-level energy consumption and electricity price gap are statistically and economically associated with commercial mortgage defaults	The US	Linear probability model and logistic regression model with securitized commercial mortgage data, n= around 1900	(Wallace et al., 2018)
Lower interest rates for borrowers	MBS participating in the green bond programs receive a statistically and economically significant lower interest rate than traditional MBS. MBS financed under green bond programs are associated with LTVs that are 2% to 10% higher than their traditional MBS counterpart	The US	Regression model with data from multifamily mortgage-backed security loans issued by FNMA, n=8369	(Devine & McCollum, 2022)
Lower cost of debt	Doubling a REIT portfolio's share of environmentally certified buildings (LEED and Energy Star labels) for the average REIT from 3 to 6 percent lowers the REIT corporate bond spread by 21 to 74 bp.	The US	Regression analysis with data on 211 REITS	(Eichholtz et al., 2019)

3.3.1 Green Real Estate Securitisations Market Outlook

The green real estate securitisation market is primarily US-based and concentrated on mortgage-backed securities. Fannie Mae is the world's largest green real estate securities issuer, with USD 117 billion issued for multifamily green MBSs and USD 3.4 billion for single-family green MBSs (Fannie Mae, 2023a). Freddie Mac is the second largest player in the green securitisation markets, with nearly USD 2 billion of single-family green RMBSs issuance by the end of 2022 (Freddie Mac, 2023). The first European RMBS was issued in 2016 by Obvion in the Netherlands. In 2021, Firstmac issued the first fully green Australian residential MBS (RMBS) (KangaNews, n.d.). In China, green asset securitisation issuance has started picking up in 2022 (South China Morning Post, 2022).

3.3.2 Green Securitisation Frameworks

Currently, there are no global frameworks specifically for green securitisations. However, the EU Green Bond Standard can also be applied to securitisations, but synthetic securitisation is excluded. The European Commission and the European Banking Authority (EBA) agree that given the low number of green assets to be securitised, there is no scope for creating a dedicated sustainability label. Instead, the EU Green Bond Framework can be applied. Green securitisation is typically based on the issuer's green frameworks (often specifically for the asset subclass, e.g., multi- or single-family) that set the green metrics and processes.

How are most green real estate securitisations defined in practice?

In the US, Fannie Mae has two primary programs for green lending: Green rewards for existing buildings and the Green Building Certification Pricing Break for new builds. Fannie Mae has published a list of accepted green building certifications as proxies for green mortgages to be included in their green securitisations, divided into four groups based on how well the certification requirements align with environmental targets (Fannie Mae, 2023a, 2023b). The higher the group, the better the mortgage pricing. On the other hand, Freddie Mac's Green Bond Single- and Multifamily Frameworks are ICMA's Green Bond Principles-aligned. For multifamily mortgages, Freddie Mac requires a 30 % energy, water/sewer consumption saving with a minimum of 15 % for energy. Freddie Mac requires an Energy Efficiency Rating Index Score of 60 or less for newly constructed single homes or a renewable energy source (solar or geothermal). Freddie Mac involves energy efficiency installations (solar or geothermal) for existing homes eligible for green loans to be included in green securitisations (Freddie Mac, 2021a, 2021b).

3.4 Emerging Green Real Estate Financing Instruments

Many existing green financing instruments are inaccessible to low-income households primarily due to the high upfront costs. To make these significant investments widely available, there is a clear need for innovative financing instruments that distribute the costs and rewards of decarbonising investments. For example, the EU's Energy Performance of Buildings (EPBD) recast of April 2024 calls for EU states to promote the effective development and use of enabling funding and financial tools. In addition to green loans and mortgages, the EPBD recast mentions energy performance contracting, pay-as-you-save financial incentives, and on-bill schemes to guide investments into low-carbon building stock (European Commission, 2024b). *Energy performance contracting* is a contractual arrangement between a recipient and a provider of energy efficiency improvements. The provider is paid based on achieving a specified level of energy efficiency or another agreed-upon performance criterion, such as financial savings, with enhancements verified and monitored throughout the contract term. (EU 2023/1791, 2023) *A pay-as-you-save financial scheme* refers to a loan program dedicated to energy performance improvements, where repayments are directly linked to the achieved energy savings. This scheme also considers other economic factors such as energy cost indexation, interest rates, increased asset value, and loan refinancing.

(European Commission, 2024b). *On-bill schemes* are financing methods for energy renovation investments in buildings that use utility bills as the repayment vehicle. On-bill schemes require engagement with a broader range of stakeholders, including energy companies. (European Commission, 2024b). The US has utilised on-bill schemes for over 30 years by financing over USD 2 billion, with 60 % directed to residential buildings. On-bill schemes help solve the challenges with high upfront investment costs, may increase debt levels for families, and provide a possible solution to the owner-tenant dilemma. However, no uniform definitions exist for on-bill schemes that can take very different structures based on the source of financing, association with the property's meter and underwriting methodologies. (Vincenzo Bianco, 2020)

How can novel business models broaden access to green real estate investments?

Heating-as-service and *cooling-as-service* provide other mechanisms to balance the significant upfront costs of low-carbon investments, making them more readily available to low-income households. In these business models, the service providers – rather than the end user, own and operate the user's heat pumps or other (low-carbon) equipment. The provider then charges fees for their heating, electricity, and cooling services. Buying services instead of actual energy equipment lowers the financial risks for consumers by reducing or eliminating upfront costs for purchases and installation. It also reduces technical risks as the service provider is responsible for the maintenance. For suppliers, heating-as-service models may increase consumer loyalty, access to operational data to improve services, reduce environmental impacts, and incentives to increase energy efficiencies and revenues from selling the services. (IRENA, 2024).

What colours are included in sustainable finance besides green?

Blue financing is another emerging climate finance theme with increased global interest from investors, institutions, and insurers (IFC, 2024). Blue finance tackles preservation and improving clean water resources, rebuilding ocean prosperity, restoring biodiversity, and regenerating ocean health. Since 2020, IFC has provided more than USD 1.53 billion in blue bonds and loans to private institutions, even if no global industry standards or guidelines exist yet (IFC, 2024). Blue-labelled bonds encompass activities supporting the sustainable use of water, coastal, and marine resources while fostering livelihood improvement. Morgan Stanely estimates that blue bonds will be a USD 3 trillion investment opportunity by 2050 (Morgan Stanley, 2023).

SNAPSHOT 11: World's first Blue Sovereign Bond

Overview
In 2012, the Republic of Seychelles committed to increase the marine protection of its Exclusive Economic Zone (1.4 km[2]) from 0.04 % to 30 % by 2020. This required the government to mobilise significant capital for conservation investments and develop a marine resource strategy. One climate finance instrument Seychelles used in its blue economy intiative was launching the world's first **sovereign blue bond** in 2018.

Key features
- The blue bond combined private and public investment to expand marine protected areas and promote sustainable fishing practices.
- The bond raised USD 15 million.
- The Seychelles blue bond was backed by a USD 5 million guarantee from the World Bank, along with USD 5 million concessionary loan from the Global Environment Facility.
- The bond investors received an annual interest rate of 6.5 %.

Impact
- As of 2020, the Seychelles government exceeded their target, protecting 32 % of the Seychelles Exclusie Economic Zone and Territorial Sea.
- Half of the protected areas consist of areas of top priority where marine and costal plants are rare, endangered or unique.
- Other island economies, such as Sri Lanka, are exploring blue bonds for their blue economies.

Sources: (CSF, 2023; World Bank, 2019).

3.5 The Role of Transition Finance

Green finance is about financing what is already environment-friendly today, while transition financing is funding what is transitioning to environment-friendly performance levels over time (European Commission, 2024a). Often, transition finance enables the decarbonisation of high-emitting entities and hard-to-abate sectors. In addition to real-economy emission reduction and expectations of net-zero alignment, transition finance is also about phasing out fossil fuels. Overall, transition finance is based on transition plans that describe the company's or entity's pathway to net-zero performance over time. Net-Zero Banking Association's core guiding principles for transition finance are centred around credible, feasible and sufficiently ambitious net-zero-aligned transition plans. Moreover, transition finance must meaningfully advance a company's net-zero journey.

What's the role of transition finance in the real estate sector?

In the real estate sector, transition finance (or "brown-to-green" finance) aims to transform older, energy-efficient buildings into low-carbon and resilient buildings aligned with the Paris Agreement objectives. In practice, the real estate sector could use transition finance to finance energy efficiency improvements by raising energy performance certificates from F to C, for example. Even if this increase is not eligible for green finance, it would still significantly reduce overall emissions. Whereas the current energy performance certificates are based on estimated, calculated energy use and emissions, the NZBA Guidelines for Climate Target-Setting for Banks set that transition plans should instead use absolute emissions (e.g., annual tCO_2C/m^2) and sector-specific emission intensity (e.g. annual $kgCO_2e/m^2$), and disclosed annually. The recommendation is to use actual consumption data and supplier-specific emission factors to produce the best accuracy on greenhouse gas emissions.

SNAPSHOT 12: EU's Social Taxonomy Proposal

Overview

EU's sustainable finance strategy includes both environmental and social aspects. EU's proposed Social Taxonomy from 2022 is a classification system for economic activities that significantly contribute to EU's social goals. High demand for social bonds for housing, healthcare and jobs for target groups shows investors see social investments as opportunities, while neglecting social aspects risks associations with human rights abuses like child and slave labour.

Key features

- While environmental objectives and criteria are science-based, Social taxonomy proposal is based on international authorative standards, e.g., the International Bill on Human Rights.
- Similar to the Environmental Taxonomy, the Proposed Social Taxonomy would consist of social objectives, definitions of substantial contributions, do-no-significant harm (DNSH) criteria, and minimum safefards.
- The EU's poposed social taxonomy has three objectives: 1) decent work (throughout the value-chain), 2) adequate living standards and wellbeing for end-users, and 3) inclusive and sustainable communities and societies. Thus, housing is one of the primary sectors relevant to the Social taxonomy.
    - The Social Taxonomy proposal illustrates that in the real estate sector, the Social Taxonomy could improve the availability and accessibility of good-quality housing units.
    - e.g., by setting a percentage of flats with at least an x % cheaper rent available for low-income and disadvantaged people) and improving accessibility (e.g., by building open spaces for social activities, and ensuring presence of public services).
    - The DNSH criteria would set minimum standards for housing units to meet environmental standards set in the EU Taxonomy's biodiversity and ecosystems categories.

Impact

- Currently, the relationship with the proposed Social Taxonomy and the Environmental Taxonomy is unclear.
- The Social Taxonomy would guide investors, issuers and asset managers in defining and evaluating financial products with social objectives and prevent 'social washing'.
- When realised, social taxonomy combined with the enrivonmental taxonmy could alleviate the inequality and inaccessibility issues related to current green mortgages, for example.

Sources: Platform on Sustainable Finance (2022).

4. Green Metrics and Proxies in Real Estate Financing

This chapter describes the primary metrics, proxies and indicators used in green real estate financing instruments, followed by a Table 8 linking the metrics to different green financing frameworks and taxonomies.

4.1 Green Building Rating Systems (GBRS)

GBRS are usually third-party, voluntary, and market-driven standards that provide real estate investors and bondholders information about an existing building or construction project's sustainability and environmental performance (OECD 2022). UK-based BREEAM, US-based LEED, and Australia's Green Star are among the widely applied multi-attribute GBRSs. While green certifications aim to enhance transparency and comparability among green building projects, different rating systems lack standard definitions and standardisation in practice. A further challenge is that the rating systems mainly focus on energy performance optimisation, with less focus on decarbonisation and renewable energy (OECD 2022). Due to the low weight set for embodied building emissions, recent research by Amiri et al. (2021) noted that GBRS fails to establish robust benchmarks for a low-carbon transition.

LEED and BREEAM are widely used in ICMA's Green Bond Principles, whereas Climate Bond Standards only regard LEED Gold combined with ASHRAE 90.1. to be eligible. CBS has assessed the BREEAM rating scheme as not correlated with carbon emissions. Thus, Climate Bond Standards does not consider BREEAM a suitable proxy for low-carbon buildings (Climate Bonds Standards 2023b). For Australia's Green Star homes, the Climate Bond Standards consider only residential properties certified by the Green Building Council of Australia adhering to Renewable Energy Pathway A or B and exclude those with swimming pools as eligible (CBI, 2021).

4.2 (Nearly) Zero-Energy Building Codes

A building code regulates construction. As a legal instrument, it ensures that construction follows safety protocols and accords with the regulated building system. Codes provide physical and socially acceptable performance concerning the building, the welfare of its occupants and the community in which the building is located. Many codes are progressing to green codes to accommodate climate change risks, supporting (nearly) zero-energy carbon strategies (AIA, 2016).

(Nearly) Zero-energy carbon building codes can limit operational energy use and carbon emissions. Over 90 countries have implemented mandatory or voluntary codes for either the buildings sector or the non-residential segment. Yet, current building codes only cover around 15 % of expected floor area growth by 2050 in emerging and developing economies. The building envelope is vital for the building sector's decarbonisation, dramatically affecting its long-term energy efficiency, durability, and resilience (IEA 2023). IEA has established zero-carbon-ready buildings' energy codes as an essential tool to reduce energy consumption in space heating.

SNAPSHOT 13: Evolving Building Codes & Green Finance

Overview

Building codes have evolved from providing safe sites for builders and residents, to being more energy efficient, supporting construction from more sustainable materials, and energy efficiency approaches. With the challenges from climate change, there has been a push for building codes to implement decarbonisation and end of life strategies that align better with the circular economy. There is also interest in green finance to support the construction of (nearly) zero-carbon buildings, incorporating whole of life decarbonisation strategies.

Key features

- Building codes can be prescriptive or performance based or a combination of both. Prescriptive codes set minimum specifications on a component-by-component level, whereas performance-based codes allow the market to achieve high efficiency with the method working best in each case.
- A significant challenge for these endeavours has been the availability, and shortfall in the market, of green finance options. This is even more testing for developing nations that are yet to implement buildings codes or, for those who do have a regulatory system for building codes, to ensure that they have (nearly) Zero-energy carbon building codes.
- Opportunities for green finance may be even more remote for developing nations at a time when such instrumentality is highly necessary than ever before.
- Building code regulations should be supported with informational policy instruments, and incentives to ensure compliance and progress.

Impact

- Developing and adopting new building energy carbon codes usually takes several years, with additional time for implementation. Given these long lead times. Therefore, it is a priority to initiate new codes at the earliest opportunity.

Sources: AIA (2016); Chastas et al. (2016); Crawford (2011); IEA (2022).

4.3 Energy Ratings

There are various energy rating and labelling schemes worldwide. Energy Performance Certificates (EPC) and Energy Labels are typically colour-coded ratings varying on a scale from A to G, with A being the most energy-efficient rating by amount of energy used per square meter, the CO2 emission levels in tonnes per year, and fuel costs, and used, for example, in the EU, UK, Turkey, the US (trademarked as Energy Star). Australia has its own NABERS program, measuring building energy efficiency, water usage, waste management, indoor environment quality, and environmental impact. Europe and the UK require disclosing an EPC during property sales and leases; the UK has even introduced a minimum EPC level of E for rental properties (European Union 2010; UK Government 2023).

SNAPSHOT 14: On the Energy Performance Gap

Overview

The energy performance gap refers to the phenomenon where the predicted and realised energy performance of an asset differ. For properties with an energy rating, such as the EPC in the EU, this gap would be seen as the difference between the actual energy use and the estimated energy use on the EPC. Research has found that energy-efficient dwellings often exhibit a positive energy performance gap, indicating higher energy use than predicted, while less efficient dwellings tend to show a negative gap, indicating lower energy use than estimated. Occupant behaviour plays a significant role in these discrepancies. Moreoever, energy ratings have been criticised for only addressing operational emissions and neglecting whole lifecycle perspectives.

Key features

- The energy performance gap may lead to striking lack of variation in average actual energy use across different energy ratings, as evidenced for example in Ireland (Coyne & Denny, 2021).
- Spanish faculty building's estimated and real energy consumption deviated on average by 30 % (Cozza et al, 2020).
- The error rate in UK's EPC records is estimated to be between 36 to 62 % (Hardy & Glew, 2019).
- EU's EPBD revision accepted in 2024 takes step towards addressing greenhouse gas emissions over the whole lifecycle of the buildings. From 2030, the EPBD requires lifecycle GHG emissions to be calculated and disclosed on EPCs.

Impact

- Estimating energy consumption and savings based on energy labels alone is not currently viable. Instead, actual consumption data should be used.

Sources: Coyne & Denny (2021); Cozza et al. (2020); European Commission (2024b); Hardy & Glew (2019).

4.4 Primary Energy Demand (PED)

Primary Energy Demand (PED) is the calculated amount of energy needed to meet the energy demand associated with a building's typical uses. It is expressed by a numeric indicator of total primary energy use in kWh/m2 per year and based on the relevant national calculation methodology. The EU Taxonomy requires a PED reduction of 10 % compared to national nearly-zero energy building requirements for new buildings and a PED reduction of 30 % for renovations (EU 2024).

4.5 Whole Life Carbon Assessments

Both Climate Bond Standards and the EU Taxonomy require new buildings to report on whole-life carbon assessment (WLCA) – global warming potential. CBS requires this for new buildings starting in 2026, and the EU taxonomy only applies to buildings larger than 5000 m2. This includes product, construction and end-of-life stages according to EN 15978 or similar (Climate Bonds Standards 2023a; EU 2024).

Emissions Performance Trajectory Targets. The new building criteria introduced in December 2023 in Climate Bond Standards calculate Emissions Performance Targets based on location- and building-type specific emission trajectories, which take the top 15 % of buildings in a city as the initial emission benchmark and then decline to zero emissions in 2050 (Climate Bonds Standards 2023a). CBS also uses emission intensity targets for building renovations, requiring a minimum improvement of 30% post-retrofit upgrade for a 5-year bond and 50 % emissions upgrade for a 30-year bond. (Climate Bonds Standards 2023a).

4.6 Green Ratings and Certifications

As discussed in Chapter 4.1, certifications are crucial in most green finance frameworks. In addition to certifying their green finance frameworks, companies can get a portfolio and company-level sustainability (ESG) scores or ratings. Over the past decade, these ESG ratings have become essential signals of sustainability risk mitigation and long-term viability for the capital markets.

What ESG scoring methods are used in the real estate sector?

One of the most adopted scoring systems in the real estate industry is the Global Real Estate Sustainability Benchmark (GRESB). Originating in the Netherlands in 2009, GRESB is an investor-driven, voluntary framework for ESG performance, reporting on tangible assets and providing standardised and validated data to capital markets (Devine et al. 2022). The GRESB assessments align with the Paris Climate Agreement, the Sustainable Development Goals and other major international reporting frameworks. Real estate and infrastructure assessment results are published annually as global benchmarks (GRESB 2024).

CBI also provides an entity-level certification for non-financial undertakings with high climate targets aligned with the Climate Bonds Sector Criteria (CBS 2023b). For eligible entities, two levels of Entity Certification are available: "Aligned" and

“Transition”. “Aligned” means that the entity’s climate change mitigation targets align with the CBS Sector Criteria at the time of Certification until the net-zero emission target is reached. “Transition” level certification, on the other hand, is granted to entities that are not aligned with the Sector Criteria at the time of certification but align by 31st December 2030 and after reaching the net-zero targets.

What are the challenges with ESG rating systems?

However, like the GBRS, ESG rating systems lack transparency and comparability. In June 2023, the European Commission proposed a regulation for ESG rating activities to respond to these challenges. The regulation, currently pending approval by the EU Council and the Parliament, aims to enhance the reliability and comparability of ESG ratings through the authorisation requirements of ESG rating providers. Furthermore, the new regulation demands that financial market participants disclose the methodologies used to determine the ESG rating in their marketing materials.

Table 8. Comparison of approved proxies in green financing frameworks for different instruments.

	IMCA's Green Bond / Loan Principles	CBI's Climate Bond Standards	EU Green Bond Standard & EU Taxonomy
Green bonds (residential)	LEED, BREEAM, ANSI/ASHRAE/IES/USGBC Standard 189.1, International Green Construction Code, local & national codes and guidelines (EPC etc)	Top 15% benchmark based on local proxy (national building code, EPC) or certified by LEED Gold or Platinum + ASHRAE 90.1*, EDGE**, Living Building Challenge	Buildings built before 31 Dec 2020: EPC A or top 15% national PED; Buildings built after 31 Dec 2020: PED -10% compared to national NZEB threshold and WLCA (GWP)***
Green loans (residential)	LEED, BREEAM, ANSI/ASHRAE/IES/USGBC Standard 189.1, International Green Construction Code, local & national codes and guidelines (EPC etc)	?	Buildings built before 31 Dec 2020: EPC A or top 15% national PED; Buildings built after 31 Dec 2020: PED -10% compared to national NZEB threshold and WLCA (GWP)***
Green covered bonds (ECBC, 2023)	LEED, BREEAM, ANSI/ASHRAE/IES/USGBC Standard 189.1, International Green Construction Code, local & national codes and guidelines (EPC etc)	?	Buildings built before 31 Dec 2020: EPC A or top 15% national PED; Buildings built after 31 Dec 2020: PED -10% compared to national NZEB threshold and WLCA (GWP)***
Green mortgages	LEED, BREEAM, ANSI/ASHRAE/IES/USGBC Standard 189.1, International Green Construction Code, local & national codes and guidelines (EPC etc)	?	Buildings built before 31 Dec 2020: EPC A or top 15% national PED; Buildings built after 31 Dec 2020: PED -10% compared to national NZEB threshold and WLCA (GWP)***
Energy-efficient mortgage loans	Energy Star (US)	?	Energy performance meets or exceeds relevant market best practice standards in line with current EU legislative requirements and/or an improvement in energy performance of at least 30% (source: EEM Initative)
Green mortgage securities	LEED, BREEAM, ANSI/ASHRAE/IES/USGBC Standard 189.1, International Green Construction Code, local & national codes and guidelines (EPC etc)	Top 15% benchmark based on local proxy (national building code, EPC) or certified by LEED Gold or Platinum + ASHRAE 90.1*, EDGE**, Living Building Challenge	

* Only if the local proxy is not available
** Only for developing countries
*** For buildings larger than 5000 m2

5. Summary & Conclusions

This report has provided a detailed overview of the recent development of green real estate financing markets. Overall, we observe a clear trend towards greater standardisation and global alignment, even if voluntary green finance standards, such as ICMA's Green Bond Principles and CBI's Climate Bond Standards, still play prominent roles. At the metrics level, we identify that emissions are starting to become the critical focus instead of energy efficiency. Moreover, as the operational emissions are reduced through efficiency improvements, the embodied emissions locked during the construction phase are becoming a key consideration. A welcome and healthy shift towards whole lifecycle emissions is observed in green finance frameworks and related regulations.

An essential aspect of green finance is climate change adaptation, as real estate as a physical sector faces multiple physical climate risks ranging from floods to fires and hurricanes that are expected to become more common due to the warming climate. These physical climate risks have started to affect real estate financing, insurance, and values and thus require careful addressing. Some green finance frameworks, such as the EU Taxonomy, require the physical risks to be addressed (through DNSH compliance), whereas, in most frameworks, the mitigation aspect and physical risks are not directly included.

Partly due to these physical risks, we observe that whereas initially, the green finance discussion revolved around greenium – the potential discount for green financing – the debate in the real estate sector is instead broadening to brown discounts and other benefits of green financing instruments, like lower default rates and arrears. Assets with poor sustainability credentials are more expensive to finance and insure. Together the penalties associated with unsustainable assets coupled with the potential benefits from green finance emphasise the strategic importance of integrating sustainability into real estate investment to achieve favorable financing terms, lower operating costs, and enhanced market appeal.

Moreover, while green bonds have been the primary green financing instrument thus far, they have limited capacity for real estate decarbonisation as they are only accessible to some more prominent institutions. Mobilising decarbonisation in the consumer residential sectors is critical, and new developments are expected in developing countries. The development of green mortgage markets is also essential for the growth of the green real estate securitisation market. However, the green mortgage markets often rely on energy performance certificates that currently rely on calculations rather than actual consumption. Scaling the green mortgage markets would also require achieving standardisation and global data availability as green mortgages and loans lag compared to green bonds.

Last, effectively decarbonising the real estate sector requires most buildings to undergo renovations by 2050. While green finance is prominent in rewarding the most environmentally performing properties, transition finance is expected to significantly support the transition until 2050 and help the sector align with net-zero trajectories.

References

Actuaries Institute. (2023). *Home Insurance Affordability Update*. Actuaries Institute. https://actuaries.asn.au/docs/thought-leadership-reports/home-insurance-affordability-update.pdf.pdf?sfvrsn=7737bcf4_4

AIA. (2016). *The AiA Guide to the IGCC, International Green Construction Code*. The American Institute of Architects. https://content.aia.org/sites/default/files/2016-04/Ind-AIAGuidetothe-IgCC.pdf

Akomea-Frimpong, I., Kukah, A. S., Jin, X., Osei-Kyei, R., & Pariafsai, F. (2022). Green finance for green buildings: A systematic review and conceptual foundation. *Journal of Cleaner Production*, *356*, 131869. https://doi.org/10.1016/j.jclepro.2022.131869

An, X., & Pivo, G. (2020). Green Buildings in Commercial Mortgage-Backed Securities: The Effects of LEED and Energy Star Certification on Default Risk and Loan Terms. *Real Estate Economics*, *48*(1), 7–42. https://doi.org/10.1111/1540-6229.12228

AOFM. (2024). *Issuance Program: Budget 2024-25 | AOFM*. https://aofm.gov.au/program/issuance-program, https://www.aofm.gov.au/program/issuance-program

Bachelet, M. J., Becchetti, L., & Manfredonia, S. (2019). The Green Bonds Premium Puzzle: The Role of Issuer Characteristics and Third-Party Verification. *Sustainability*, *11*(4), Article 4. https://doi.org/10.3390/su11041098

Baulkaran, V. (2019). Stock market reaction to green bond issuance. *Journal of Asset Management*, *20*(5), 331–340. https://doi.org/10.1057/s41260-018-00105-1

Berensmann, K. (2017). *Upscaling green bond markets: The need for harmonised green bond standards* (Research Report 12/2017). Briefing Paper. https://www.econstor.eu/handle/10419/199800

Bhutta, U. S., Tariq, A., Farrukh, M., Raza, A., & Iqbal, M. K. (2022). Green bonds for sustainable development: Review of literature on development and impact of green bonds. *Technological Forecasting and Social Change*, *175*, 121378. https://doi.org/10.1016/j.techfore.2021.121378

Billio, M., Costola, M., Pelizzon, L., & Riedel, M. (2022). Buildings' Energy Efficiency and the Probability of Mortgage Default: The Dutch Case. *The Journal of Real Estate Finance and Economics*, *65*(3), 419–450. https://doi.org/10.1007/s11146-021-09838-0

Bloomberg. (2024a, January 3). World's Biggest Banks Made $3 Billion on Green Debt in 2023—Bloomberg. *Bloomberg*. https://www.bloomberg.com/news/articles/2024-01-03/world-s-biggest-banks-made-3-billion-on-green-debt-last-year?embedded-checkout=true

Bloomberg. (2024b, April 1). A reality check for sustainable finance | Insights. *Bloomberg Professional Services*. https://www.bloomberg.com/professional/insights/sustainable-finance/a-reality-check-for-sustainable-finance/

Bloomberg. (2024c, April 1). US Home Insurance Premiums May Hit a Record This Year, Report Warns. *Bloomberg.Com*. https://www.bloomberg.com/news/articles/2024-04-01/us-home-insurance-premiums-may-hit-a-record-this-year-report-warns

Bloomberg. (2024d, April 9). If US Inflation Reflected Rising Home Insurance Costs, It'd Be Even Higher. *Bloomberg.Com*. https://www.bloomberg.com/news/articles/2024-04-09/a-key-us-inflation-metric-doesn-t-count-homeowners-insurance

Braune, D. A., Grantham, R., Linnig, U., Climate-KIC, E., Madlani, R., Motta, M., & di Milano, P. (2021). *HOW BLENDED FINANCE CAN CATALYSE BUILDING RENOVATION*. 17.

Caldecott, B., Clark, A., Koskelo, K., Mulholland, E., & Hickey, C. (2021). Stranded Assets: Environmental Drivers, Societal Challenges, and Supervisory Responses. *Annual Review of*

Environment and Resources, *46*(Volume 46, 2021), 417–447. https://doi.org/10.1146/annurev-environ-012220-101430

CBI. (2021). *Residential AUS - Green Star Homes proxy v1.pdf*. Climate Bonds Initiative. https://www.climatebonds.net/files/files/standards/Buildings/Proxies/Residential%20AUS%20-%20Green%20Star%20Homes%20proxy%20v1.pdf

CBI. (2023). *CHINA SUSTAINABLE DEBT STATE OF THE MARKET REPORT 2022*. Climate Bonds Initiative. https://www.climatebonds.net/files/reports/cbi_china_sotm_22_en.pdf

CBI. (2024a). *China solidifies leadership in Green Finance for 2023*. https://www.climatebonds.net/files/releases/chinasotm_mediarelease_16052024_0.pdf

CBI. (2024b, May 20). *Certified Bonds*. Climate Bonds Initiative. https://www.climatebonds.net/certification/certified-bonds

Chastas, P., Theodosiou, T., & Bikas, D. (2016). Embodied energy in residential buildings-towards the nearly zero energy building: A literature review. *Building and Environment*, *105*, 267–282. https://doi.org/10.1016/j.buildenv.2016.05.040

Che Husin, S., Mohd Zaki, N. I., & Abu Husain, M. K. (2019). Implementing sustainability in existing building through retrofitting measures. *International Journal of Civil Engineering and Technology*, *10*, 1450–1471.

Climate Action Tracker, Climate Analytics, & Next Climate Institute. (2023). *COP28 initiatives will only reduce emissions if followed through*. Climate Action Tracker. https://climateactiontracker.org/documents/1197/CAT_2023-12-09_COP28_InitiativesAssessment.pdf

Climate Bonds Initiative. (2020). *Green Loans—Australia & New Zealand* (p. 14). Climate Bonds Initiative. https://www.climatebonds.net/files/reports/cbi-green-loans-aus-nz-final-14102020.pdf

Climate Bonds Initiative. (2022). *Climate Bonds Initiative Green Bond Database Methodology*. Climate Bonds Initiative. https://www.climatebonds.net/files/files/CBI_Method_Criteria_03F.pdf

Climate Bonds Initiative. (2023, January 31). *Green and other Labelled Bonds Held Market Share in 2022 Amidst Fall of Global Fixed-Income*. Climate Bonds Initiative. https://www.climatebonds.net/resources/press-releases/2023/01/green-and-other-labelled-bonds-held-market-share-2022-amidst-fall

Climate Bonds Initiative. (2024a, January 18). *Climate Bonds Market 2024*. Climate Bonds Initiative. https://www.climatebonds.net/

Climate Bonds Initiative. (2024b, February 8). *Certified Climate Bonds Database*. Climate Bonds Initiative. https://www.climatebonds.net/certification/certified-bonds

Climate Bonds Initiative. (2024c, February 8). *Market Data—Green Bonds*. Climate Bonds Initiative. https://www.climatebonds.net/market/data

Climate Bonds Initiative. (2024d, April 16). *Market Data—Interactive Data Platform*. Climate Bonds Initiative. https://www.climatebonds.net/market/data

Climate Bonds Standards. (2023). *Buildings Criteria- The Buildings Eligibility Criteria of the Climate Bonds Standard & Certification Scheme*. Climate Bonds Initiative.

Commonwealth of Australia. (2018). *Trajectory for low energy buildings*. COAG Energy Council. https://web.archive.org.au/awa/20210603102158mp_/https://energyministers.gov.au/sites/prod.energycouncil/files/publications/documents/Trajectory%20for%20Low%20Energy%20Buildings.pdf

Commonwealth of Australia. (2023). *Australian Government Green Bond Framework*. Australian Office of Financial Management. https://www.aofm.gov.au/sites/default/files/2023-12-05/Green%20Bond%20Framework_WEB.pdf

COP28. (2024, May 7). *COP28: Global Renewables And Energy Efficiency Pledge*. https://www.cop28.com/en/global-renewables-and-energy-efficiency-pledge

Cortellini, G., & Panetta, I. C. (2021). Green Bond: A Systematic Literature Review for Future Research Agendas. *Journal of Risk and Financial Management*, *14*(12), Article 12. https://doi.org/10.3390/jrfm14120589

Coyne, B., & Denny, E. (2021). Mind the Energy Performance Gap: Testing the accuracy of building Energy Performance Certificates in Ireland. *Energy Efficiency*, *14*(6), 57. https://doi.org/10.1007/s12053-021-09960-1

Cozza, S., Chambers, J., Deb, C., Scartezzini, J.-L., Schlüter, A., & Patel, M. K. (2020). Do energy performance certificates allow reliable predictions of actual energy consumption and savings? Learning from the Swiss national database. *Energy and Buildings*, *224*, 110235. https://doi.org/10.1016/j.enbuild.2020.110235

Crawford, R. (2011). *Life Cycle Assessment in the Built Environment* (1st ed.). Routledge. https://www.routledge.com/Life-Cycle-Assessment-in-the-Built-Environment/Crawford/p/book/9780367576981

CRREM. (2021). *CRREM SURVEY ON TRANSITION RISK IN REAL ESTATE*. https://www.crrem.eu/wp-content/uploads/2022/04/CRREM-Transition-Risk-Survey.pdf

CRREM. (2024). *Carbon Risk Real Estate Monitor – CRREM Project*. https://www.crrem.eu/about-crrem/

CSF. (2023). *Blue Bonds Primer*. Centre for a Smart Future. https://www.csf-asia.org/wp-content/uploads/2024/01/Blue-Bonds-Primer-by-CSF_Dec2023.pdf

Curtis, Q., Weidemaier, M. C., & Gulati, M. (2023). *Green Bonds, Empty Promises* (Abstract 4358775; Public Law and Legal Theory Research Paper Series 2023-14). University of Virginia School of Law. https://papers.ssrn.com/abstract=4350209

Darko, A., Zhang, C., & Chan, A. P. C. (2017). Drivers for green building: A review of empirical studies. *Habitat International*, *60*, 34–49. https://doi.org/10.1016/j.habitatint.2016.12.007

Devine, A., & McCollum, M. (2022). Advancing energy efficiency through green bond policy: Multifamily green mortgage backed securities issuance. *Journal of Cleaner Production*, *345*, 131019. https://doi.org/10.1016/j.jclepro.2022.131019

Domain. (2024). *Perils 2024 Report*. Domain. https://s3.ap-southeast-2.amazonaws.com/ffx.adcentre.com.au/domain/2024/CRTV-3128/Domain_Perils+Report.pdf

Duan, T., & Li, F. W. (2024). Climate change concerns and mortgage lending. *Journal of Empirical Finance*, *75*, 101445. https://doi.org/10.1016/j.jempfin.2023.101445

EBA. (2023a). *EBA opinion on green loans and mortgages*. European Banking Authority. https://www.eba.europa.eu/sites/default/files/2023-12/61f2dee7-3ab2-4eb0-b239-587fa8b1bbd3/EBA%20opinion%20on%20green%20loans%20and%20mortgages_1.pdf

EBA. (2023b). *EBA REPORT IN RESPONSE TO THE CALL FOR ADVICE FROM THE EUROPEAN COMMISSION ON GREEN LOANS AND MORTGAGES*. European Banking Authority. https://eba.europa.eu/sites/default/files/2023-12/e7bcc22e-7fc2-4ca9-b50d-b6e922f99513/EBA%20report%20on%20green%20loans%20and%20mortgages_0.pdf

ECBC. (2023). *ECBC European Covered Bond Fact Book 2023* (18th Edition; ECBC PUBLICATION). European Mortgage Federation-European Covered Bond Council. https://hypo.org/app/uploads/sites/3/2023/08/ECBC-Fact-Book-2023-FINAL.pdf

EIB. (2021). *Evaluation of the EIB's Climate Awareness Bonds*. European Investment Bank. https://www.eib.org/attachments/ev/ev_report_evaluation_eib_climate_awareness_bonds_en.pdf

Eichholtz, P., Holtermans, R., Kok, N., & Yönder, E. (2019). Environmental performance and the cost of debt: Evidence from commercial mortgages and REIT bonds. *Journal of Banking & Finance*, *102*, 19–32. https://doi.org/10.1016/j.jbankfin.2019.02.015

Energy Efficient Mortgage Label. (2023). *Harmonised Disclosure Template: EEM Label*. https://www.energy-efficient-mortgage-label.org/hdt

Energy Efficient Mortgages Action Plan. (2019). *D5.3..Technical Report on ....the Econometric Assessment and Results*. Energy Efficient Mortgages Initiative. https://energyefficientmortgages.eu/wp-content/uploads/2021/07/BE-IT-NL-UK-Correlation-Analysis.pdf

EPRA. (2024). *European Listed Real Estate. Special report: Estimating a green premium in listed real estate bonds* (MARKET RESEARCH). European Public Real Estate Association. https://prodapp.epra.com/media/Green_Bonds_Report_2024_-_Final_1704795331285.pdf

ESMA. (2023). *The European sustainable debt market: Do issuers benefit from an ESG pricing effect?* European Securities and Markets Authority. https://data.europa.eu/doi/10.2856/468709

EU 2023/1791. (2023). *Directive—2023/1791—EN - EUR-Lex*. https://eur-lex.europa.eu/eli/dir/2023/1791/oj

European Commission. (2020). *EU taxonomy for sustainable activities* [Text]. European Commission - European Commission. https://ec.europa.eu/info/business-economy-euro/banking-and-finance/sustainable-finance/eu-taxonomy-sustainable-activities_en

European Commission. (2022). *EU Taxonomy Compass: Construction and Real estate* [Text]. European Commission - European Commission. https://ec.europa.eu/sustainable-finance-taxonomy/sectors/sector/7/view

European Commission. (2024a). *Overview of sustainable finance—European Commission*. https://finance.ec.europa.eu/sustainable-finance/overview-sustainable-finance_en

European Commission. (2024b, April). *Revised Energy Performance of Buildings Directive (EPBD)* [QUESTIONS AND ANSWERS]. European Commission - European Commission. https://ec.europa.eu/commission/presscorner/detail/en/qanda_24_1966

Falkenbach, H., Lindholm, A.-L., & Schleich, H. (2010). Environmental Sustainability: Drivers for the Real Estate Investor. *Journal of Real Estate Literature*, *18*(2), 203–223. https://www.jstor.org/stable/24884091

Fannie Mae. (2023a). *Single-Family Green MBS Approved Certifications*. https://capitalmarkets.fanniemae.com/media/21041/display

Fannie Mae. (2023b). *Form 4250—Green Building Certifications for Green Mortgage Loans*. https://multifamily.fanniemae.com/media/11586/display

Fatica, S., Panzica, R., & Rancan, M. (2021). The pricing of green bonds: Are financial institutions special? *Journal of Financial Stability*, *54*, 100873. https://doi.org/10.1016/j.jfs.2021.100873

Financial Times. (2023, April 10). European commercial real estate: The cracks are starting to show. *Financial Times*. https://www.ft.com/content/733a24d7-056d-4f02-8b20-8ba9f566e9f7

First Street Foundation. (2023). *The 9th National Risk Assessment—The Insurance Issue*. First Street Foundation. https://report.firststreet.org/9th-National-Risk-Assessment-The-Insurance-Issue.pdf

Flammer, C. (2020). Green Bonds: Effectiveness and Implications for Public Policy. *Environmental and Energy Policy and the Economy*, *1*, 95–128. https://doi.org/10.1086/706794

Flammer, C. (2021). Corporate green bonds. *Journal of Financial Economics*, *142*(2), 499–516. https://doi.org/10.1016/j.jfineco.2021.01.010

Flavelle, C. (2020, June 19). Rising Seas Threaten an American Institution: The 30-Year Mortgage. *The New York Times*. https://www.nytimes.com/2020/06/19/climate/climate-seas-30-year-mortgage.html

Fortune. (2021, November 12). Buildings not retrofit for net zero face a looming 'brown discount' as real estate goes green. *Fortune*. https://fortune.com/2021/11/12/buildings-not-retrofit-net-zero-face-brown-discount-real-estate-green-premium/

Fox, R., & Tulip, P. (2014). The User Cost of Housing | RDP 2014-06: Is Housing Overvalued? *Research Discussion Papers*, *September*. https://www.rba.gov.au/publications/rdp/2014/2014-06/the-user-cost-of-housing.html

Freddie Mac. (2021a). *Freddie Mac Multifamily Green Bonds Framework*. https://mf.freddiemac.com/docs/KG_Bond_Framework.pdf

Freddie Mac. (2021b). *Freddie Mac Single Family Green Bond Framework*. https://capitalmarkets.freddiemac.com/mbs/docs/Freddie_Mac_SF_Green_Bond_Framework.pdf

Freddie Mac. (2023, July). *Freddie Mac Reports Nearly $1.4 Billion of 2022 Single-Family Green Securities Issuance | Freddie Mac*. https://freddiemac.gcs-web.com/news-releases/news-release-details/freddie-mac-reports-nearly-14-billion-2022-single-family-green/
Gesamtverband der Versicherer. (2023, June 14). *Klimaschäden könnten zu Verdoppelung der Prämien in der Wohngebäudeversicherung führen* [Media Information]. https://www.gdv.de/gdv/medien/medieninformationen/klimaschaeden-koennten-zu-verdoppelung-der-praemien-in-der-wohngebaeudeversicherung-fuehren--136474
Gianfrate, G., & Peri, M. (2019). The green advantage: Exploring the convenience of issuing green bonds. *Journal of Cleaner Production*, *219*, 127–135. https://doi.org/10.1016/j.jclepro.2019.02.022
Gilchrist, D., Yu, J., & Zhong, R. (2021). The Limits of Green Finance: A Survey of Literature in the Context of Green Bonds and Green Loans. *Sustainability*, *13*(2), Article 2. https://doi.org/10.3390/su13020478
Government of Ireland. (2023). *Climate Action Plan 2023—CAP 2023—Changing Ireland for the Better*. https://assets.gov.ie/270956/94a5673c-163c-476a-921f-7399cdf3c8f5.pdf
Guin, B., & Korhonen, P. (2020). *Does Energy Efficiency Predict Mortgage Performance?* (No. 852; Staff Working Paper). Bank of England. https://www.bankofengland.co.uk/-/media/boe/files/working-paper/2020/does-energy-efficiency-predict-mortgage-performance.pdf
Hardy, A., & Glew, D. (2019). An analysis of errors in the Energy Performance certificate database. *Energy Policy*, *129*, 1168–1178. https://doi.org/10.1016/j.enpol.2019.03.022
Hoss, A., & Luppi, L. (2024). *The state of ESG investing in Canada's commercial real estate market: Opportunities and risks*. *12*.
Ibn-Mohammed, T., Greenough, R., Taylor, S., Ozawa-Meida, L., & Acquaye, A. (2013). Operational vs. Embodied emissions in buildings—A review of current trends. *Energy and Buildings*, *66*, 232–245. https://doi.org/10.1016/j.enbuild.2013.07.026
ICMA. (2022). *Analysis of China's Green Bond Principles*. International Capital Markets Association. https://www.icmagroup.org/assets/Analysis-of-Chinas-Green-Bond-Principles.pdf
IEA. (2020). *Net Zero by 2050—A Roadmap for the Global Energy Sector*. International Energy Agency. https://iea.blob.core.windows.net/assets/deebef5d-0c34-4539-9d0c-10b13d840027/NetZeroby2050-ARoadmapfortheGlobalEnergySector_CORR.pdf
IEA. (2022, September 1). *All countries targeted for zero-carbon-ready codes for new buildings by 2030 – Analysis*. IEA. https://www.iea.org/reports/all-countries-targeted-for-zero-carbon-ready-codes-for-new-buildings-by-2030-2
IEA. (2023a). *Buildings – Breakthrough Agenda Report 2023 – Analysis*. International Energy Agency, International Renewable Energy Agency, UN Climate Change High-Level Champions. https://www.iea.org/reports/breakthrough-agenda-report-2023/buildings
IEA. (2023b). *Buildings—Energy System*. IEA. https://www.iea.org/energy-system/buildings
IFC. (2024). *Blue Finance* [Text/HTML]. IFC. https://www.ifc.org/en/what-we-do/sector-expertise/financial-institutions/climate-finance/blue-finance
IFRS. (2024a). *IFRS - IFRS S1 General Requirements for Disclosure of Sustainability-related Financial Information*. IFRS S1 General Requirements for Disclosure of Sustainability-Related Financial Information. https://www.ifrs.org/issued-standards/ifrs-sustainability-standards-navigator/ifrs-s1-general-requirements/
IFRS. (2024b). *IFRS - IFRS S2 Climate-related Disclosures*. IFRS - IFRS S2 Climate-Related Disclosures. https://www.ifrs.org/issued-standards/ifrs-sustainability-standards-navigator/ifrs-s2-climate-related-disclosures/
IIGCC. (2019). *Investor Expectations for listed Real Estate Companies*. The Institutional Investors Group on Climate Change. https://139838633.fs1.hubspotusercontent-eu1.net/hubfs/139838633/Past%20resource%20uploads/Investor%20Expectations%20for%20listed%20Real%20Estate%20companies_November%202019.pdf

IIGCC. (2023). *Addressing whole life carbon in real estate portfolios: A step-by-step guide*. The Institutional Investors Group on Climate Change. https://139838633.fs1.hubspotusercontent-eu1.net/hubfs/139838633/Brand%20Tier%202%20-%20resized/IIGCC%20Addressing%20whole%20life%20carbon%20in%20real%20estate%20portfolios%202023.pdf

Immel, M., Hachenberg, B., Kiesel, F., & Schiereck, D. (2022). Green Bonds: Shades of Green and Brown. In M. de Jong & D. diBartolomeo (Eds.), *Risks Related to Environmental, Social and Governmental Issues (ESG)* (pp. 21–34). Springer Nature Switzerland. https://doi.org/10.1007/978-3-031-18227-3_3

International Energy Agency. (2023). *Net Zero Roadmap: A Global Pathway to Keep the 1.5 °C Goal in Reach—2023 Update*. International Energy Agency. https://iea.blob.core.windows.net/assets/13dab083-08c3-4dfd-a887-42a3ebe533bc/NetZeroRoadmap_AGlobalPathwaytoKeepthe1.5CGoalinReach-2023Update.pdf

International Energy Agency, International Renewable Energy Agency, & United Nations Climate Change. (2023). *The Breakthrough Agenda Report 2023: Accelerating Sector Transitions Through Stronger International Collaboration*. OECD. https://doi.org/10.1787/692cdb6b-en

IPCC. (2023). *AR6 Synthesis Report: Climate Change 2023 — IPCC*. Intergovernmental Panel on Climate Change. https://www.ipcc.ch/report/sixth-assessment-report-cycle/

IPEEC. (2018). *Zero Energy Building Definitions and Policy Activity—An international Review*. IPEEC Building Energy Efficiency Taskgroup. https://www.dcceew.gov.au/sites/default/files/documents/zero-energy-building-definitions-policy-activity-international-review.pdf

IRENA. (2024). *30 Heating and cooling as a service*. https://www.irena.org/Innovation-landscape-for-smart-electrification/Power-to-heat-and-cooling/30-Heating-and-cooling-as-a-service

James Eyres. (2023, April 25). How climate change could hit your mortgage. *Australian Financial Review*. https://www.afr.com/companies/financial-services/banks-to-drill-down-on-climate-risk-to-mortgages-20230425-p5d32k

JLL. (2022). *The return on sustainability—How the 'value of green' conversation is growing up* [Global Research]. https://www.us.jll.com/content/dam/jll-com/documents/pdf/research/global/return-on-sustainability-jan-2022.pdf

KangaNews. (n.d.). *Firstmac sprouts first all-green RMBS in Australia*. Retrieved May 22, 2024, from https://www.cefc.com.au/media/wxifqold/firstmac-sprouts-first-all-green-rmbs-in-australia.pdf

Kaza, N., Quercia, R. G., & Tian, C. Y. (2014). Home Energy Efficiency and Mortgage Risks. *Cityscape*, *16*(1), 279–298. https://www.jstor.org/stable/26326871

Keenan, J. M., & Bradt, J. T. (2020). Underwaterwriting: From theory to empiricism in regional mortgage markets in the U.S. *Climatic Change*, *162*(4), 2043–2067. https://doi.org/10.1007/s10584-020-02734-1

Lambert, D., Lyons, P., & Carroll, J. (2023). *Going Green – The Growth in Green Mortgage Financing in Ireland* [Financial Stability Notes]. Central Bank of Ireland. https://www.centralbank.ie/docs/default-source/publications/financial-stability-notes/going-green-the-growth-in-green-mortgage-financing-in-ireland.pdf

Larry Fink. (2020). Larry Fink's Annual 2020 Letter to CEOs. *BlackRock*. https://www.blackrock.com/americas-offshore/en/larry-fink-ceo-letter

Lau, P., Sze, A., Wan, W., & Wong, A. (2022). The Economics of the Greenium: How Much is the World Willing to Pay to Save the Earth? *Environmental and Resource Economics*, *81*(2), 379–408. https://doi.org/10.1007/s10640-021-00630-5

Lee, C. L., Gumulya, N., & Bangura, M. (2022). The Role of Mandatory Building Efficiency Disclosure on Green Building Price Premium: Evidence from Australia. *Buildings*, *12*(3), Article 3. https://doi.org/10.3390/buildings12030297

Leskinen, N., Vimpari, J., & Junnila, S. (2020). A Review of the Impact of Green Building Certification on the Cash Flows and Values of Commercial Properties. *Sustainability*, *12*(7), 2729. https://doi.org/10.3390/su12072729

Lin, L., & Hong, Y. (2022). Developing a Green Bonds Market: Lessons from China. *European Business Organization Law Review*, *23*(1), 143–185. https://doi.org/10.1007/s40804-021-00231-1

LMA. (2020a). *Guidance on the application of the Green Loan Principles in the real estate finance (REF) lending context—Green Buildings*. Loan Market Association. https://www.lma.eu.com/application/files/2316/0552/7456/01_LMA_Case_Study_REF_Investments_Green_Buildings_V06.pdf

LMA. (2020b). *Guidance on the application of the Green Loan Principles in the real estate finance (REF) lending context—Retrofit Projects*. Loan Market Association.

Löffler, K. U., Petreski, A., & Stephan, A. (2021). Drivers of green bond issuance and new evidence on the “greenium.” *Eurasian Economic Review*, *11*(1), 1–24. https://doi.org/10.1007/s40822-020-00165-y

MacAskill, S., Roca, E., Liu, B., Stewart, R. A., & Sahin, O. (2021). Is there a green premium in the green bond market? Systematic literature review revealing premium determinants. *Journal of Cleaner Production*, *280*, 124491. https://doi.org/10.1016/j.jclepro.2020.124491

Marmolejo-Duarte, C., & Chen, A. (2019). The Uneven Price Impact of Energy Efficiency Ratings on Housing Segments and Implications for Public Policy and Private Markets. *Sustainability*, *11*(2), 372. https://doi.org/10.3390/su11020372

McCarthy, R., & Reid, G. (2024). *Assessing Physical Climate Risk in Repo-eligible Residential Mortgage-backed Securities | Bulletin – April 2024* (Australia). *April*. https://www.rba.gov.au/publications/bulletin/2024/apr/assessing-physical-climate-risk-in-repo-eligible-residential-mortgage-backed-securities.html

McCord, M., Haran, M., Davis, P., & McCord, J. (2020). Energy performance certificates and house prices: A quantile regression approach. *Journal of European Real Estate Research*, *13*(3), 409–434. https://doi.org/10.1108/JERER-06-2020-0033

Morgan Stanley. (2023, April 11). *Investing in the Blue Economy*. Morgan Stanley. https://www.morganstanley.com/ideas/blue-economy-investing-ocean-priorities

Nanayakkara, M., & Colombage, S. (2019). Do investors in Green Bond market pay a premium? Global evidence. *Applied Economics*, *51*(40), 4425–4437. https://doi.org/10.1080/00036846.2019.1591611

OECD. (2021). *Mortgage finance across OECD countries* (OECD Economics Department Working Papers 1693; OECD Economics Department Working Papers, Vol. 1693). https://doi.org/10.1787/f97d7fe0-en

OECD. (2022). *Real estate finance and climate transition: Market practices, challenges and policy considerations* (OECD Business and Finance Policy Papers 09; OECD Business and Finance Policy Papers, Vol. 09). https://doi.org/10.1787/fa86b326-en

Olubunmi, O. A., Xia, P. B., & Skitmore, M. (2016). Green building incentives: A review. *Renewable and Sustainable Energy Reviews*, *59*, 1611–1621. https://doi.org/10.1016/j.rser.2016.01.028

Partridge, C., & Medda, F. R. (2020). The evolution of pricing performance of green municipal bonds. *Journal of Sustainable Finance & Investment*, *10*(1), 44–64. https://doi.org/10.1080/20430795.2019.1661187

Platform on Sustainable Finance. (2022). *Final Report on Social Taxonomy* (p. 84) [Final report]. European Commission. https://ec.europa.eu/info/sites/default/files/business_economy_euro/banking_and_finance/documents/280222-sustainable-finance-platform-finance-report-social-taxonomy.pdf

Ram, M., Bogdanov, D., Aghahosseini, A., Gulagi, A., Oyewo, olomon A., Child, M., Caldera, U., Sadovskaia, K., Farfan, J., Barbosa, L. S. N. S., Fasihi, ahdi, Khalili, S., Breyer, C., Fell, H.-J., Traber, T., Caluwe, F. D., Gruber, G., & Dalheimer, B. (2019). *Global Energy System based on 100% Renewable Energy – Power, Heat, Transport and Desalination Sectors*. [Research Report]. Study by Lappeenranta University of Technology and Energy Watch Group.

RBA. (2023). *September | 2023 | Bulletin* (Australia). RESERVE BANK OF AUSTRALIA. https://www.rba.gov.au/publications/bulletin/2023/sep/index.html

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 (Text with EEA Relevance), 198 OJ L (2020). http://data.europa.eu/eli/reg/2020/852/oj/eng

RICS. (2022). *2022 RICS Sustainability Report.pdf*. Royal Institute of Chartered Surveyors. https://www.rics.org/contentassets/fabee7a1008a4222ba688c8ba45af6c2/2022-rics-sustainability-report_final.pdf

Röck, M., Saade, M. R. M., Balouktsi, M., Rasmussen, F. N., Birgisdottir, H., Frischknecht, R., Habert, G., Lützkendorf, T., & Passer, A. (2020). Embodied GHG emissions of buildings – The hidden challenge for effective climate change mitigation. *Applied Energy*, *258*, 114107. https://doi.org/10.1016/j.apenergy.2019.114107

Sangiorgi, I., & Schopohl, L. (2023). Explaining green bond issuance using survey evidence: Beyond the greenium. *The British Accounting Review*, *55*(1), 101071. https://doi.org/10.1016/j.bar.2021.101071

Savills. (2023, September 20). Total Value of Global Real Estate: Property remains the world's biggest store of wealth. *Savills Impacts*. https://www.savills.com/impacts/market-trends/the-total-value-of-global-real-estate-property-remains-the-worlds-biggest-store-of-wealth.html

Sergei, G., & Alesya, B. (2022). In Search of Greenium. Analysis of Yields in the European Green Bond Markets. *Procedia Computer Science*, *214*, 156–163. https://doi.org/10.1016/j.procs.2022.11.161

Slimane, M., Mahtani, V., & da Fonseca, D. (2020). *Facts and Fantasies about the Green Bond Premium*. https://doi.org/10.13140/RG.2.2.19600.84486

South China Morning Post. (2022, September 9). *Mortgage-backed green securities are surging in China, Fitch says*. South China Morning Post. https://www.scmp.com/business/china-business/article/3191836/mortgage-backed-green-securities-are-surging-china-beijing

Tang, D. Y., & Zhang, Y. (2020). Do shareholders benefit from green bonds? *Journal of Corporate Finance*, *61*, 101427. https://doi.org/10.1016/j.jcorpfin.2018.12.001

The SustainAbility Institute by ERM. (2022). *Over Two Years with the EU Taxonomy*. The SustainAbility Institute by ERM. https://www.sustainability.com/globalassets/sustainability.com/thinking/pdfs/2022/sai-eu-taxonomy-expert-briefing.pdf

UK Government. (2023, April 13). *Domestic private rented property: Minimum energy efficiency standard - landlord guidance*. GOV.UK. https://www.gov.uk/guidance/domestic-private-rented-property-minimum-energy-efficiency-standard-landlord-guidance

UNCTAD. (2023). *CHAPTER III: CAPITAL MARKETS AND SUSTAINABLE FINANCE* [World Investment Report]. United Nations Trade and Development. https://unctad.org/system/files/official-document/wir2023_ch03_en.pdf

UNEP FI. (2023). *Climate Risks in the Real Estate Sector* (Sectoral Risk Briefings: Insights for Financial Institutions). United Nations Environment Programme. https://www.unepfi.org/wordpress/wp-content/uploads/2023/03/Real-Estate-Sector-Risks-Briefing.pdf

United Nations Environment Programme. (2021). *2021 Global Status Report for Buildings and Construction*. Global Alliance of Buildings and Construction. https://globalabc.org/sites/default/files/2021-10/GABC_Buildings-GSR-2021_BOOK.pdf

United Nations Environment Programme. (2022). *2022 Global Status Report for Buildings and Construction: Towards a Zero‑emission, Efficient and Resilient Buildings and Construction Sector*. United Nations Environment Programme.

United Nations Environment Programme. (2024). *2023 Global Status Report for Buildings and Construction: Beyond foundations - Mainstreaming sustainable solutions to cut emissions from the buildings sector*. United Nations Environment Programme. https://doi.org/10.59117/20.500.11822/45095

Vincenzo Bianco. (2020). *Overview of On-Bill Building Energy Renovation Schemes* [Renonbill]. University of Genova.

Wallace, N., Issler, P., Mathew, P., & Sun, K. (2018). *Impact of Energy Factors on Default Risk in Commercial Mortgages*. University of California, Berkeley. https://eta-publications.lbl.gov/sites/default/files/p_mathews_-_report_-_impact_of_energy_factors_on_default_risk_in_commercial_mortgages.pdf

Wang, J., Chen, X., Li, X., Yu, J., & Zhong, R. (2020). The market reaction to green bond issuance: Evidence from China. *Pacific-Basin Finance Journal*, *60*, 101294. https://doi.org/10.1016/j.pacfin.2020.101294

Wilkinson, S. J., & Sayce, S. (2020). Decarbonising real estate: The evolving relationship between energy efficiency and housing in Europe. *Journal of European Real Estate Research*, *13*(3), 387–408. https://doi.org/10.1108/JERER-11-2019-0045

World Bank. (2019). *Seychelles launches World's First Sovereign Blue Bond* [Press Release 2019/066/ENV]. World Bank. https://doi.org/10/29/seychelles-launches-worlds-first-sovereign-blue-bond

Zerbib, O. D. (2019). The effect of pro-environmental preferences on bond prices: Evidence from green bonds. *Journal of Banking & Finance*, *98*, 39–60. https://doi.org/10.1016/j.jbankfin.2018.10.012

Zhang, H. (2020). *Regulating green bonds in the People's Republic of China: Definitional divergence and implications for policy making* (Working Paper 1072). ADBI Working Paper Series. https://www.econstor.eu/handle/10419/238429

Zhang, J., Song, Z., & Nedopil, C. (2024). *China Green Finance Status and Trends 2023-2024*. Griffin University. https://doi.org/10.25904/1912/5205

Zhou, X., & Cui, Y. (2019). Green Bonds, Corporate Performance, and Corporate Social Responsibility. *Sustainability*, *11*(23), Article 23. https://doi.org/10.3390/su11236881

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