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Subject: Measuring the Effectiveness of Green Bonds in Financing Renewable Energy Projects: A Comparative Study

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“Measuring the Effectiveness of Green Bonds in Financing Renewable Energy Projects: A Comparative Study”

SUMMARY

Relevance of the study: Research on measuring the effectiveness of green bonds in financing renewable energy projects is essential for ensuring accountability, transparency, and efficiency in sustainable finance. It provides insights into how effectively these financial instruments channel funds towards environmentally beneficial initiatives. By evaluating metrics such as project impact, financial performance, and environmental outcomes, this research helps stakeholders make informed decisions, refine investment strategies, and optimize resource allocation. Ultimately, it promotes confidence among investors, encourages the growth of green finance markets, and accelerates the transition to a low-carbon economy.

The purpose of the study: The study aims to assess how efficiently green bonds allocate funds to renewable energy projects, evaluating their impact, financial performance, and environmental outcomes for informed decision-making.

Used research methods: Analysis, synthesis, tabular and graphical comparison methods were included in the research work.

Information base of the research: The dissertation work was researched based on the researches of local and foreign authors, articles, internet resources and statistical data.

Limitations of the study: The literature on the subject is limited.

Scientific novelty and practical results of the research: The research on measuring the effectiveness of green bonds in financing renewable energy projects holds significant scientific innovation and practical implications. It pioneers methodologies for assessing the environmental and financial impacts of green bonds, contributing to the evolution of sustainable finance. By integrating interdisciplinary approaches, such as finance, environmental science, and policy analysis, it fosters a deeper understanding of how financial instruments can drive renewable energy deployment. This knowledge informs policymakers, investors, and practitioners, facilitating more informed decision-making and promoting the scalability and replicability of successful green bond models globally, thereby accelerating the transition to a low-carbon economy.

Areas where results can be used: In assessing returns, and financial health indicators to measure the profitability and sustainability of green bond-financed renewable energy projects, quantifying metrics such as carbon emissions reductions, added renewable energy generation capacity and other environmental benefits to measure the contribution of green gardens to sustainability goals, evaluating metrics related to project lead times, cost overruns, and resource efficiency to ensure effective implementation of green bond-financed projects, monitoring metrics such as credit ratings, bond prices, and investor demand to gauge market perception and confidence in green bonds financing renewable energy projects , project risks, including technological, regulatory and market, to ensure green bond investments are adequately mitigated and managed, in measuring metrics such as job creation, community engagement and improved social well-being to assess the broader societal benefits of green bond-financed renewable energy initiatives assessing the alignment of green bond-financed projects with national or international renewable energy targets, climate goals, and sustainability policies to ensure consistency and effectiveness in achieving broader policy goals.

Keywords: *green bonds, market risks, renewable energy, financial services*

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1. INTRODUCTION

In recent years, there has been a growing global concern about climate change and its adverse effects on the environment. As a result, there has been a concerted effort to transition towards more sustainable and environmentally friendly energy sources, such as renewable energy. Financing these projects, however, remains a significant challenge.

Green bonds are reserved especially for initiatives that improve the climate or the environment. Projects that support clean transportation, sustainable agriculture, energy efficiency, renewable energy, and other green initiatives are financed or refinanced using the money raised via green bonds.

Even if green bonds are becoming more and more popular, their usefulness in funding renewable energy projects needs to be assessed. This evaluation is necessary to determine how much green bonds contribute to the accomplishment of environmental and climate goals, as well as how they impact investors and financial markets.

This study aims to assess the effectiveness of green bonds in financing renewable energy projects through a comparative analysis. This study aims to address the following research topics by contrasting the performance of conventional and green bonds:

1. How do green bonds compared to conventional bonds in terms of financing renewable energy projects?

2. What are the environmental and climate impacts of renewable energy projects funded by green bonds?

3. In comparison to traditional bonds, how do investors view the pros and cons of green bonds?

To address these questions, this study will employ a mixed-methods approach, combining quantitative analysis of bond performance data with qualitative assessment of environmental impacts and investor perceptions. The quantitative analysis will involve comparing the financial performance and risk profiles of green bonds and conventional bonds issued by renewable energy projects.

The findings of this study are expected to provide valuable insights into the role of green bonds in financing renewable energy projects and their impact on environmental sustainability. By shedding light on the strengths and limitations of green bonds, this study aims to inform policymakers, investors, and other stakeholders in their efforts to promote sustainable finance and combat climate change.

1.1. Research problem and significance

Research problem: The effectiveness of green bonds in financing renewable energy projects is a topic of significant interest, given the growing need for sustainable energy sources and the increasing popularity of green finance instruments. However, there is a lack of comprehensive comparative studies examining the actual impact and effectiveness of green bonds specifically in financing renewable energy projects. This gap in research hinders our understanding of whether green bonds are truly effective in achieving their intended goals and whether they outperform traditional financing methods in this context.

Significance:

1. Addressing Climate Change: By lowering greenhouse gas emissions, renewable energy initiatives are essential to reducing climate change

2. Investor Trust: Understanding the efficiancy of green bonds helps to an increase in investor confidence in sustainable finance. Increased capital flows into renewable energy could result from more investors joining green bond markets if green bonds are shown to be successful in funding renewable energy projects.

3. Financial Sector Innovation: The financial sector is increasingly exploring innovative ways to promote sustainability. Green bonds represent one such innovation. Understanding their effectiveness can spur further innovation in financial instruments designed to support renewable energy and other sustainability initiatives.

4. Market Expansion: If green bonds are found to be more effective than traditional financing methods, it could lead to the expansion of green bond markets. This expansion can provide more opportunities for renewable energy developers to access capital and accelerate the transition to a low-carbon economy.

5. Stakeholder Engagement: Stakeholders such as environmental NGOs, governmental bodies, and community organizations have a vested interest in the success of renewable energy projects. Understanding the effectiveness of green bonds in financing these projects can facilitate meaningful stakeholder engagement and collaboration in promoting sustainable development.

By addressing these issues, this comparative study aims to shed light on the effectiveness of green bonds in financing renewable energy projects and contribute to the advancement of sustainable finance practices.

1.2. Research objectives

The following are some study goals to gauge how well green bonds work to fund renewable energy projects:

1. Comparative Analysis: To evaluate the effectiveness of renewable energy projects funded by green bonds versus those funded by traditional methods, a comparative analysis will be carried out.
2. Financial Performance Evaluation: Examine how renewable energy projects funded by green bonds fare financially in comparison to those funded by non-green bonds.
3. Environmental Impact Assessment: To evaluate how green bond-financed renewable energy projects affect the environment in terms of energy generation, carbon emissions reduction, and other pertinent environmental metrics.
4. Stakeholder perception: to find out how stakeholders such as governments, investors, and project developers perceive the efficiency of green bonds in funding renewable energy initiatives.
5. Market trends and dynamics: to examine growth rates, investor preferences, and market saturation in the green bond market for funding renewable energy projects.
6. Case Studies: To look at particular case studies of renewable energy projects financed by green bonds that have been successful and unsuccessful in order to pinpoint important elements influencing their efficacy.
7. Long-Term Sustainability: Examine how green bond financing for renewable energy projects can be sustained over the long run, taking into account the capacity to grow investments and keep projects viable.
8. Social and Economic Impacts: Evaluate how local communities, job creation, and socioeconomic development are affected by renewable energy projects funded by green bonds.
9. Suggestions for enhancement: Provide suggestions for improving the efficiency of green bonds in funding renewable energy initiatives, encompassing regulatory changes, funding systems, and stakeholder engagement tactics.

By tackling these goals, the study can add to the larger conversation on sustainable finance and offer insightful information about how well green bonds work as a funding source for renewable energy projects.

1.2.1. Research goals

Research for the study on evaluating how well green bonds work to fund renewable energy initiatives:

1. Evaluating the Green Bond Market's Growth to examine the market's growth patterns for green bonds, particularly as they relate to funding renewable energy initiatives. Determine the major participants and industries in the issuing and investing of green bonds.
2. Evaluation of Financing Needs for Renewable Energy: Identify the funding needs for renewable energy initiatives. Evaluate how well conventional funding approaches may satisfy these demands.
3. Comprehending Green Bond Mechanisms: Examine the composition and operation of green gardens to investigate the precise criteria and standards that are applied when designating bonds as "green."
4. Comparison with Conventional Financing: To assess how well green bonds work in funding renewable energy projects in comparison to more conventional financing techniques (such as bank loans and equity financing).
5. Effect on the Development of Renewable Energy Projects: Determine whether green bonds make it easier for renewable energy projects to obtain funding. Evaluate how green bonds affect the planning and execution of renewable energy projects.
6. Environmental and Social Repercussions: Evaluating the social and environmental effects of green bond-funded renewable energy projects. To determine if these initiatives achieve the desired sustainability outcomes.
7. Return and risk analysis: Examine the returns and risks of investing in green bonds in comparison to conventional bonds.
8. Determine the risk-adjusted returns of the green bonds when investing in renewable energy projects.
9. Case Studies and Comparative Analysis: To give a few instances of green bond-financed renewable energy projects.

These research goals ought to offer a thorough framework for examining how well green bonds function to fund renewable energy initiatives.

1.2.2. Research questions

Some research questions might be considered for research on measuring the effectiveness of green bonds in financing renewable energy projects:

1. What are the key features of green bonds compared to traditional bonds and how do these features affect their effectiveness in financing renewable energy projects?
2. How do green bond issuance and placement processes differ from traditional bonds, and how do these differences affect the financing of renewable energy projects?
3. What are the main motivations behind investors' decisions to purchase green bonds for renewable energy projects, and how do these motivations affect the overall effectiveness of green bonds in financing?
4. What criteria do investors and issuers use to judge the success or failure of green bonds in financing renewable energy projects, and how do these criteria differ from those used for traditional bonds?
5. What are the main challenges and barriers to the issuance and adoption of green bonds for financing renewable energy projects, and how do these challenges affect their effectiveness?
6. How do regulatory frameworks and standards such as the Green Bond Principles or the Climate Bond Initiative affect the effectiveness of green bonds in financing renewable energy projects?
7. What are the environmental and social impacts of renewable energy projects financed through green bonds, and how do these impacts compare to projects financed through traditional bonds?

1.2.3. Research model

This study aims to evaluate the effectiveness of green bonds as a financing mechanism for renewable energy projects using a comparative research model. However, their effectiveness in financing renewable energy initiatives remains a matter of debate.

Objectives of the study:

1. To assess the financial performance of renewable energy projects financed through green bonds.

2. To compare the financial results of projects financed by green bonds with projects financed by traditional methods.

3. To assess the environmental impact of renewable energy projects financed by green bonds.

4. To determine the elements influencing how well green bonds finance renewable energy projects.

5. To offer suggestions on how to best utilise green bonds to promote the growth of renewable energy.

Methodology:

1. Literature Review: To review the existing literature on green bonds, renewable energy financing and related topics to create a theoretical framework.

2. Data collection: Financial and environmental data of renewable energy projects financed by green bonds and conventional methods.

3. Benchmarking: Financial performance (eg ROI, YTM, NPV,) and environmental impact (eg CO2 emissions reduction, energy production) of green bond financed projects with conventionally financed projects.

4. Statistical analysis: Statistical methods such as regression analysis to identify factors that affect the effectiveness of green bonds.

5. Case Studies: Specific case studies are explored to provide qualitative insights into the successes and challenges of green bond financing.

6. Recommendations: Based on the findings, recommendations for green bond issuance and renewable energy financing stakeholders will be developed.

Expected Results:

1. Insights into the financial implications of renewable energy projects financed through green bonds.

2. Comparison of green bond financed projects with conventionally financed projects.

3. Understanding the environmental impact of green bond-financed renewable energy initiatives.

4. Identification of factors affecting the effectiveness of green bonds in financing renewable energy.

5. Recommendations on optimizing the use of green bonds for the development of renewable energy.

Keywords: green bonds, sustainable economy, renewable energy, benchmarking, financial performance, and environmental impact.

2. GREEN BONDS AND THEIR ROLE IN SUSTAINABILITY

2.1. Definition and Characteristics of Green Bonds

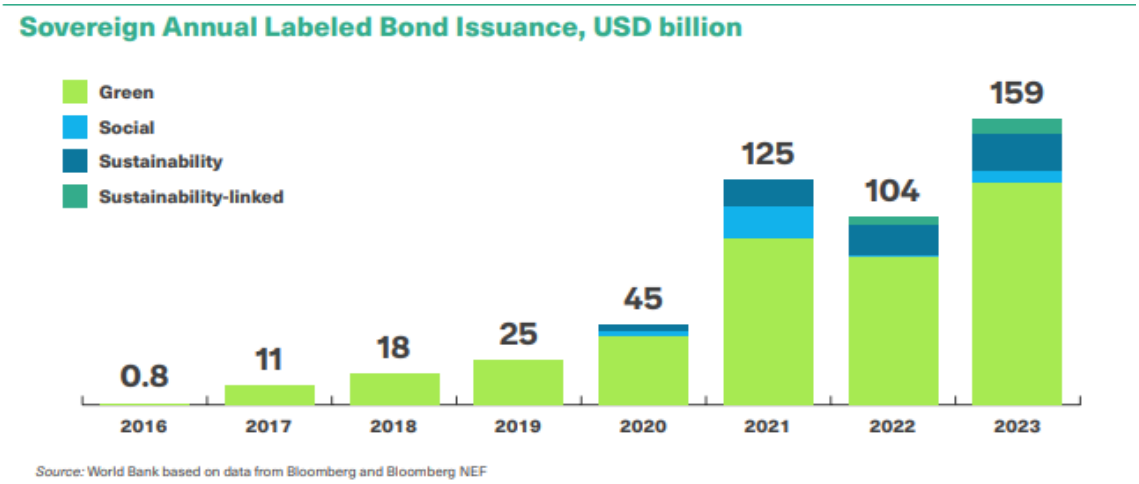
Issues such as environmental protection, reducing climate change, and ensuring sustainability have been on the agenda in recent years. When talking about these preferences and needs, it is clear that the costs of meeting these priorities are local and the benefits are global. For this reason, countries and international organizations are looking for solutions to create the right balance between costs and benefits. As a financial instrument in this direction, in the early 2000s, financial institutions were looking for opportunities to support solutions to environmental threats - high-quality, liquid financial products that do not carry additional project risk. As a result of joint activity with international organizations, green bonds have been issued by multilateral development banks since 2007 and are developed by sectors. Green bonds are intended to finance environmental friendly projects, promote sustainability, and fund social and environmental improvement initiatives. Clean transportation, sustainable water management, energy efficiency, pollution prevention, ecosystem preservation, and sustainable agriculture are just a few of the projects that are financed by green bonds. (Kandır, Yakar, 2017: 161). In addition, green bonds are also issued to promote environmentally friendly technologies and mitigate climate change.

The primary issuer of green bonds is the World Bank.. Since 2008, the World Bank issued over USD 19 billion equivalent in Green Bonds through over 220 bonds in 28 currencies. About a third of these bonds were used to support renewable energy and energy efficiency projects, 27 percent for clean transportation, and 15 percent for agriculture (World Bank, 2024; 45).

According to the Climate Bond Initiative, green bonds of $655.9 billion were issued in 2024. (https://www.climatebonds.net/). Poland issued the first sovereign green bond in 2016, building on the momentum created by the 2015 Paris Agreement.3. A total of USD 159 billion in labelled bonds were issued by 34 sovereign issuers in 2023; Argentina, Brazil, Cyprus, India, Israel, Turkey, and the United Arab Emirates were the first to do so. Interest from both sovereign issuers

and investors has increased, despite the fact that they only make up 10% of the total issuance of labelled bonds as of 2023. (World Bank Impact Report 2024 on Green Bonds)(figure 1)

Figure: 1



In the market for branded bonds, fifty sovereign issuers had issued USD 486 billion as of 2023. Twenty-three of them are emerging markets, accounting for USD 116 billion in total issuances as of 2023, or around 2.4% of all global issuances. Chile is the largest developing market sovereign issuer of labelled bonds, and it is the only nation to issue sustainability bonds, social bonds, green bonds, and the first sovereign bond related to sustainability.

Green bonds operate similarly to other government or corporate bonds. Borrowers offer these securities to finance ecologically friendly initiatives like ecosystem restoration or pollution control. Furthermore, the fact that bonds receive the majority of tax benefits and incentives suggests that this kind of financial instrument is a reliable source of finance for green projects. Since these bonds are typically linked to assets and supported by the issuing entity's balance sheet, they typically have the same credit rating as the issuers' other financial obligations. (Johansson, Lundgren, 2012).

Although the factors that make these bonds "green" are regulated in different ways, these criteria are mainly in accordance with the "Green Bond Principles" defined by the International Capital Markets Association.

Advantages of Green Bonds: Various studies exist to assess the benefits and impacts of green bonds. As one such study, it would be appropriate to analyze the research conducted by Maltais and Nykvist (2020) - the results of in-depth interviews with public and private sector representatives of the Swedish green bond market in 2017-2018. The main target audience of this

study are issuers and investors who are participants in green bond markets. In the analysis, financial and non-financial benefits of green bonds for issuers and investors were clarified through interviews. The result of the study is reflected in Table 1:

Table 1. Advantages of green bonds for every type of market player in all bond markets.

Issuers	Investors
Expanding the investor base	Investing in specific green projects or assets without incurring substantial additional risk
Reducing capital costs	Facilitate accountability of investments in support of sustainability to customers and other stakeholders
Facilitating access to capital	Attracting customers to the company has not become easier
Promotion of branding	Facilitating branding and offering new premium products to customers
Financial benefit due to the low interest rates they have to pay on the bond	Attracting qualified and competent personnel
Increasing the reputation of issuers because their bonds support sustainable development	Improving sustainability dialogue with issuers and within the organization
High demand	Supporting the further integration of a sustainability perspective within the organization

Sourch: (Maltais and Nyqvist (2020))

According to this study, green bonds provide more non-financial benefits than financial benefits. However, the financial benefits of green bonds to issuers outweigh the financial benefits to investors.

In a study conducted by Deschryver and De Mariz (2020) on the same topic, the following results were obtained as a result of interviews conducted with 11 experts on issuers, investors and brokers in 2019:

Table 2. Benefits of green bonds for each category of market participants across bond markets.

Sweats	preference 1	preference 2		preference 3
issuer	Favorable sustainability reputation with customers/public	Alignment with mission and strategic vision		Access to a larger and/or more diverse investor base
investor	Favorable sustainability reputation with customers/public	Development/enhancement of disclosure compliance		A more sustainable financial income in the long run
broker	Favorable sustainability reputation with customers/public	Access to a larger and/or more diverse investor base		More sustainable financial return in the long term

Sourch: (AlonsoConde and Rojo-Suarez (2020))

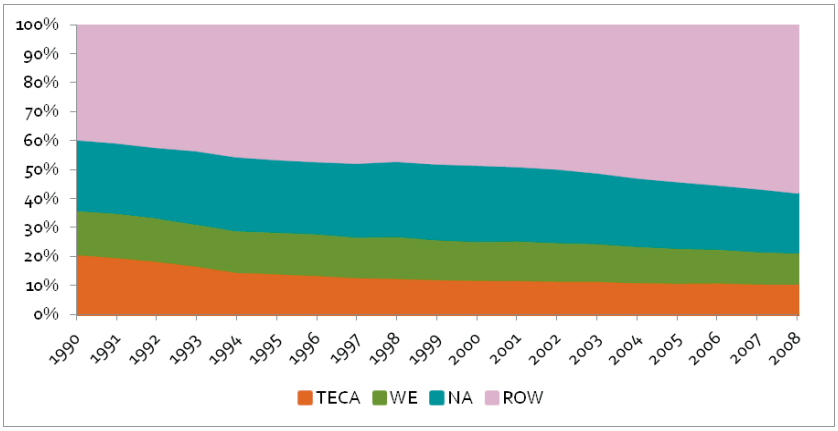
The advantages of green bonds have enormous potential in a number of areas, according to studies. As a result, green bonds can help firms in both monetary and non-monetary ways. More concessions, reduced interest rates, and easier access to finance are examples of financial advantages; accountability, transparency, and reputation are examples of non-financial advantages. Additionally, by often increasing the liquidity of infrastructure assets, green bonds can assist institutional investors in increasing investments in sustainable infrastructure.

Green bonds also provide great benefits to investors. Green bonds primarily provide investors with financial returns that support the environment. This allows investors to contribute to the sustainable development of food security, health, energy supply and other priority areas. Also, green bonds provide direct investment in the "greening" of "brown" sectors while raising the reputation of investors. This, in turn, helps increase the transparency and accountability of investors to the state, society and other interested parties, and facilitates the management of additional risks.

Green bond investments are a means of creating value for investors, customers and society as a whole, financing projects aimed at social protection for companies. Green bonds increase the

potential for institutional investors to support climate and environment-friendly investments through liquid instruments without forgoing financial returns. It is also of great importance in increasing the social value and transparency of fixed income investments.

Diagram 1. Territorial distribution of co2 emissions by region, in millions. Tons



Note: TECA – countries with economies in transition in Europe and Central Asia, WE – Western Europe, NA – North America. ROW - rest of the world.

Source: UNECE calculations.

Is it possible to implement a green growth model in practice? Yes, it is possible, provided that it is possible to significantly improve energy efficiency indicators. The energy sector accounts for approximately two-thirds of CO2 and other greenhouse gas emissions. Energy is vital for economic development and for improving the quality of life For the nations of Europe and Central Asia as well as for the entire world, ensuring a sufficient, dependable, and ecologically conscious supply of energy supplies is a challenge. There will be nine billion people on the planet by 2050, up from the current seven billion. A 50% reduction in greenhouse gas emissions through the use of safe, reasonably priced, and environmentally friendly energy resources is necessary to prevent catastrophic climate change while fostering economic progress. Enhancing energy efficiency at every link in the chain, from energy production to energy consumption, is essential to resolving this issue.

But the benefits of green bonds do not end with businesses and market participants alone. Green bonds also bring public social and environmental benefits. Therefore, green initiatives that are financed by green bonds also contribute to environmental protection. According to the World Bank's 2018 Green Bond Impact Report, investments in World Bank green bonds can reduce the carbon emissions of 1.5 million barrels of oil equivalent consumed in Mexico and save 4.8 million

tons of untreated wastewater from flowing into rivers in China each year, ensuring forest regeneration. supported projects that prevent and global energy savings equivalent to Chile's energy consumption in 2015 (World Bank, 2018; 5).

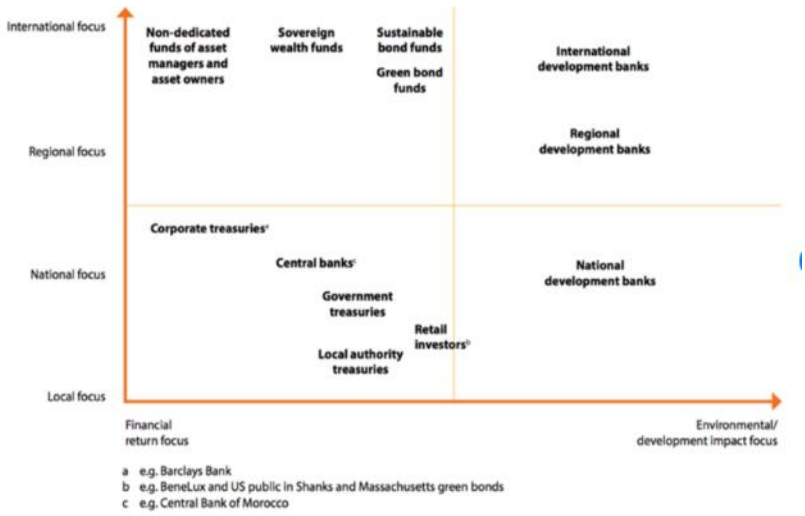
Booth's research highlights the benefits of green bonds to a wide range of stakeholders, including market participants and society. Although the benefits and degree of benefits obtained by all countries from these bonds are different, it is clear that this financial instrument is necessary and has great potential in supporting environmental protection. These benefits create a wide corridor of opportunities in promoting the green economy, from intra-organizational sustainability to public benefit. This reveals the need to use green bonds as an innovative financial instrument for environmental protection by realizing the power of investment, cooperation and innovation.

2.2. Linking Green Bonds to Sustainable Objectives

Green Bonds are created to finance Sustainable Goals, environmental protection and socially significant projects.

The Sustainable Development Sector may include bonds issuers, as well as sub-federal and municipal bonds. The sector consists of three distinct segments: the Sustainable Development Bonds Segment, the Sustainable Development Goals Bonds Segment and the National and Adaptation Projects Segment.

If the issue, issuer or investment project corresponds to the goals and results of national projects, bonds can be included in the Segment of National and Adaptation Projects: "Ecology", "Housing and urban ecology", "Comprehensive Plan for Modernization and Expansion". Bonds are basic infrastructure, "Demography", "Health", "Education", "Support of labor productivity and employment", "Culture" or "Application of the best available technologies" federal project, as well as government bodies or officials. The criteria (taxonomy) of adaptation projects are provided by the principles and standards to the stated principles (https://www.moex.com/s3019).



Different profiles of investors in the green bond market (Source: Williams et al., 2017, p. 6).

2.2.1. Challenges and Innovations in Promoting Sustainability

1. Solar Power Output Variability

One of the main disadvantages of solar energy is its inherent unpredictability. The time of day and the weather have a great effect on how much power solar panels can generate. Such as, nighttime or cloudy days significantly reduce solar energy production, which leads to lesser energy production. (Gil-Bazo, Ruiz-Verd´u, Santos, 2010: 243–263).

2. Requirements For Land And Space

In order to install solar panels, solar power plants require a large amount of land. Large-scale solar farms capacity to cover vast areas could be a disadvantage in areas with dense populations and a limited land. Additionally, not all residences or commercial buildings have the room required to mount solar panels on their roofs. Thus, the space and land requirements for solar energy installations may limit their broad use, especially in urban locations where land is limited.

3. High Start-Up Costs

Installing solar panels can be expensive initially, even if solar energy offers long-term advantages like reduced electricity prices and environmental benefits. Although the cost of solar panels has decreased over time, the initial expenditure still significantly limits many potential consumers.

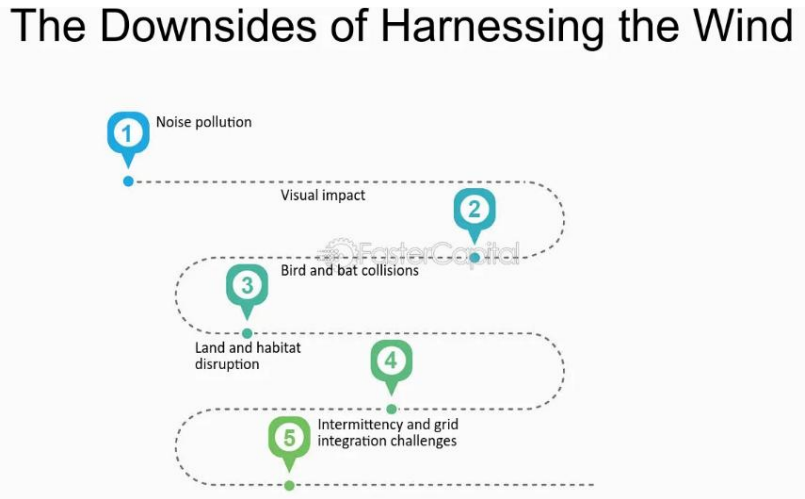
4. Intermittent Energy Storage Problems

In order to overcome the solar power outage, energy storage is essential. By storing excess energy generated during sunny spells and using it at times when solar production is low, a

consistent supply of electricity may be maintained. Despite this, batteries and other energy storage technologies are still very expensive and have limited capabilities. In order to fully utilise solar energy and provide a steady supply of electricity, efficient and reasonably priced energy storage systems are needed.

5. Geographical Restrictions

Solar energy is more appropriate in some geographic locations than others. More direct sunshine is received year-round in areas nearer the equator, which makes them perfect for producing solar energy. However, the effectiveness of solar panels is decreased in areas farther from the equator, such as northern latitudes, when daylight hours are shorter and sunlight is less intense. These geographical limitations might prevent solar energy from being widely used in some areas, necessitating the use of alternate renewable energy sources there.



Source: Challenges and Limitations - Disadvantages: Uncovering the Disadvantages of Renewable Energy Sources

2.2.2. Long-Term Sustainability Goals and Green Finance

It is necessary to provide financial flows based on ESI principles for the implementation of the socio-economic development strategy and the realization of the national priorities defined in the main areas of the economy. The role of the financial system in supporting the transition to a sustainable economy is exceptional. In this regard, in order to support the adaptation of the country's economy to sustainable development imperatives, the CBA has included the transformation of the financial sector into sustainable finance among its strategic priorities.

The main goal of the roadmap is to support the formation of a sustainable financial system that takes into account climate and environmental, as well as social and governance factors, and

ensure financial stability. Taking into account advanced international practices, the roadmap covers the integration of climate change and ESI criteria into the CBA's control framework, as well as the strategic decision-making and risk management processes of financial institutions, the formation of relevant market standards in this area, and the establishment of an ecosystem for sustainable financial instruments. Actions to be taken in this direction will cover all ESI factors, including climate changes and environmental risks. Although the main focus of this document is on financial stability risks caused by climate and environmental factors, measures to be taken on social and governance factors will also be covered by other relevant strategic programs of CBA. The wide-ranging action plan outlined will cover various segments of the financial sector, including banking, insurance and capital markets. A number of measures to be implemented by this document require coordination and cooperation with relevant stakeholders (state institutions, sector associations, international partners, etc.).

The main international initiatives towards sustainable finance, with a special emphasis on climate change and environmental risk regulation, include:

- Establishment of the Working Group on Sustainable Finance by the G20 to achieve the goals of the 2030 Agenda for Sustainable Development;
- Preparation of a document of principles on the effective management and control of climate-related financial risks by the Basel Committee on Banking Supervision;
- Preparation of a guideline document on the Green financial system by the World Bank for regulators and other organizations responsible for policy decisions;
- Formation of a number of regional and international platforms for the exchange of experience and provision of technical assistance on sustainable finance.

2.3. Market Size and Growth of Green Bonds

The fiscal system plays an important role in shaping the trajectory of the green economy by providing incentives and mechanisms that promote environmentally sustainable practices. In the context of evaluating green economy prospects, the fiscal system acts as a powerful tool to direct economic activities to environmentally friendly initiatives. One of the main tax incentives to develop a green economy is tax reduction for renewable energy projects. As highlighted by Gasimli et al. (2022), governments can create favorable conditions for the development of renewable energy sources by offering tax breaks to businesses and individuals investing in solar, wind, hydro and other sustainable energy projects. These reductions in taxes not only attract investment, but also

make renewable energy more competitive in the market. In addition to renewable energy, tax credits for sustainable practices provide an additional layer of financial incentive. Businesses that adopt environmentally friendly technologies, implement energy-saving measures or engage in environmentally sustainable activities can benefit from tax credits. This approach not only promotes environmental benefits, but also promotes a broader culture of corporate responsibility and sustainability. Thus, this approach aligns economic growth with environmental responsibility, promoting a more comprehensive approach to the green economy (Cato, 2009).

In the context of environmental sustainability, the participation of social communities plays an important role in the success of green initiatives. Beyond the technical aspects of implementing environmentally friendly projects, it is critical to measure public awareness, participation levels, and overall community support. The metrics embedded in the data systems provide insights into these qualitative dimensions, offering policymakers a theoretical-practical approach to how local populations perceive and engage with environmentally sustainable efforts. Such information is a direct tool for developing awareness sessions, solving public problems, and building cooperative relationships with communities. The main objective is to develop a sense of shared responsibility among the public, thereby increasing the likelihood of a smooth and universally accepted transition to a green economy.

Sustainable development requires not only environmental considerations, but also social equity. Assessing access to green resources through comprehensive metrics is important in this regard. These metrics should carefully examine how environmental benefits and challenges are distributed among different socioeconomic groups. By assessing social equity in the context of access to green resources, consideration should be given to addressing potential inequalities that may exist during the decision-making process. Thus, through this step, the advantages of the green economy are distributed among all segments of the society in an inclusive manner, and conditions are created for purposeful interventions to correct the imbalances.

The main international financial policy tool in the transition to a green economy is de-emission trading. Although emissions trading is mentioned in Article 17 of the Kyoto Protocol, it has been implemented in practice in various ways before the date of the Kyoto Protocol as a kind of policy instrument. A system based on the purchase and sale of pollution fees, known as "trading permits" in English, has been used as a financial instrument in the United States since 1977 (Pearce and Turner, 1990, 188; Özdemir, 2009). In fact, it can be emphasized that the argument put forward by Coase and known in the literature as "Coase theorem" is effective in the application of this tool,

which we can characterize as a kind of market mechanism. In his famous article "Social cost problem" published in 1960, Coase argued that environmental problems can be solved by identifying the users of environmental resources, that is, those who have the right to use them (Barzel and Kochin, 1992). This, in turn, is said to encourage the lowest cost reduction to achieve emission reductions as a condition of the transfer of property rights (Christiansen, 2001).

The adoption of measures at the national level to facilitate the fulfillment of the obligations of the countries that have signed the Kyoto Protocol, which regulates emissions trading and has entered into force in 2005, on the limitation and reduction of emissions, has created supportive flexibility mechanisms in this area. These mechanisms consist of the Clean Development Mechanism (CDM), Joint Implementation and Emissions Trading, and their main objectives are as follows (Özcağ and Hotunluoğlu, 2015):

- Promote sustainable development through technology transfer and investments;
- Reduce emissions in effective ways to achieve the countries' Kyoto targets;
- Encouraging the private sector and developing countries to contribute to emissions reduction efforts.

Along with mandatory instruments such as flexibility mechanisms regulated by the Kyoto protocol, projects and investments in various fields such as renewable energy thanks to voluntary carbon, energy efficiency, solid waste management, afforestation and greenhouse gas reduction have started to be developed (Özturk et al. , 2012, 308). Mandatory carbon markets under the Kyoto Protocol reached an economic size of $175 billion in 2011 after they came into effect in 2005. In addition to this economic measure achieved in 2011, 10.2 billion tons of carbon dioxide reduction permits were purchased and sold (Barlas, 2013).

The role of the fiscal system in assessing green economy prospects is multifaceted. This system includes tax credits, carbon pricing mechanisms and innovative financial instruments. These tools not only stimulate environmentally responsible behavior, but also contribute to the overall transition and sustainable economy. A well-designed financial system can be key to driving positive change and developing a green economy for generations to come. In addition, a comprehensive information system is essential for informed decision-making and effective policy implementation. Combining ecological, economic and social indicators, such a system provides a unified understanding of the complex interaction between human activity and the environment. As the world strives for a sustainable future, investing in advanced information infrastructure is a

strategic imperative for shaping policies that balance economic growth with environmental stewardship and social justice.

2.3.1. Investor Motivations for Supporting Green Bonds

Now, we will review the most popular funding sources available for green bonds and connect these sources to the most typical phases of company development that these investors usually participate in. Company management can save time and effort by concentrating exclusively on the most likely sources of funding during its development stage, as each source of capital has a stage at which it invests. Understanding the "dilution effects" of each round of cash on the company's current shareholders, including the founders and management, is just as important as being aware of the benefits for funding sources. Finally, it is critical to recognize that each investment source has investment limitations, certain expectations for returns, and different motivations that drive their financing choices.

For investors post-coronavirus has created countless options. However, each nation's standing in a number of crucial areas will determine how much it gains from this exciting new scenario. Here we present a summary of the European nations that are leading and lagging behind in the race to attract the biggest investments in this industry and attain the greatest number of successful new ventures. Our results also imply that broad scientific foundations are insufficient to offer an advantage in new venture formation.

Green bonds have emerged as a reliable and scalable fixed-income solution to help finance a radical transformation of the energy mix. Openness to participation, free dialogue and sharing of best practice make the green bond market one that governments and policymakers around the world are keen to promote.

The slowdown in 2022 was not unique to the green bond market either rising rates signaled a slowdown in the overall issuance of not only green bonds, but also conventional bonds.

Also note that this maturity gap narrows to 2022, making green bonds less vulnerable. It's really pure math. So with higher yields, bonds have become less sensitive to market movements and we have less duration for, say, a global green bond index. Additionally, we saw more emission at the shorter end of the curve.

In recent years, it has become more attractive for issuers to finance themselves at the long end of the curve because yields have been so low. It's different now. So we expect more and more emissions in the short and medium parts of the curve.

In general, the green bond index has a longer duration than the traditional ones – this bias is reduced given this new trend of shorter maturities for primary issues (https://www.im.natixis.com/intl/esg/markets-and-motivations-for-green-bonds).

Graph: 1

The graph 1 illustrates the performance of the S&P Green Bond Index for the one-year period concluding on December 13, 2024. The current value of the index is 130.07, reflecting a total return of 2.74 over the past year. The index value rose from roughly 126 in early January 2024 to 130.07 by December 2024. Beginning of 2024: The index exhibited an upward trend, reaching a peak in January before stabilising from February to April. Post-Peak Decline: Following September, the index exhibited a steady decrease, indicating possible market corrections or diminished demand for green bonds in the fourth quarter of 2024. A return of 2.74% can be regarded as moderate when compared to conventional corporate or government bonds. Green bonds typically exhibit marginally lower yields attributed to their "green premium," which represents the expense incurred by investors to endorse sustainable initiatives. This return indicates that green bonds continue to be viable and competitive within fixed-income markets. The positive return indicates sustained investor interest in green bonds as instruments for financing renewable energy initiatives and sustainable infrastructure. This supports the argument that green bonds increasingly align financial markets with sustainability objectives.

The S&P Green Bond Index recorded a return of 2.74% in 2024, indicating an increasing incorporation of sustainability within financial markets. The index demonstrates resilience and investor confidence in financing green projects, notwithstanding short-term volatility. This supports the function of green bonds in attaining global sustainability objectives and highlights their competitiveness within fixed-income markets. (S&P Green Bond Index)

2.4. Environmental Impact Assessment in Green Bond Issuance

Whether green bonds have measurable positive effects on the environment is a basic question. Two prerequisites would need to be met for this to happen: green bonds must fund environmentally beneficial initiatives, and issuers of green bonds must refrain from engaging in any other economically damaging activity (Climate Bonds Initiative, 2018).

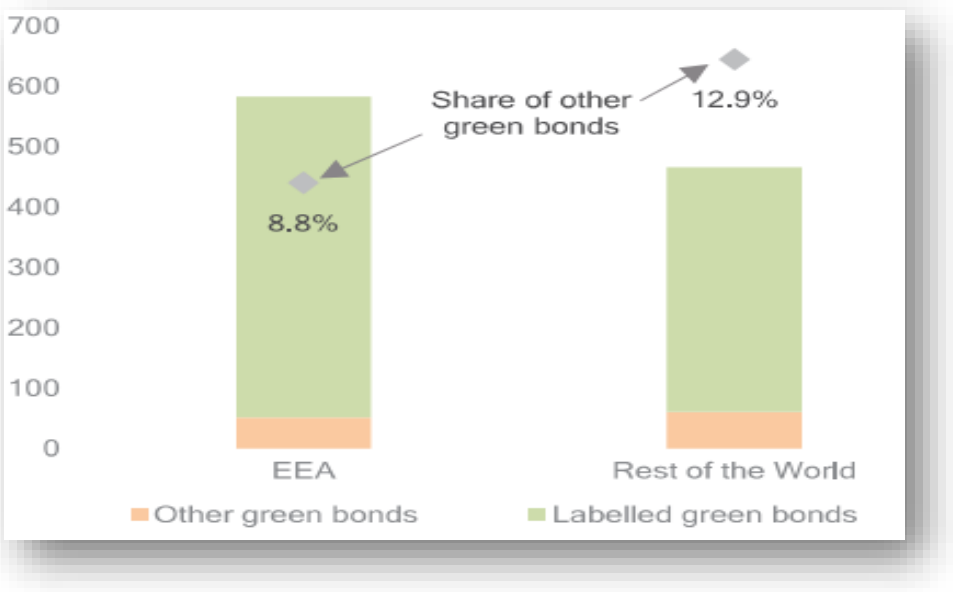
The development of industry standards, particularly the Climate Bond Standards and the Green Bond Principles, which have improved market standardisation and openness, was ultimately spurred by worries about "greenwashing" in the face of fast market expansion. These rules, which specified the types of projects acceptable for financing, were a first step towards ensuring that green bonds had a positive environmental impact, as 90% of the global green bond market used one of these two classifications. They received a really positive reception.

According to the Green Bond Principles, issuing a green bond involves four essential components (ICMA, 2018):

Use of proceeds: An explanation of how the proceeds are used, highlighting the differences between financing new projects and re-financing; attainment of anticipated environmental benefits and support for environmental goals

- Evaluation and selection process for the project: explains how the project fits into the eligible green project categories, eligibility requirements, and use of current standards or certifications; suggests assigning an agent to conduct an external review to verify compliance with the Principles for the project;
- Management of proceeds: Monitoring the net profits given to qualified green projects and the temporary placement of funds that have not yet been awarded; suggesting the employment of a third party (such as an auditor) for verification purposes;
- Reporting: Annual reporting on the allocation of funds until they are depleted, together with a list of projects and their anticipated effects; the inclusion of performance indicators is advised. (Fatica, S. and R. Panzica, 2021).

Fig 2.1. Global green bond market outstanding



Source: Climate Bonds Initiative, Refinitive EIKON ESMA

3. RENEWABLE ENERRGY PROJECTS AND THEIR FINANCING CHALLENGES

According to European academics, the green economy is directly linked to energy efficiency, the use of renewable energy, and sustainable production and consumption. It also improves people's well-being and generates new job opportunities.

It should be mentioned that the green economy can be characterised as either a new economic concept or as a significant addition of environmental and human elements to the fundamentals of the traditional economy.

The foundation of this new economic idea (green economy) is the realisation of the value of both people and nature, as well as the improvement of human well-being, poverty reduction, and the efficient and optimal use of finite natural resources.

There isn't yet a clear-cut, widely recognised definition of what the term "green economy" means. As a result, many nations develop distinct meanings according to their own circumstances.

Actually, in the current conditions, the understanding of the green economy, its scientific definition, and its socio-philosophical investigation differ in different countries with different approaches, which should be accepted as normal. Because the degree of socio-economic development of different countries is different. For example, there is a significant difference in terms of sustainable development between developed countries (DCs), developing countries (DCs)

and newly industrialized countries (NICs). These differences are also reflected in the level of green economy of the respective countries and the steps taken in this direction. Thus, it is evident from a philosophical-sociological summary of the aforementioned that the green economy, which serves as the primary pillar of the socio-economic and ecological domains, is the basis for sustainable development.

3.1- Financing Models and Structures

Green bonds, designed to finance projects with environmental benefits, have proven effective in driving investments into renewable energy projects. The financing models and structures of green bonds play a crucial role in their success. Here are key aspects of these models and structures:

- Standard Green Bonds. Standard green bonds operate like traditional bonds but are specifically earmarked for green projects. Issuers raise capital from investors and commit to using the proceeds exclusively for environmentally sustainable activities. This model relies on the credibility of the issuer and transparency in reporting the use of funds.
- Green Revenue Bonds. Green revenue bonds are backed by the revenue generated from the green project itself. For renewable energy projects, this typically involves revenue from the sale of electricity generated by wind farms, solar panels, or other renewable sources. This model ties the bond's repayment directly to the project's financial success, aligning investors' interests with the performance of the renewable energy project.
- Green Securitization. Green securitization involves pooling together various green assets, such as loans for renewable energy installations, and issuing securities backed by these assets. This structure allows for diversification of risk and can attract a broader range of investors by offering varying risk-return profiles. It also helps in scaling up the financing available for smaller renewable energy projects.
- Green Covered Bonds. Green covered bonds are debt securities backed by a pool of green assets. These bonds offer dual recourse to investors: they have claims on both the issuing entity and the underlying pool of assets. This structure provides additional security to investors and can help in achieving lower financing costs for renewable energy projects.
- Sovereign and Sub-Sovereign Green Bonds. Governments at national and local levels can issue green bonds to finance large-scale renewable energy projects. Sovereign green bonds benefit from the creditworthiness of the issuing government, often resulting in lower

interest rates. These bonds can drive significant investment into national renewable energy initiatives and infrastructure.

- Corporate Green Bonds. Corporations, particularly those in the energy sector, can issue green bonds to finance their renewable energy projects. Corporate green bonds allow companies to demonstrate their commitment to sustainability, potentially enhancing their brand value and attracting environmentally conscious investors.
- Development Finance Institution (DFI) Green Bonds. DFIs issue green bonds to fund renewable energy projects in developing countries. These institutions, such as the World Bank or regional development banks, use their strong credit ratings to mobilize capital for high-impact projects. This model is particularly effective in regions where local financing options are limited.

Effectiveness Measures:

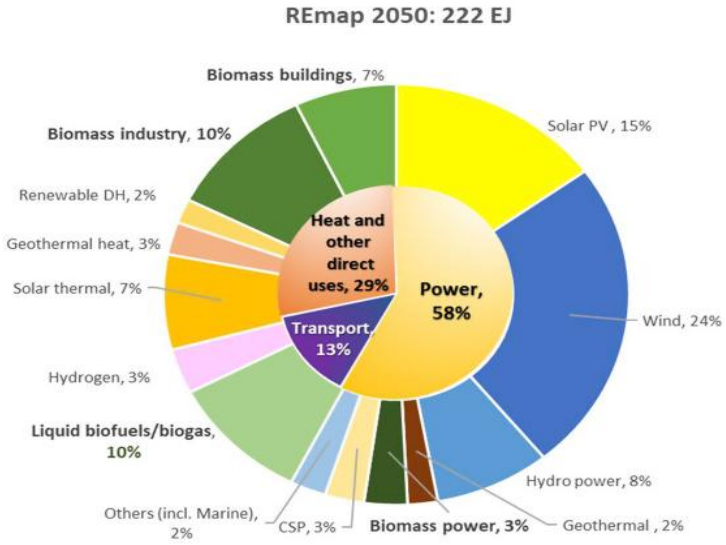
- Environmental Impact Reporting: Green bonds should include robust frameworks for measuring and reporting the environmental impact of the projects they finance. This includes metrics such as CO2 emissions reduced, renewable energy capacity installed, and other ecological benefits.
- Financial Performance Metrics: Evaluating the financial performance involves assessing the return on investment, cost-effectiveness, and risk-adjusted returns of the green bonds compared to traditional bonds. Effective green bonds should demonstrate that investing in renewable energy can be financially viable and attractive.
- Transparency and Certification: Adherence to standards such as the Green Bond Principles or the Climate Bonds Standard ensures transparency and accountability. Third-party verification and certification can enhance investor confidence and trust in the green bond market.
- Long-Term Sustainability: Assessing the durability and operational efficiency of funded renewable energy projects over their lifespans is essential. Projects must be resilient to changing environmental conditions and adaptable to technological advancements to maintain their effectiveness.
- Social and Economic Impact: Beyond environmental benefits, green bonds should be evaluated for their social and economic impacts, such as job creation, energy access improvement, and local economic development.

The financing models and structures of green bonds are integral to their effectiveness in funding renewable energy projects. By leveraging diverse structures such as green revenue bonds, securitization, and sovereign green bonds, the green bond market can attract a wide range of investors and mobilize significant capital. Rigorous impact measurement, financial performance assessment, and adherence to transparency standards are essential for ensuring that green bonds not only support the transition to renewable energy but also provide attractive returns and contribute to broader sustainable development goals.

3.2- Effectiveness measures for sustainable finance

Effectiveness measures for sustainable finance through Green Bonds encompass a comprehensive evaluation framework, ensuring that these financial instruments fulfill their role in promoting renewable energy projects and fostering a transition towards a low-carbon economy; such measures span various dimensions including environmental impact, financial performance, transparency, social benefits, and long-term sustainability. Firstly, environmental impact metrics such as greenhouse gas emissions reduction, renewable energy capacity installed, and energy generation provide quantifiable indicators of the ecological benefits derived from investments made through Green Bonds, showcasing their contribution to mitigating climate change and advancing environmental sustainability. Secondly, financial performance indicators such as return on investment, cost of capital, and risk-adjusted returns gauge the economic viability and attractiveness of Green Bonds to investors, demonstrating that sustainable investments can generate competitive financial returns. Thirdly, transparency and reporting standards ensure accountability and build investor confidence by requiring adherence to frameworks like the Green Bond Principles and providing regular, transparent reporting on fund allocation and project progress. Additionally, social impact metrics including job creation, energy access improvement, and community development highlight the broader societal benefits derived from Green Bond-funded projects, contributing to inclusive growth and poverty alleviation. Finally, long-term sustainability measures such as project lifespan, maintenance efficiency, and resilience to environmental changes ensure that Green Bonds support enduring, impactful solutions that address current and future environmental challenges, thereby promoting sustainable development and environmental stewardship on a global scale.

Fig. 3.4. Breakdown of renewables use in total final energy consumption terms, REmap 2050.



Various methods, policies and models have been developed and are widely used around the world to increase electricity generation from renewable energy. These methods, policies and models; They are classified under three main headings: regulatory models, business models, financial incentives and other public supports, and are detailed in Table 3.1.

Table 3.1 Investment and financing models

Investment and financing models	Submodels
A-Regulatory models	Fixed price guarantee
	Premium warranty
	Green certificate
	Bidding and auction
	Design based on counter measurement
B- Business models	Project financing
	Third Party Property
	Energy cooperative
	Equity-based crowdfunding
	Green garden
	Renewable energy fund
	Reduction of investment and production taxes
	Tax deduction from the sale of electricity

C- Financial incentives and other public support	Direct payment for electricity production
	Loans, grants, subsidies and discounts

Investment and production tax deductions, electricity sales tax deductions, direct payments for electricity production, loans, grants, subsidies and concessions on various issues are included in the scope of financial incentives and other government support. In this context, applications are generally implemented to support regulatory models and business models. Per regulatory models; It can be explored under five subheadings: fixed price guarantee, premium guarantee, green certification, tender and auction, and meter-based design. Models in this area can be applied single or multiple models simultaneously, depending on factors such as the type of renewable energy source, technology and installed capacity. Business models can be explored under six subheadings: project finance, third-party ownership, energy cooperative, equity-based crowdfunding, green bond, and renewable energy fund (Comello, Reichelstein, 2017).

It is not possible to draw general conclusions about the intensity of use of the above-mentioned models on a global or regional basis. It is seen that changes are made in the applied models over time, taking into account the developments in the market and economic conditions. The performance of the preferred model and the conditions within it may require changes to the models and/or the introduction of a new model. Investment and financing models applied in some selected countries are listed in Table 3.2.

Table 3.2. Investment and financing models by country

Countries	Fixed price guarantee	Premium guarantee	green certificate	tender	Model based on meter measurement
Germany	✓	✓		✓	✓
Chinese	✓		✓		
USA					
California	✓				✓
New York					✓
Slovakia	✓				
Sweden			✓		
Ireland	✓				
France	✓			✓	

Australia			✓		✓
Japan	✓				
Türkiye	✓			✓	✓

Source: Akdağ and Gözen (2019)

As can be seen from Table 3.2, it is understood that the models have a wide application area. While these models can be applied alone, it is also possible to apply more than one model together. Even more than one model can be used for the same renewable energy source. For this purpose, firstly large and small scale production facilities are defined and different models can be applied for both groups (Gözen, & Durak, 2003).

Large capital expenditures are needed for the planning and design of such projects, the purchase and installation of equipment, and the hiring or training of staff to run and maintain the established systems. This is particularly true for modern technology like geothermal power plants.

Table 3.3. Financial institutions providing loans for renewable energy projects.

Financial institutions	Short description
Commercial banks	Commercial banks usually adjust interest rates and payback periods according to market conditions. They are more accessible than foreign banking and governmental entities.
International or development banks	The World Bank, the Inter-American Development Bank (IDB), the European Bank for Reconstruction and Development (EBRD), and others offer investment loans with better terms than the average for commercial banks. These financial institutions do not always operate independently; occasionally, they merge with other banks (syndicated loans). They can offer reliable collateral, reducing project risk and making it possible to use other finance sources. Some of these organisations focus on a specific field.

State banks	State banks typically make a comprehensive investigation of the borrowing company's financial performance and place strict criteria on projects. Strategic energy initiatives are actively financed by these financial institutions.
Investment banks/mutual funds	By participating in equity capital (also known as equity investors), these financial institutions are able to finance large scale of renewable energy projects.

3.3. Market Risks

Traditional strategies used by companies focused on capital investment and customer service. Organizations have tried not to take on unknown market risks, but the acceleration of change requires a shift from conservative approaches to strategy development as the energy sector fails to position itself effectively. In today's environment, strategies must be focused, aggressive and consistent.

External factors have a major impact on the strategies of companies in the electricity industry, as they must be in line with policies implemented at the national or regional level. For example, in Europe the focus is on decarbonisation, energy security and affordability. North America focuses on serving foreign supply markets, energy security and affordability while protecting the domestic market. In the Asia-Pacific region, policies are aimed at addressing increasing urban pollution while supporting industrial growth.

3.4 Key Milestones in Azerbaijan’s Green Energy Transition

The transition risk arising from global decarbonization calls and its impact on Azerbaijan's economy and financial system will be inevitable in the long term. Given the global challenges of low carbon and decarbonization, Azerbaijan's commitment to achieving greenhouse gas reduction goals will both support sustainable development and create an important foundation for accelerating the transition to a non-oil economy (Ibikunle, Steffen, 2015: 337–355).

The financial system needs a road map to manage the risks arising from climate and ESI factors and to realize the available opportunities. At present, measures to apply sustainable and

green finance in the financial system of Azerbaijan are not systematically implemented. The financial sector's awareness of sustainable finance is not at an adequate level, there is no regulatory and legal framework for sustainable finance, classification of sustainable activities, sustainable financial instruments and mechanisms for promoting the development of these instruments, as well as the risk system. In this regard, it is considered necessary to prepare an appropriate road map for the development of sustainable finance (chromeextension://efaidnbmnnibpcajpcglclefindmkaj/https://uploads.cbar.az/assets/dc1546b51b6aa6b3d92409836.pdf).

Therefore, the technical potential for renewable energy sources in Azerbaijan is 157 GW at sea and 135 GW on land. The estimated economic potential of renewable energy sources is 27 GW, which includes 3,000 MW of wind energy, 23,000 MW of solar energy, 380 MW of biofuel potential, and 520 MW of mountain river potential (Johansson, D. and Lundgren, 2012).

In 2023, 29.3 billion kWh of electricity were produced in the republic. During this time, SPPs produced 1757.2 million kWh of power, while other sources (KES, GES, and BMTYZ) produced 359 million. Throughout the year, wind power plants generated 56.6 million kWh. 79.4 million kWh from solar installations. The Solid Household Waste Incineration Plant has 223 million kWh. The amount of electricity generated was kWh. Approximately 7% of the total electricity produced came from renewable energy sources.

Moreover, various studies are currently underway to evaluate the feasibility of generating electricity from renewable energy sources and to outline the necessary steps and regulations required to fully harness this potential. Eight regions have been identified to assess and rank their potential for renewable energy sources. Important strides are already being made towards implementing pilot projects in three chosen areas. Plans are in place to develop projects that will distribute electricity generation capabilities from renewable energy sources, utilize land deemed unsuitable for agriculture, and tap into the solar energy potential available nationwide, while contrasting with wind energy initiatives. The procedure for employing auctions to acquire specific prioritized renewable energy sources in high-potential regions is still ongoing. The project titled "Support for Holding Renewable Energy Auctions in Azerbaijan" (EBRD) is actively being pursued by the European Bank for Reconstruction and Development. Within this project, details regarding the terms and conditions of the auction will be provided, along with the establishment of qualifying documents, invitations for bids, and agreements for the purchase and sale of power. Resolution No. 470 from the Cabinet of Ministers of the Republic of Azerbaijan, dated December

25, 2023, has designated a 300.77-hectare parcel of land in the Pirsaat settlement of the Garadagh region for the development of a hydroelectric power plant.

In order to attract private and foreign investments in the field and to create new production capacities, the President of the Republic of Azerbaijan's order "On the acceleration of reforms in the energy sector of the Republic of Azerbaijan" dated May 29, 2019 No. 1209, established a "roadmap for the development of offshore wind energy in Azerbaijan" with the International Finance Corporation, a division of the Banki Group. In this regard, the "Memorandum of Understanding on cooperation in the field of using offshore wind energy between the Ministry of Energy of the Republic of Azerbaijan and the World Bank Group" was approved. The projects envisaged under the Memorandum of Understanding are based on the "Offshore Wind Energy Development Program" of the IFC.

In the Azerbaijani part of the Caspian Sea, the total technical potential of wind energy was 157 GW, according to the preliminary investigation (125 GW in deep water basins and 35 GW in shallow water basins). Support is also provided within the project's structure, which includes implementing auxiliary investments, partnering with the private sector, and luring investors to related maritime projects. Effective use of the sea's potential will strengthen the economy of the country and create new job opportunities.

On December 15, 2022, the Ministry of Energy and Fortescue Future Industries (FFI) from Australia entered into a Framework Agreement to collaborate on the research and development of renewable energy initiatives and the prospects of "green hydrogen" in Azerbaijan. This agreement encompasses the planning and execution of renewable energy and "green hydrogen" projects in Azerbaijan with a total potential capacity of 12 GW.

On May 3, 2021, President Ilham Aliyev issued a decree entitled "On measures related to the establishment of the 'Green Energy Zone' in the liberated territories of the Republic of Azerbaijan." The Ministry of Energy and the Japanese firm "TEPSCO" signed a contract to engage a specialized international consulting company to address the objectives stemming from the decree and to develop the concept for the creation of the "Green Energy Zone" in the reclaimed areas. Consequently, a Concept document outlining the establishment of the "Green Energy Zone" was completed as part of the tasks outlined in the agreement. To implement part 3 of President of the Republic of Azerbaijan's Order No. 2620, dated May 3, 2021, regarding the creation of a "green energy" zone in the liberated territories, the Cabinet of Ministers of Azerbaijan endorsed the "Action Plan for the establishment of a 'green energy' zone in the liberated territories of the

Republic of Azerbaijan in 2022-2026" on June 21, 2022, through Decree No. 357s. On August 3, 2022, the Cabinet of Ministers of Azerbaijan established the "Working group on coordination and monitoring of the application of green technologies and energy efficiency requirements in the liberated territories of the Republic of Azerbaijan" via Order No. 459s. To deliberate on the responsibilities outlined in the "Action Plan for the establishment of a 'green energy' zone in the liberated territories of the Republic of Azerbaijan in 2022-2026," the sub-working group's Working Group and the Working Group regularly conduct discussions related to the implementation of the "green energy" zone in the reclaimed territories. Based on the "Monitoring Execution Schedule" approved by the Working Group meeting to assess projects planned or executed in the territories liberated from occupation regarding the adoption of green technologies and energy efficiency initiatives, monitoring has been ongoing in these areas since June 2023.

On December 22, 2022, the Ministry of Energy and the European Bank for Reconstruction and Development (EBRD) signed a Memorandum of Understanding to provide technical support for the growth of the electric power sector in the Republic of Azerbaijan. The purpose of this memorandum is to facilitate the progress of our nation's low-carbon electric energy sector by promoting renewable energy, improving the infrastructure, enhancing energy efficiency, minimizing methane emissions, and collaborating on the gradual exploration and application of innovative technologies such as "green hydrogen." In this partnership, the World Bank will assist the consulting firm "CESI" in executing the project titled "Technical assistance to increase the share of renewable energy in the electrical energy system of Azerbaijan." This framework includes the development of a strategy for decarbonizing the energy sector, as well as recommendations for pertinent legislation and technological advancements. (https://minenergy.gov.az/az/alternativ-ve-berpa-olunan-enerji/azerbaycanda-berpa-olunan-enerji-menbelerinden-istifade).

The "State Program for the Socio-Economic Development of the Nakhchivan Autonomous Republic for 2023-2027" Detailed Action Plan for 2023-2024 envisions the formation of a "Green Energy Zone" as well as the development of a Concept and Action Plan. For the construction of renewable energy projects in Nakhchivan, contracts were signed with companies "Nobel Energy Management," "TotalEnergies," and "A-Z Czech Engineering" for green energy projects with a combined capacity of more than 1000 MW. (https://minenergy.gov.az/az/alternativ-ve-berpa-olunan-enerji/azerbaycanda-berpa-olunan-enerji-menbelerinden-istifade).

The existence of major market barriers and the perception of the possibility of high risk prevent the financing of projects in the field of renewable energy sources in Azerbaijan. Dedicated

credit lines for investments in energy efficiency and renewable energy sources are limited and market involvement is not large. Potential projects lead to a lack of primary and secondary legislation, as well as preventing sufficient awareness of the benefits of renewable energy sources.

While measures have recently been taken to align the regulation of the banking sector with international standards, projects in the field of renewable energy sources continue to face problems in terms of access to capital in Azerbaijan due to the lack of liquidity in the local banking system and the presence of high interest rates reaching 30% per annum in the local currency. Collateral requirements from local banks are strict and local financing of renewables is very expensive compared to more developed markets.

President Ilham Aliyev's strong socioeconomic and political accomplishments ensure that our nation's power will grow much more in the years to come. These prospects ensure that our Republic's economic sovereignty will be strengthened and that, by 2030, it will have developed into a strong state with a high social welfare society founded on contemporary living standards. To further improve the welfare of its citizens, the state of Azerbaijan has decided to pursue the development of a socially orientated market economy.

New "driving forces" must be found for sustainable economic growth, deep diversification of the national economy, and full realization of export potential for goods and services. Although the oil sector is one of the pillars of socio-economic development, the non-oil economy should become the center of development.

It should be mentioned that the ideas of "Smart city" and "Smart village" are intended to be applied in the areas that have been liberated from occupation. In addition to improving the Karabakh region's appeal as a hub for technical innovation and startups, the implementation of "Smart Village" technology will foster the growth of social innovations and small business ventures in those areas. We may observe that the "Smart village" project was first implemented in the Third Agali village of Zangilan district on the directive of President Ilham Aliyev, the Supreme Commander of the Republic of Azerbaijan. Five primary components will be used to carry out the "Smart Village" project. Alternative energy, social services, housing, production, and "smart agriculture" will all be covered in this initiative. Only alternative energy sources will be used to meet the village's energy needs, which will include 200 newly constructed homes.

The use of renewable and alternative energy sources is modern, innovative, and environmentally friendly technology, as President Ilham Aliyev stated: "This is our vision of the future." There is reason to believe that the idea of "green energy" will have a beneficial impact on

the completion of the tasks assigned, given the country's strategy of employing renewable and alternative energy sources. In the areas devastated by the Armenian occupation, considerable restoration work has begun based on the idea of building using the newest technologies.

To put it briefly, the restoration of Azerbaijan's territorial integrity has given our nation fresh opportunities to undertake construction and restoration projects. Together with friendly and fraternal nations, our people will effectively accomplish this significant objective [https://philosophy.edu.az/index.php?newsid=1431].

With 50% of the nation's GDP coming from the energy sector, it is the largest economic sector and plays a crucial role in the economy. The effective management of the ensuing revenue streams and the successful exploitation of natural gas and oil resources are key factors in economic growth. By creating new, large-scale projects and fixing old machinery, foreign direct investment has revitalised the nation's oil industry, despite the State Oil Company of the Republic of Azerbaijan's (SOCAR) declining output.

Azerbaijan has been selected to serve as the host nation for the 29th Conference of the Parties (COP29), which will take place in Baku in November. Baku Stadium, which has a track record of successfully hosting international events, has been chosen to host COP29 in Azerbaijan.

Making the most of its renewable energy potential is a crucial part of Azerbaijan's plan to reduce greenhouse gas emissions by 40% by 2050. The country intends to diversify its current energy infrastructure and increase the share of renewable electricity to 30% by 2030 in order to become a leader in green energy. In its next Nationally Determined Contribution, which is aligned with the 1.5 standard, Azerbaijan will update its national goals as part of its pledge to set an example.

The potential for wind energy in Azerbaijan is enormous, with both onshore and offshore resources offering substantial chances for the production of sustainable electricity. The nation has a remarkable 157 GW of offshore wind technological capability in addition to 3 GW of onshore wind commercial potential. With noteworthy projects now under way in collaboration with businesses like Masdar and ACWA Power, significant progress has already been achieved in realising this promise. Approximately 10% of the nation's yearly domestic electricity generation comes from hydropower. Since the Karabakh and East Zangazur regions contain about 25% of the nation's freshwater resources, hydropower is essential to reaching the 2050 Net Zero goal in

these Green Energy Zones. With an astounding installed capacity of 424 MW, the Mingachevir Hydroelectric Power Plant is the jewel in the crown of Azerbaijan's hydroelectric infrastructure. The economic potential of solar energy in Azerbaijan is 23 GW. Due to its excellent environment, which includes 2,400–3,200 hours of sunshine each year, Azerbaijan has a lot of potential for producing solar energy. The 230 MW Garadagh Solar PV Plant was opened in October 2024. The nation is continuing to sign agreements with parties interested in its solar energy, and a number of other initiatives are under progress. Azerbaijan is collaborating with governmental and private sector partners, such as companies and multilateral development banks, who are key players in the COP29 negotiations, as it grows its solar energy infrastructure (https://cop29.az/en/conference/what-is-cop29).

4. Analysis and the Results

4.1. Overview of dataset

Market turbulence and contagion are currently caused by the interconnectedness of global financial markets and the co-movement of trading stages. In addition to reminding investors of the importance of portfolio diversification, the global financial crisis of 2008 reinforced financial markets that at first seemed to be unrelated to one another. Investors can also benefit from a specific risk-return trade-off thanks to their broad portfolios of international financial assets. However, globalisation has led to the emergence of high rates of interconnected situations such as financial market volatility, spillover, and causation (Le, Abakah, and Tiwari, 2020: 1). As the financial markets become more interconnected and complex, investors are starting to gravitate towards new and varied products. One of the main goals for government organisations and environmental experts is to create a low-carbon economic structure that is less harmful to the environment and climate. This has led to the creation of several programs, including funding green projects (Naeem, Adekoya, and Oliyide, 2021: 1). Green bonds are considered the most important financial instrument for financing green projects. (Naeem and others, 2021:1).

In addition to addressing climate change adaptation and mitigation, green bonds also address other environmental issues such as biodiversity loss, natural resource depletion, and soil, water, and air pollution. (SBN, 2018: 3) Sustainable Banking Network. In 2007, the European Investment Bank introduced green bonds as a means of financing prospective environmentally

conscious businesses. It is a financial product that was created specifically to supply debt market capital for green projects that put climate protection first. These are usually supported by the balance sheet of the issuing company as well as a financial asset. As a result, their credit rating frequently matches those of the other debts owed to its issuers. Green bonds often have the status of a bond issued for objectives that support sustainability, climate adaptation, and the mitigation or mitigation of climate change. (Leirvik and Antoniuk, 2021: 1). The creation of thematic bond markets has been made possible by investors' desire for bonds with a variety of instruments and uses, in addition to standard bond markets.

Green bonds are a well-known sustainable investment vehicle that is gaining popularity among environmentally conscious investors as well as those who see the great potential that governments' plans to address climate change and the risks that go along with it hold for businesses. Within the scope of the commitment made by many countries in the 2015 Paris Climate Agreement, creating a global unity for the transition to a climate-resilient economic order, the green bond market has become a market for many international issuers and investment funds, pension funds, insurance institutions, small and medium-sized institutions and individuals. It is expected to develop rapidly by attracting the attention of a wide range of investors, including investors. Stock exchanges of many countries such as Italy, England, Mexico and China have created specific green bond market segments in order to contribute to the green bond market. These created market segments will contribute to increasing the liquidity, transparency and reputation of green bonds as a step in growing the financial resources required to green the world economy (Reboredo, 2018: 38-39).

Research on green bond markets is growing and concentrating on specific topics. Few studies have been conducted on the interactions between specific markets, despite the fact that there are studies on causality, volatility, and market interaction. State-issued bonds are one example. The relationship between the long-standing country bond market and the green bond market is also regarded as significant. Government bonds are used by states to fund their operations, and investors can profit from investing in low-risk country bonds. Bond interest rates are automatically set based on the market's supply and demand balance. Depending on various market developments, interest rates might go either higher or downward. In this sense, investors who are worried about climate change are drawn to the green bond market, which is seen of being modern. Therefore, establishing a causal relationship between the country bond and green bond markets becomes essential.

Nanayakkara and Colombage (2019), in their study examining the price differences of green bonds and conventional bonds in capital markets around the world with daily observations from 2016-2017, found that green bonds are traded at a premium of 63 basis points compared to a comparable corporate bond issue.

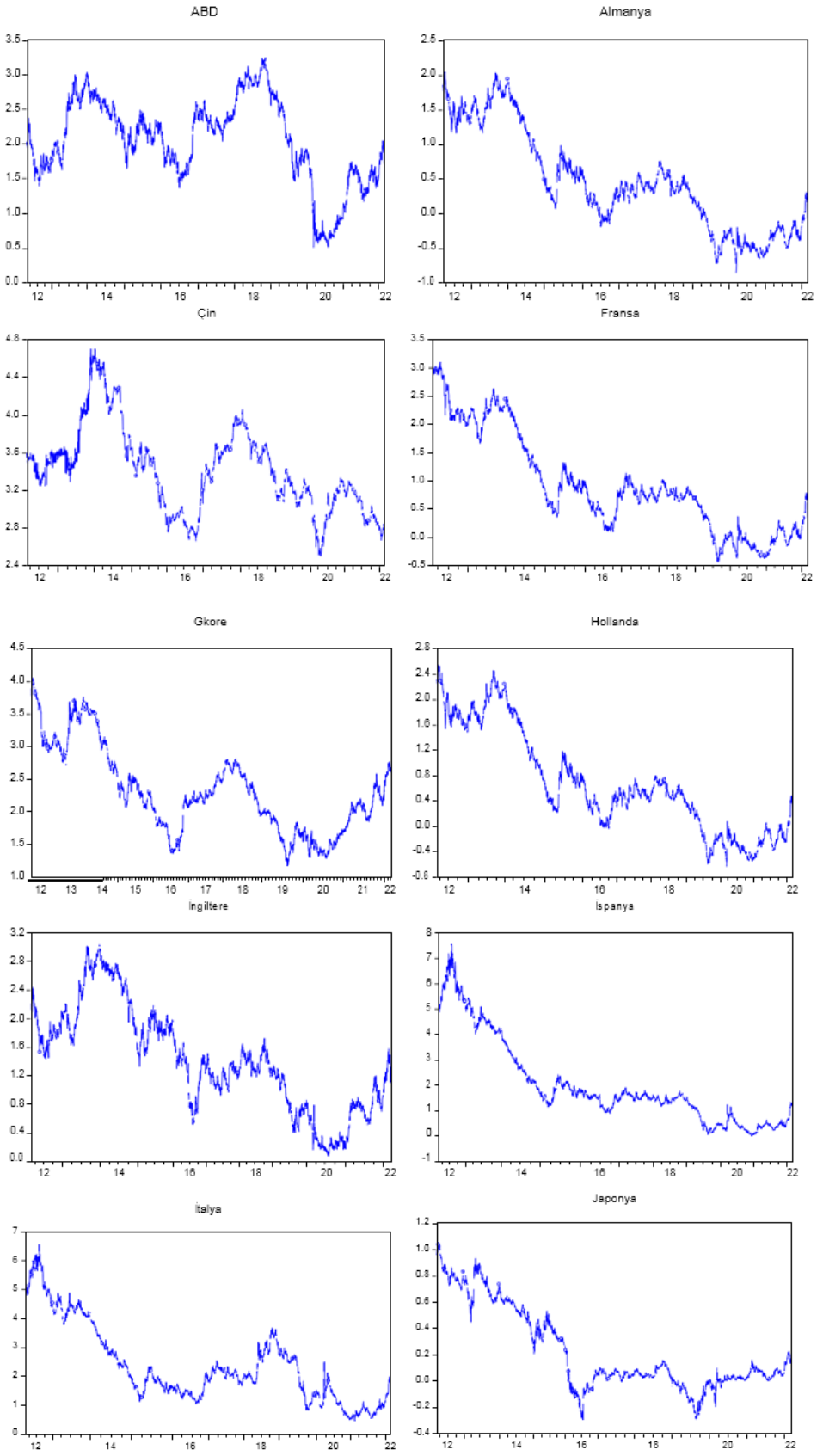
Zerbib (2019) found that the yield of a green bond is lower than the yield of a conventional bond in his study comparing the yield of green bonds with equivalent synthetic non-green bonds using the matching method from bonds issued from July 2013 to December 2017. In addition, it was concluded that the premium is -2 basis points on average for all sample and individual Euro and Dollar bonds, and this negative premium is more significant for financial and low-grade bonds.

Gao, Li and Wang (2021), in their study, which investigated the dynamic return and volatility spreads with the multidimensional DCC-GJRGARCH model along with the net connectivity analysis between China's green bonds and the main financial markets, bidirectionally between the green bond market and the conventional bond markets; have determined that there are significant one-way risk spreads from the green bond market, stock and commodity markets. In the results of white connectivity analysis, they came to the conclusion that it provides specific information about connectivity and power in different sub-periods corresponding to financial events.

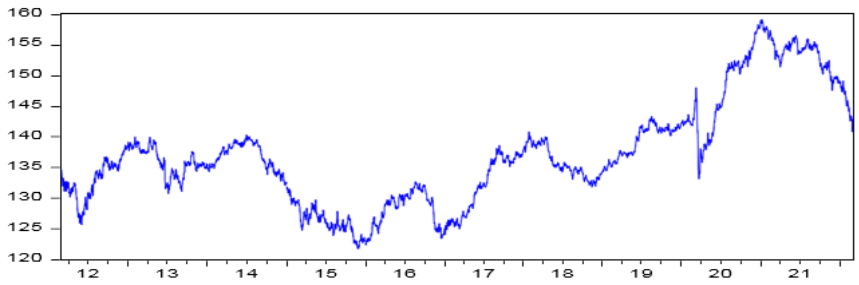
Liu et al. (2021), in their study of the dynamic dependence structure between green bonds and various global and sectoral clean energy markets between July 5, 2011 and February 24, 2020, found that there is a time-varying positive mean and tail dependence between green bonds and clean energy stock markets, and clean found that extreme downward and upward movements in energy stock markets have a spillover effect on the green bond market. They also determined that the risk spread between the markets is asymmetric.

Nguyen et al. (2021), in their study of the correlation between green bonds and other asset markets including stocks, commodities, clean energy and conventional bonds between 2008 and 2019, found that the correlation between stocks, commodities and clean energy is relatively high; have revealed that the diversification benefit is important due to the low or negative correlation of green bonds with stocks and commodities (Liu, N., Liu, C., Da, B., Zhang, T. ve Guan, F. (2021)1-12). The daily graphs of the series used in the analysis are shown below.

Fig 4.1. Daily Values of Green Bonds and Government Bonds



S&P Green Bond Index



As can be seen in the graphs, it is observed that there is mostly a downward trend in the country's government bonds from the start of the data, and after 2020, there is an increase in interest rates, which can indicate that a large increase trend has been entered. It is known that during economic crises, natural disasters or any epidemic that can affect the world, the country's bond interest tends to rise. This situation can be seen in the study, and during the 2020 Covid-19 epidemic, the increase in demand for government bonds, which investors see as a safe harbor, increases bond interest rates. The most important reason for this is that investors see government bonds as a risk-free return tool and think that the probability of countries not being able to pay their debts is almost zero compared to companies. When it comes to situations of confusion or uncertainty in the financial markets, the first markets that individual and institutional investors think of turning to are the government bonds market. Looking at the S&P Green bond index, it can be said that it has entered a rising trend since the beginning of 2017, when it was in a certain fluctuation range until 2017. Since then, the concept of green bonds has started to take root in the market, and the increase in the demand of investors has revealed a significant increase in prices. As investors who want to diversify their portfolios started to turn to this area, the market volume and price dynamics started to increase. After reaching its peak at the end of 2020, a downward trend in the index value has started to emerge as a result of situations such as the increase in uncertainty in the global markets, postponement of some investments by companies, and the emergence of fund needs of companies

The practical stage of the work is to evaluate and compare the performance of green bonds and corporate bonds using statistical tools. The objective is to evaluate their financial returns, market uptake, and relevance by utilizing a combination of data-driven methodologies and a case study that is based on real-world scenarios. This chapter offers a comprehensive knowledge of the differences and similarities that exist between these two types of bonds by concentrating on statistical analysis and providing examples from real-world situations. The financial metrics used for comparison include **Return on Investment (ROI)** and **Yield to**

Maturity (YTM). ROI measures the profitability of an investment and serves as an essential metric for bond investors. Yield to Maturity (YTM) provides a comprehensive measure of a bond's annualized return if held to maturity. To contextualize the statistical findings, this chapter includes a case study comparing a green bond and a corporate bond issued by the same company.

Data from 2024 were utilized in order to carry out the investigation. We obtained the information from a variety of sources, including:

1) The Stock Exchange of London;

2) The securities exchange of Luxembourg;

3) Official website of Volkswagen Group;

4) The Nasdaq.

The dataset contains a total of forty bonds, with twenty of them being green bonds and twenty being corporate bonds. The bonds differ in current prices, par values, and maturities. The selection of green bonds was based on their compatibility with the objectives of environmental sustainability, whilst the selection of corporate bonds was made to illustrate typical investments that do not have a particular focus on sustainability. The most important metrics for each bond, including Return on Investment (ROI) and Yield to Maturity (YTM), were computed and presented in the table 4.1 below. Appendix A contains a detailed list of the bonds that were investigated in this study. The method for calculating return on investment that was utilized for this analysis is as follows:

$$ROI(\%)=((\text{Coupon Payment}\times\text{Par Value})+(\text{Par Value}-\text{Price}))/\text{Price}\times 100$$

Where:

- Coupon Payment refers to the bond's annual interest income that is received from the bond.
- A bond's par value, also known as its face value, is the amount that is normally reimbursed when the bond matures.
- The price at which the bond was purchased or its current worth on the market.

In the descriptive statistics part the dataset provides key financial metrics—Return on Investment (ROI) and Yield to Maturity (YTM)—for both green bonds and corporate bonds. By analyzing the mean, median, and standard deviation of these metrics, we can gain insights into the performance and variability of each bond type. Also an independent t-test was performed to compare the means of ROI and YTM for green and corporate bonds.

Through the examination of the bond performance of a particular issuer, the case study brought the conclusions into the realm of real-world significance.

While using this approach…

- Selected five green and five corporate bonds issued by Volkswagen Financial Services AG.
- Evaluated ROI, YTM, and other financial metrics for these bonds.
- Compared performance indicators to illustrate practical implications of the statistical findings.

Table: 4.1

Type	Coupon	Price	Par value	ROI %	YTM %
Green Bonds	3,85%	101	100	2,74	3,8
Green Bonds	3,31%	99	100	3,96	3,4
Green Bonds	2,50%	100	100	2,62	2,5
Green Bonds	2,50%	100	100	2,78	2,7
Green Bonds	4,00%	100	100	4,00	4,0
Green Bonds	2,63%	100	100	2,82	2,7
Green Bonds	4,00%	100	100	3,54	3,9
Green Bonds	4,25%	101	100	3,70	4,1
Green Bonds	3,49%	100	100	3,49	3,5
Green Bonds	2,50%	100	100	2,65	2,6
Green Bonds	3,63%	100	100	3,73	3,6
Green Bonds	3,75%	100	100	3,75	3,7
Green Bonds	3,50%	100	100	3,50	3,5

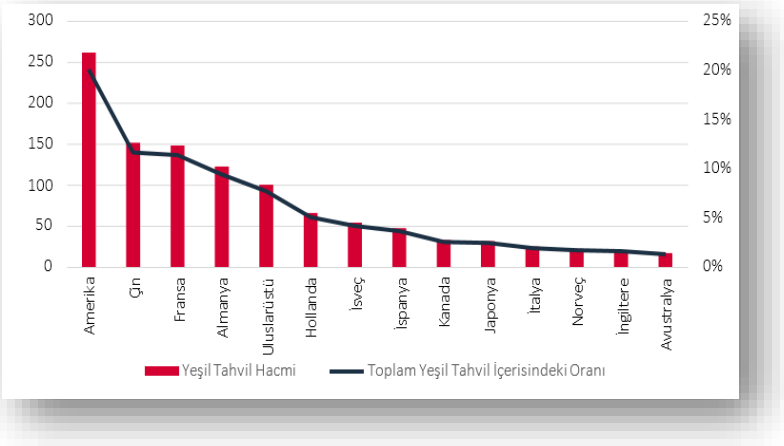
Green Bonds	3,08%	100	100	2,74	2,8
Green Bonds	3,73%	100	100	3,40	3,6
Green Bonds	2,63%	100	100	2,54	2,5
Green Bonds	3,15%	100	100	3,15	3,1
Green Bonds	2,71%	100	100	3,07	2,7
Green Bonds	4,00%	100	100	4,00	4,0
Green Bonds	3,70%	100	100	3,39	3,7
Corporate Bonds	4,50%	98	100	6,22	5,1
Corporate Bonds	5,75%	101	100	4,21	4,6
Corporate Bonds	5,75%	104	100	2,09	4,6
Corporate Bonds	5,00%	100	100	6,00	6,4
Corporate Bonds	5,75%	103	100	2,82	5,3
Corporate Bonds	5,25%	103	100	1,74	4,6
Corporate Bonds	6,00%	102	100	3,79	4,7
Corporate Bonds	7,25%	106	100	1,10	5,2
Corporate Bonds	5,38%	100	100	5,38	5,4
Corporate Bonds	5,88%	105	100	0,55	5,1
Corporate Bonds	6,13%	103	100	3,33	4,9
Corporate Bonds	5,75%	104	100	1,60	5,1
Corporate Bonds	6,00%	106	100	0,33	4,6
Corporate Bonds	6,00%	100	100	6,00	4,2
Corporate Bonds	5,63%	101	100	4,48	4,6
Corporate Bonds	5,90%	105	100	0,54	5,0
Corporate Bonds	5,38%	98	100	7,14	5,8
Corporate Bonds	5,75%	100	100	5,75	5,8
Corporate Bonds	4,50%	100	100	4,20	4,5
Corporate Bonds	2,63%	100	100	2,88	2,7

4.2 Descriptive statistics

The first green bond in the world was issued by the European Investment Bank in 2007 under the name "climate awareness bond" (Hyun, Park, & Tian, 2019). Although multilateral development banks, including the European Investment Bank and the World Bank, made a slow start in this field, the green bond market has grown rapidly in the last fifteen years. In 2021, new green bond issuances exceeded $489 billion worldwide, almost doubling in the last year (Toole, 2022).

A few countries stand out in green bond issuance. The USA is the leading country in this regard, and China, Germany and France also issue green bonds in significant numbers and volumes. Developed countries of continental Europe and the Far East (Japan, Singapore, South Korea) also attract attention in green bond issuance. Turkey has a long way to go when it comes to green bonds, and the green transformation potential of our country is an important data.

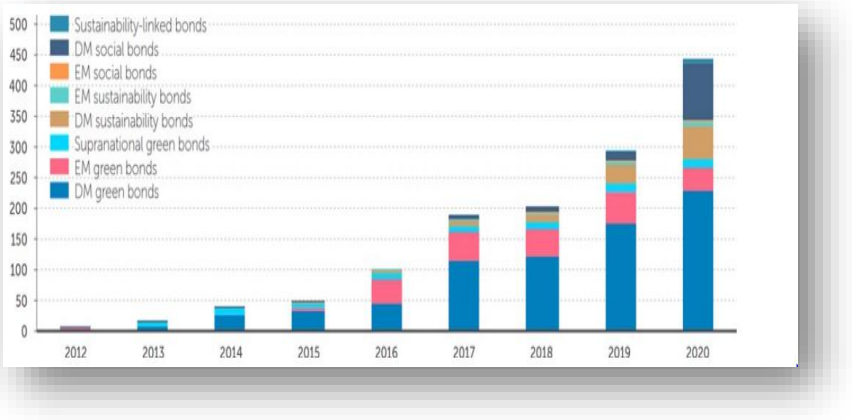
Chart 4.2: 15 Countries That Issued the Most Green Bonds by the 1st Half of 2021 (billion USD)



The graph showing the change in global SDG-themed debt issuances over the years is as follows. The acceleration of the increase in SDG-themed debt issuance draws attention in the chart. Although green bonds in developed markets constitute more than half of SDG-themed funds, social bonds in these markets come second after green bonds and are half the size of green bonds in terms of bond volume. The increase in SDG-themed funds in emerging markets in the last 5 years is remarkable, but it remains far behind compared to these bonds issued in developed markets. While SDG-themed funds were only 50 billion dollars in 2015, this figure increased almost 9 times in 2020. In emerging markets, $40 billion worth of emerging market green bond issuances took place

in 2020. In emerging markets other than China, a 21% increase has been observed since 2019. Green bond issuance in these countries is expected to amount to 260 billion USD between 2021 and 2023.

Chart 4.3: Change in SDG Themed Funds by Years (Billion USD)



Yield to Maturity (YTM) and Return on Investment (ROI) are two important financial indicators that are utilized in the process of evaluating the performance of bonds. ROI represents the percentage gain or loss an investor achieves from their initial investment, while YTM estimates the annualized return if the bond is held until it matures. These metrics provide insights into the profitability and long-term value of bonds, making them critical for comparing green and corporate bonds.

4.2.1 ROI Comparison

Table 4.2.1 (calculated in excel)

Metric	**Green Bonds ROI**	**Corporate Bonds ROI**
Mean	3,28	3,46
Median	3,40	3,56
Standard Dev.	0,50	2,08

- **Mean ROI:**

  The average ROI for green bonds is **3.28%**, while corporate bonds have a slightly higher

average ROI of **3.46%**. This indicates that, on average, corporate bonds offer marginally better returns than green bonds. However, the difference is minimal, suggesting comparable performance between the two types of bonds in terms of ROI.

- **Median ROI:**
  The median ROI for Green Bonds is **3.40**, while for Corporate Bonds is **3.56**. The medians are relatively near to one another, which suggests that the middle values of return on investment (ROI) for both types of bonds are comparable, despite the fact that Corporate Bonds have a somewhat higher central tendency.

- **Standard Deviation of ROI:**
  The standard deviation for green bonds is **0.50**, significantly lower than the **2.08** for corporate bonds. It is clear from this that green bonds offer returns that are more consistent and predictable, making them a more secure choice for investors that place a higher priority on reducing risk. Corporate bonds, on the other hand, are characterized by a greater degree of unpredictability, which indicates a wider range of possible outcomes, which may include both bigger rewards and higher dangers together.

4.2.2 YTM Comparison

Table: 4.2.2

Metric	**Green Bonds YTM**	**Corporate Bonds YTM**
Mean	3.3	4.9
Median	3.5	5.0
Standard Dev.	0.56	0.75

- **Mean YTM:**
  In terms of yield to maturity, green bonds have an average YTM of **3.3%**, while corporate bonds significantly outperform with an average YTM of **4.9%**. This suggests that corporate bonds are more attractive for investors seeking higher long-term returns.
- **Median YTM:**
  The median YTM for green bonds is **3.5%**, which is lower than the **5.0%** median YTM

for corporate bonds. Consequently, this provides additional evidence that corporate bonds continuously give higher yields, which makes them a superior option for maximizing revenue over the course of time.

- **Standard Deviation of YTM:**
  When compared to corporate bonds, green bonds have a standard deviation of 0.56 months until maturity, while corporate bonds have a standard deviation of 0.75. This suggests that green bonds offer yields that are more consistent, but corporate bonds have a greater degree of variance, which is a reflection of the higher risk and reward possibilities associated with corporate bonds.

Key Takeaways

- **Green Bonds:**
  Green bonds are more stable and predictable than traditional bonds, with lower standard deviations for both return on investment and yield to maturity. Investors who are risk averse or who place a higher value on sustainability than high returns are good candidates for these investments.
- **Corporate Bonds:**
  The average yield to maturity and return on investment (ROI) for corporate bonds are higher, but the volatility of these bonds is higher. Investors that are ready to take on a greater level of risk in exchange for the possibility of better financial rewards are likely to be interested in these bonds.

The purpose of this analysis is to illustrate the trade-offs that exist between green bonds and corporate bonds. Green bonds are superior in terms of stability, however corporate bonds are the most profitable.

4.3 Independent Samples t-Test

The independent samples t-test that have been included in research does a comparison between the yield to maturity (YTM) or the return of investment (ROI) of corporate bonds and green bonds.

4.3.1 Independent Samples t-Test for YTM

Group Statistics

	Type	N	Mean	Std. Deviation	Std. Error Mean
YTM	GreenBonds	20	3,3200	,55970	,12515
	CorporateBonds	20	4,9100	,74261	,16605

Table: 4.3.1

The findings of the t-test indicate that there is a discernible and statistically significant distinction between the average yield to maturity (YTM) of Green Bonds and Corporate Bonds at the time of maturity. If we compare the yield to maturity (YTM) of Green Bonds (3.32%) to that of Corporate Bonds (4.91%), we find that there is a mean difference of 1.59% between the two types of bonds. In addition to being statistically significant ($p < 0.001$), this difference is also significant in terms of its effect size (Cohen's $d = -2.418$), which shows that the difference is quite substantial and has major implications in practice.

As a result of the fact that the Levene's test (table 3.3.2) demonstrates that the variances of the two groups are comparable to one another ($p = 0.914$), the assumption of equal variances is really correct, and the t-test findings are reliable.

Independent Samples Test

		Levene's Test for Equality of Variances		t-test for Equality of Means							
						Significance		Mean	Std. Error	95% Confidence Interval of the Difference	
		F	Sig.	t	df	One-Sided p	Two-Sided p	Difference	Difference	Lower	Upper
YTM	Equal variances assumed	,012	,914	-7,647	38	<,001	<,001	-1,59000	,20793	-2,01094	-1,16906
	Equal variances not assumed			-7,647	35,320	<,001	<,001	-1,59000	,20793	-2,01199	-1,16801

Table: 4.3.2

A t-test with independent samples with:

$t = -7.647$, $df = 38$, and $p < 0.001$ (two-sided)- this study assumes that the variances are equal

$t = -7.647$, $df = 35.32$, $p < 0.001$ (two-sided) indicates that equal variances are not assumed to exist.

The results of both of the tests reveal that there is a difference in the mean YTM that is statistically significant, with a p-value that is substantially lower than 0.001. As a result of this, it

can be seen that the yield to maturity (YTM) of Green Bonds and Corporate Bonds is significantly different from one another.

Independent Samples Effect Sizes

		Standardizer[a]	Point Estimate	95% Confidence Interval Lower	Upper
YTM	Cohen's d	,65755	-2,418	-3,232	-1,586
	Hedges' correction	,67089	-2,370	-3,168	-1,554
	Glass's delta	,74261	-2,141	-3,045	-1,211

a. The denominator used in estimating the effect sizes.
Cohen's d uses the pooled standard deviation.
Hedges' correction uses the pooled standard deviation, plus a correction factor.
Glass's delta uses the sample standard deviation of the control (i.e., the second) group.

Table: 4.3.3

The fact that the coefficient of determination (Cohen's d) is -2.418, which indicates that the difference in YTM is not only statistically significant but also practically significant. Due to 95% Confidence Interval for the mean difference is [-2.01, -1.17], which demonstrates that the difference in YTM is in fact significant and that the range does not include zero (table 3.3.3).

To put it simply, depending on their yield to maturity (YTM), investors are likely to earn a significantly higher return on Corporate Bonds compared to Green Bonds. This supports the idea that Green Bonds may sacrifice some profitability, likely due to their focus on sustainability and environmental goals.

4.3.2 Independent Samples t-Test for ROI

A t-test is used to compare the Return on Investment (ROI) of Green Bonds and Corporate Bonds, and the results are presented in the table below. With a standard deviation of 0.50113, the return on investment (ROI) for green bonds is 3.2785 on average, with a little amount of variance. Despite the fact that the average return on investment (ROI) for corporate bonds is marginally greater at 3.4575, the standard deviation for this type of investment is significantly higher at 2.08493 (table 4.3.4).

Group Statistics

	Type	N	Mean	Std. Deviation	Std. Error Mean
ROI	GreenBonds	20	3.2785	.50113	.11206
	CorporateBonds	20	3.4575	2.08493	.46620

Table: 4.3.4

The statistical significance of the p-value for Levene's test is less than 0.001, indicating that the variances of the two groups are not equal. The mean difference in return on investment (ROI) is -0.179, which indicates that corporate bonds hold a somewhat greater value. This indicates that we should concentrate on the results for "Equal variances not assumed." -0.373 is the value of the t-value, and 0.713 is the value of the p-value (two-sided). Because the p-value is significantly higher than 0.05, the difference does not meet the criteria for statistical significance. This indicates that there is no substantial evidence to suggest that the return on investment (ROI) has a difference between Green Bonds and Corporate Bonds (table 4.3.5).

Independent Samples Test

		Levene's Test for Equality of Variances		t-test for Equality of Means							
						Significance				95% Confidence Interval of the Difference	
		F	Sig.	t	df	One-Sided p	Two-Sided p	Mean Difference	Std. Error Difference	Lower	Upper
ROI	Equal variances assumed	30.674	<.001	-.373	38	.355	.711	-.17900	.47948	-1.14966	.79166
	Equal variances not assumed			-.373	21.188	.356	.713	-.17900	.47948	-1.17560	.81760

Table: 4.3.5

Cohen's d = **-0.118**, indicating a very small effect size. This confirms that the difference between the groups is minimal and not practically meaningful. Another piece of evidence is , the confidence interval for the mean difference includes zero, further supporting the lack of a significant difference (table 4.3.6).

Independent Samples Effect Sizes

		Standardizer[a]	Point Estimate	95% Confidence Interval	
				Lower	Upper
ROI	Cohen's d	1.51626	-.118	-.738	.503
	Hedges' correction	1.54703	-.116	-.723	.493
	Glass's delta	2.08493	-.086	-.705	.536

a. The denominator used in estimating the effect sizes.
Cohen's d uses the pooled standard deviation.
Hedges' correction uses the pooled standard deviation, plus a correction factor.
Glass's delta uses the sample standard deviation of the control (i.e., the second) group.

Table: 4.3.6

Accordind to the findings, the ROI for Green Bonds and Corporate Bonds is similar to one another . While Corporate Bonds have a slightly higher average ROI, the difference is not statistically significant, and the effect size is tiny. In practical terms, both types of bonds perform similarly in terms of ROI.

4.3.3 Overall Conclusions

Corporate bonds have a significantly higher YTM than green bonds, making them more attractive for long-term investors, but there is no statistically significant difference in ROI between green and corporate bonds, suggesting that both can provide comparable short-term returns.

In summary, while corporate bonds offer higher yields, green bonds are competitive in ROI and align with environmental goals, catering to investors with diverse priorities.

4.4 Case study: Volkswagen Group.

The Volkswagen Group is a world leader in the automotive sector, with its headquarters located in Wolfsburg, Germany. Volkswagen has expanded its activities to encompass both conventional auto manufacturing and ecologically focused projects because of its strong commitment to innovation and sustainability. Since 2020, Volkswagen AG has maintained a Green Finance Framework for different types of funding, including green bonds. The framework for financial instruments focused on sustainability is defined in this publication. The company issued €3.5 billion in green bonds during the reporting year to finance its fiscal year 2022 capital expenditures that were in line with the EU Taxonomy and the recently released Green Finance Framework. Consequently, since 2020, the Volkswagen Group has issued €9.5 billion in green bonds to refinance capital expenditures on all-electric cars (BEVs). Environmentally friendly initiatives like e-mobility are specially refinanced with the money obtained under the Green Finance Framework. This satisfies the International Capital Market Association's (ICMA) Green Bond Principles' clean transport category and aligns with the European Union's and the UN's sustainable development objectives. The new Green Finance Framework's compliance with the ICMA's Green Bond Principles and the Loan Market Association's (LMA) Green Loan Principles

has been reaffirmed by Sustainalytics. (2023_Volkswagen_Group_Sustainability_Report) . Corporate bonds issued by Volkswagen serve to finance its core operations and strategic expansions. These bonds tend to deliver higher returns but with greater variability compared to green bonds.

Overview of dataset

The dataset consists of 12 bonds, including 6 green bonds and 6 corporate bonds. Various coupon rates, prices, and maturities are available for the bonds. Green bonds were selected based on their alignment with environmental sustainability objectives, while corporate bonds were chosen to represent traditional investments with no specific sustainability focus. The key metrics for each bond, such as Return on Investment (ROI) and Yield to Maturity (YTM), were calculated and summarized in the table below. In the appendix B, you will find a comprehensive list of the bonds that were investigated in this study.

Table 4.4.1

Type	ISIN	ROI	YTM
Green Bonds	XS2491738352	3.1%	3.09%
Green Bonds	XS2554487905	3.0%	2.99%
Green Bonds	XS2491738949	1.7%	2.97%
Green Bonds	XS2554488978	1.3%	3.26%
Green Bonds	XS2491738352	3.1%	3.09%
Green Bonds	XS2604697891	2.9%	3.10%

Table 4.4.2

Type	ISIN	ROI	YTM
Corporate Bonds	XS2152061904	2.9%	3.23%
Corporate Bonds	XS1082890663	2.9%	3.09%
Corporate Bonds	XS1586555945	3.9%	2.77%
Corporate Bonds	XS1910948162	3.6%	2.96%
Corporate Bonds	XS1910948329	3.7%	3.33%
Corporate Bonds	XS0908570459	3.4%	3.31%

The contrast between green bonds and corporate bonds brings to light the trade-offs that exist between ecological responsibility and financial profits. Green bonds provide more stable yields, making them attractive to environmentally conscious investors seeking steady performance. In contrast, corporate bonds provide higher yields, but they also have a greater degree of fluctuation, making them desirable to investors who place a higher priority on financial gains.

While green bonds are primarily used to fund projects with environmental benefits, including renewable energy installations, electric vehicle infrastructure, and energy efficiency upgrades, corporate bonds are versatile instruments that can finance a broad range of corporate activities, such as product development, operational expansion, and debt refinancing.

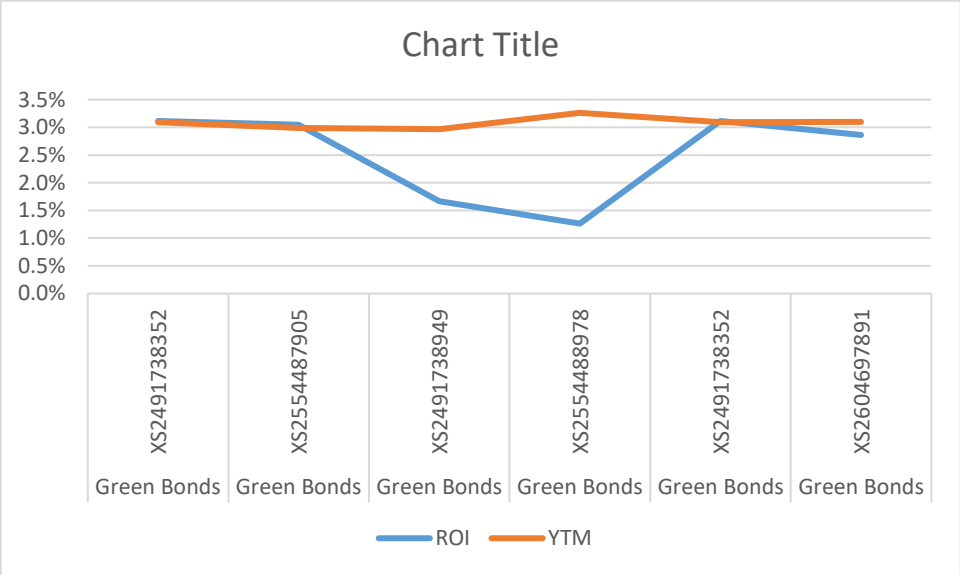


Chart 4.4.1

The chart 4.4.1 illustrates the trends in Return on Investment (ROI) (blue line) and Yield to Maturity (YTM) (orange line) for green bonds issued under various ISINs. ROI for green bonds demonstrates noticeable variability across the bonds. Most bonds exhibit ROI values close to or slightly below 3.0%, reflecting relatively stable performance for those bonds.YTM remains consistently stable across all ISINs, fluctuating narrowly around 3.0% to 3.26%. While YTM remains steady and predictable, ROI shows significant fluctuations, particularly with bonds such as XS2491738949, indicating lower profitability for those specific bonds.

Investors seeking predictable long-term returns would find these green bonds appealing due to their consistent YTM. The fluctuating ROI suggests differences in bond pricing or coupon structures that impact short-term profitability. Bonds like XS2491738949 and XS2554488978 may require further investigation into their financial terms or market conditions at issuance.

The chart 4.4.2 illustrates the trends in Return on Investment (ROI) and Yield to Maturity (YTM) for corporate bonds across various ISINs. ROI (Blue Line) demonstrates a general upward trend, peaking for certain bonds. Highest ROI ISIN XS1586555945 shows the highest ROI at approximately 3.9%, indicating strong profitability. Most bonds exhibit ROI values close to or above 3.5%, suggesting consistent profitability across corporate bonds. YTM (Orange Line) remains relatively stable, fluctuating narrowly between 2.77% and 3.33%. Lowest YTM ISIN XS1586555945 dips to 2.77%, which contrasts with its high ROI, indicating that the bond may have higher pricing but lower long-term yield. Highest YTM ISIN XS1910948329 and XS0908570459 peak at 3.33%, offering attractive long-term returns.

Corporate bonds generally maintain higher ROIs compared to green bonds, reflecting their profitability advantage. YTM for corporate bonds is stable, offering predictable long-term returns, similar to green bonds. Certain bonds (e.g., XS1586555945) show a noticeable divergence between ROI and YTM, suggesting differences in pricing or coupon structure that impact their profitability versus yield.

The relatively consistent ROI and YTM across bonds reflect moderate risk levels,making corporate bonds a viable choice for investors seeking a balance between profitability and stability.

Chart 4.4.2

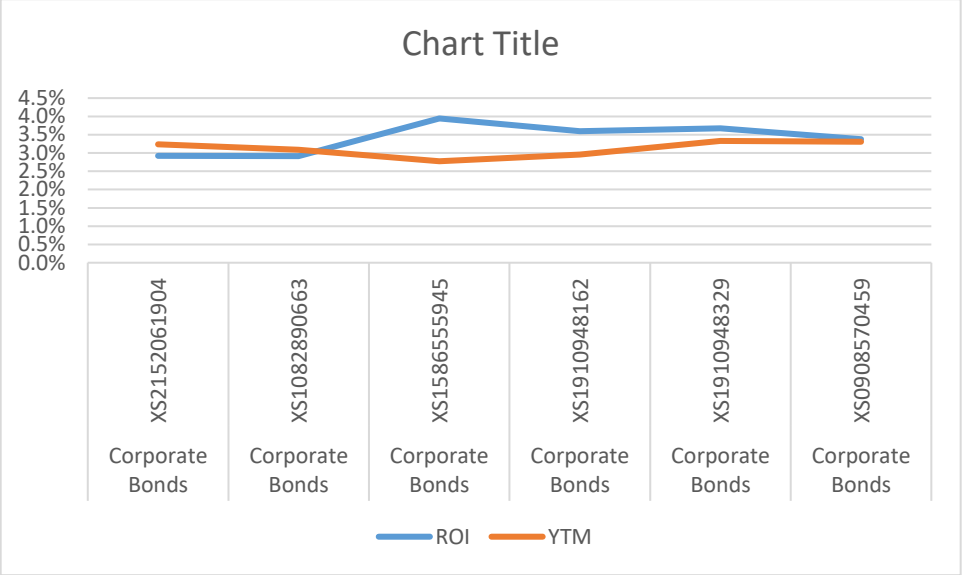


Table 4.4.3

	Green Bonds		Corporate Bonds	
	ROI	YTM	ROI	YTM
Mean	2.5%	3.08%	3.4%	3.12%
Median	3.0%	3.09%	3.5%	3.16%
St. Deviation	0.00826	0.00104	0.00418	0.00219

Mean ROI

Green bonds offer an average return of **2.5%**, reflecting moderate profitability. This relatively lower ROI is a direct result of their alignment with sustainability and environmentally friendly projects. Investors in green bonds often prioritize environmental and social impact over immediate financial returns. For example, proceeds from green bonds are typically allocated to renewable energy initiatives, energy efficiency upgrades, or climate-resilient infrastructure. These bonds serve as a tool to advance global sustainability objectives, such as those outlined in the United Nations Sustainable Development Goals (SDGs).

In contrast, corporate bonds deliver a higher average return of **3.4%**, highlighting their greater profitability. This is driven by their traditional focus on corporate financing, which often prioritizes financial returns over sustainability goals. Corporate bonds are primarily issued to support operational growth, business expansion, and general financing needs, making them an

attractive option for profit-focused investors. The higher ROI reflects the market's perception of risk and return, as corporate bonds are not constrained by sustainability criteria and can tap into a broader range of investment opportunities.

Green bonds' alignment with sustainability goals may justify their lower ROI, as they provide intangible benefits such as contributing to carbon neutrality and fostering renewable energy growth. The difference in ROI also reflects market dynamics, where corporate bonds are perceived as higher-risk but higher-reward investments, whereas green bonds are associated with stable, purpose-driven funding.

Mean YTM

The comparison of Mean Yield to Maturity (YTM) between green bonds and corporate bonds highlights the nuanced trade-offs between stability, predictability, and long-term income potential, catering to diverse investor priorities.

Green bons provide an average YTM of 3.08%, indicating steady and predictable long-term returns. This stability stems from their specific purpose of funding environmentally sustainable projects, such as renewable energy installations and energy-efficient technologies. Investors in green bonds are often drawn to their consistent performance, as the focus on sustainability adds an element of predictability to their returns.

Green bonds appeal to risk-averse investors who value stability and long-term income over short-term profitability. These bonds offer a unique combination of financial return and social impact, making them a preferred choice for institutions and individuals aligning their portfolios with Environmental, Social, and Governance (ESG) criteria.

Corporate bonds, with a slightly higher average YTM of 3.12%, reflect attractive long-term returns. The higher YTM can be attributed to their broader scope of use, which includes general business operations, expansions, and debt refinancing. These bonds typically carry more market-driven risk, as they are not restricted to sustainability-focused projects, allowing issuers to capitalize on potentially high-growth opportunities.

Corporate bonds appeal to yield-focused investors who seek higher long-term income and are willing to accept a moderate level of variability. The slightly higher YTM indicates the

market's recognition of their profit-driven purpose and broader application compared to green bonds.

In summary, green bonds, with their focus on environmental sustainability, provide more stable and predictable yields. This makes them ideal for investors prioritizing steady, long-term income with minimal volatility. Green bonds prioritize social and environmental impact alongside financial returns, whereas corporate bonds focus on maximizing financial gains for the issuer and investors. Investors must weigh their preferences for yield versus stability. Those looking for predictable income with an environmental impact will lean toward green bonds, while yield-focused investors willing to accept moderate variability will favor corporate bonds.

Median ROI (3.0%) and YTM (3.09%)

The analysis of median ROI and median YTM for green bonds and corporate bonds reveals important insights into their performance distribution and investor appeal. By connecting these metrics, we can better understand how these bond types differ in terms of stability, profitability, and alignment with investor preferences. The median values of ROI (3.0%) and YTM (3.09%) closely match the mean values for green bonds. This suggests a symmetric distribution, where most bonds deliver returns and yields close to the average. Such clustering of values reflects consistent performance, making green bonds a predictable and stable investment option. These bonds are particularly suitable for long-term income streams, offering steady returns without significant deviations.

For corporate bonds, the median ROI (3.5%) and YTM (3.16%) are slightly higher than the mean values, indicating a skewed distribution where most bonds perform better than the average. This highlights the potential for better-than-average performance in corporate bonds, with a greater likelihood of achieving higher returns and yields. The upward skew reflects the influence of some high-performing bonds, which appeal to investors willing to accept moderate risk for the possibility of better outcomes.

The choice between green and corporate bonds depends on investor priorities: stability and sustainability (green bonds) versus profitability and outperformance (corporate bonds).

Standard Deviation

ROI Standard Deviation (0.00826): Green bonds exhibit very low variability in ROI, indicating stable and predictable returns.

YTM Standard Deviation (0.00104): The minimal variability in YTM underscores the consistent income potential of green bonds over the long term.

Green bonds' stability is a result of their alignment with sustainability-focused projects, such as renewable energy investments and energy efficiency upgrades. These projects are typically backed by governments or large institutions, reducing volatility. The low standard deviation makes green bonds an ideal choice for risk-averse investors who value stability and predictable returns, even if profitability is slightly lower.

ROI Standard Deviation (0.00418): Corporate bonds demonstrate moderate variability in ROI, reflecting higher fluctuations in profitability compared to green bonds.

YTM Standard Deviation (0.00219): While slightly higher than green bonds, the variability in YTM for corporate bonds remains within manageable limits, indicating reasonable predictability in long-term yields.

The moderate variability in corporate bonds arises from their exposure to broader market and operational risks, such as economic cycles, corporate performance, and credit risks. Investors in corporate bonds are willing to accept this variability in exchange for higher potential returns, making them suitable for those prioritizing financial gains over stability.

Green bonds provide stability and reliability, making them a safe haven for investors who prioritize low risk and sustainability over maximizing returns. Corporate bonds, with their moderate variability, offer a risk-return balance that appeals to investors willing to tolerate some risk for potentially higher profitability.

Green Bonds are particularly attractive to institutional investors, pension funds, and environmentally conscious individuals who seek steady, long-term returns while supporting global sustainability goals. Corporate bonds cater to profit-driven investors who are comfortable with moderate fluctuations in returns and yields, aligning with traditional corporate financing objectives. The low variability in green bonds enhances their reputation as a secure and purpose-driven investment tool, while the moderate variability in corporate bonds reflects their adaptability to broader market opportunities.

5. DİSCUSSİON

5.1. Interpretation of results

Green bonds have emerged as a pivotal tool in financing renewable energy projects, aimed at fostering sustainable development by channeling investment into environmentally beneficial initiatives. Measuring the effectiveness of green bonds in this context involves several key factors:

- The primary measure of effectiveness is the environmental impact of the projects financed by green bonds. This includes quantifiable metrics such as the amount of greenhouse gas emissions reduced, the capacity of renewable energy generated (e.g., megawatts of solar or wind power installed), and the overall contribution to national or global renewable energy targets. Projects funded by green bonds should ideally lead to significant reductions in carbon footprints and help mitigate climate change.
- Green bonds must also demonstrate sound financial performance to attract and retain investors. This involves assessing the returns on investment compared to conventional bonds, the stability and reliability of the revenue streams from the renewable energy projects, and the cost-effectiveness of these projects. Successful green bonds should offer competitive returns while fulfilling their environmental goals, thereby proving that sustainable investments can be profitable.
- Effective measurement relies heavily on transparency and regular reporting. Issuers of green bonds are expected to adhere to stringent reporting standards, providing detailed information on how the funds are allocated, the progress of the projects, and their environmental benefits. Frameworks such as the Green Bond Principles and Climate Bonds Standard play crucial roles in establishing these reporting norms. High transparency builds investor confidence and ensures accountability.

The effectiveness of green bonds in financing renewable energy projects is multi-faceted, encompassing environmental impact, financial viability, transparency, social benefits, and long-term sustainability. Robust measurement frameworks are crucial for validating their success and driving the growth of green finance.

The analysis presented in this work underscores the dichotomy between profitability and sustainability in bond investments. Corporate bonds, characterized by higher average ROI and YTM, are inherently more lucrative but exhibit greater variability, reflecting their exposure to

market and operational risks. Green bonds, while offering lower financial returns, align with global sustainability objectives, demonstrating stable performance with minimal risk.

This study highlights the role of corporate bonds in supporting traditional financial objectives and the significance of green bonds in advancing environmentally sustainable investments. These findings set the foundation for practical recommendations in the final chapter.

Green bonds provide low-risk, stable returns, coupled with significant environmental impact, making them particularly appealing to institutional investors, ESG-focused portfolios, and risk-averse individuals. Their alignment with global sustainability initiatives, such as the United Nations Sustainable Development Goals (SDGs), further enhances their appeal as a purpose-driven financial tool.

Corporate bonds, with their higher ROI and YTM, cater to profit-seeking investors who are comfortable with moderate variability. Their broader scope of use allows issuers to finance diverse corporate activities, making them a flexible option for both issuers and investors.

Investors prioritizing predictable returns and sustainability gravitate toward green bonds. Yield-focused and profit-oriented investors are more likely to favor corporate bonds, despite their higher risk.

5.2. Discussion of the effectiveness of green bonds in financing renewable energy

Various studies are available to evaluate the benefits and impacts of green bonds. As one such study, it would be appropriate to analyze the research by Maltais and Nykvist (2020)—the results of in-depth interviews with public and private sector representatives of the Swedish green bond market in 2017–2018. The main target audience in this study is issuers and investors who are participants in green bond markets. In the analysis, financial and non-financial benefits of green bonds for issuers and investors were clarified through interviews. The result of the study is reflected in Table 5.2:

Table 5.2. Benefits of green bonds for each category of market participants in bond markets.

Issuers	Investors
Expanding the investor base	Investing in specific green projects or assets without taking substantial additional risk

Reducing capital costs	To customers and other interested parties support for the sustainability of investments facilitating accountability
Facilitating access to capital	Easier to attract customers to the company
Promotion of branding	A new premium to branding and customers making it easier to offer products
A financial benefit due to the low interest rates they have to pay on the bond	Attracting qualified and competent personnel
Increasing the reputation of issuers as they support the sustainable development of the bonds they issue	Improving sustainability dialogue with issuers and within the organization
High demand	Supporting the further integration of the perspective of sustainability within the organization

Sourch: (Maltais and Nyqvist (2020))

According to this study, green bonds provide more non-financial benefits than financial benefits. But the financial benefits of green bonds for issuers outweigh the financial benefits for investors.

Green bonds also provide great benefits for investors. Green bonds primarily means financial returns that support the environment for investors. This enables investors to contribute to the sustainable development of food security, health, energy supply and other priority areas. Also the reputation of green bonds investors and provides direct investment in the "greening" of the "brown" sectors. This, in turn, helps to increase the transparency and accountability of investors to the state, society and other interested parties, and facilitates the management of additional risks.

The financial sector, like other sectors, has great potential under the umbrella of environmental protection and supporting the green economy. Investing in the brown economy cannot expect the revival of the green economy. Therefore, it is imperative to invest in "green sectors" and "green technologies". While the benefits of environmental protection investments are global, the costs are more local. Therefore, various financial instruments are needed to balance the "burden" of costs and the "reward" of benefits. As one of these instruments, green bonds have many benefits for various stakeholders and direct market participants. Green bonds can provide financial and non-financial benefits for market participants, investors, issuers and brokers, and

environmental and social benefits for society and governments in general. For this reason, expanding research on green bonds, promoting the implementation of green bonds in countries, increasing awareness and stimulation for investors and issuers can contribute to both turning obstacles into advantages and strengthening environmental protection and sustainability in this area.

5.3. Limitations of the Study

Research in renewable energy sources has made significant strides in recent years, yet it is not without its limitations. Understanding these limitations is crucial for guiding future research efforts and maximizing the potential of renewable energy technologies. Here, we explore some of the key constraints faced in this field.

One major limitation is the intermittency and variability of renewable energy sources. Unlike fossil fuels, which provide a continuous and consistent energy supply, renewable sources such as solar and wind are dependent on weather conditions and time of day. This intermittency poses challenges for grid stability and reliability. Although advancements in energy storage technologies aim to mitigate this issue, current solutions are often expensive and limited in capacity. Additionally, integrating renewable energy into existing grids requires significant infrastructure upgrades and regulatory changes.

Another limitation is the geographical and resource constraints associated with certain renewable energy sources. For example, solar energy generation is most efficient in regions with abundant sunlight, while wind energy requires areas with consistent and strong wind patterns. Similarly, hydropower is constrained by suitable water resources, and geothermal energy is limited to areas with accessible geothermal reservoirs. These geographical constraints may limit the scalability and widespread adoption of certain renewable technologies, especially in regions where these resources are scarce.

The environmental impacts of renewable energy technologies cannot be overlooked. While renewable sources produce fewer greenhouse gas emissions during operation compared to fossil fuels, they are not entirely benign. For instance, large-scale hydropower projects can disrupt river ecosystems and lead to habitat loss and altered water flow regimes. Wind farms and solar installations can also have visual and ecological impacts on landscapes and wildlife habitats. Biomass energy, if not sourced sustainably, can contribute to deforestation and biodiversity loss. Balancing the environmental benefits with potential drawbacks is essential for ensuring the long-term sustainability of renewable energy systems.

Economic factors also present significant limitations to research in renewable energy. Despite declining costs, many renewable technologies still require substantial upfront investments, making them less financially attractive compared to conventional energy sources in the short term. Moreover, uncertainties surrounding government policies and incentives can hinder private investment in renewable energy projects. Additionally, the lack of standardized metrics for assessing the economic viability of renewable technologies makes it challenging to compare different options objectively

While research in renewable energy sources holds promise for a sustainable future, it faces several limitations that must be addressed. These include intermittency and variability, geographical constraints, environmental impacts, and economic factors. Overcoming these challenges will require interdisciplinary collaboration, technological innovation, and supportive policies to drive the transition towards a cleaner and more sustainable energy system.

6. CONCLUSİON

Measuring the effectiveness of green bonds in financing renewable energy projects is crucial for ensuring that these financial instruments achieve their intended environmental and social outcomes. Effective measurement involves a comprehensive evaluation of environmental impact, financial performance, transparency, social benefits, and long-term sustainability. By rigorously assessing greenhouse gas reductions, renewable energy capacity, and project profitability, stakeholders can validate the contributions of green bonds to climate change mitigation and sustainable development. Transparency and adherence to reporting standards foster investor confidence and accountability, while considering social impacts ensures that projects support broader economic and social goals. Long-term sustainability, including the resilience and adaptability of renewable energy installations, is essential for maintaining the benefits over time. Ultimately, a robust measurement framework is vital for the continued growth and success of green finance, reinforcing the role of green bonds as a key driver in the transition to a low-carbon economy.

The comparative analysis of green and corporate bonds reveals critical trade-offs between sustainability, profitability, and stability. With their stable and predictable performance, green bonds are ideal for risk-averse investors who value consistent returns and wish to contribute to environmental goals. Their low variability and alignment with sustainability principles make them a secure and purpose-driven investment. Offering higher ROI and YTM, corporate bonds

provide greater profitability but with moderate variability. These bonds appeal to investors seeking higher returns and flexibility in financing.

The key takeaway is that the choice between green and corporate bonds depends on the investor's objectives:

- Sustainability-focused investors prioritize green bonds for their societal impact and predictable returns.
- Profit-driven investors favor corporate bonds for their superior financial performance, despite higher variability.

This analysis underscores the importance of aligning investment decisions with financial goals and values. By highlighting the unique strengths of each bond type, this study contributes to a deeper understanding of their roles in portfolio management and their relevance in achieving both financial and non-financial objectives.

6.1. Summary of findings

The world is increasingly interconnected, evolving into a global community, driven by the ever-growing demand for energy. Energy is essential for improving people's well-being, happiness, and advancing social and economic development. Turning to renewable energy sources offers a promising solution for addressing climate change, but for this strategy to succeed in benefiting future generations, it must be implemented in a sustainable manner. This study explored the potential of renewable energy sources to enhance energy security, expand energy access, drive social and economic progress, mitigate climate change, and minimize negative environmental and health impacts. However, several obstacles hinder the ability of renewable energy to provide a long-term solution to the climate crisis. These challenges include the persistent carbon emissions from daily activities, market inefficiencies, gaps in information, and limitations in the availability of raw materials needed for renewable energy technologies. The study proposes actions and policy recommendations aimed at achieving renewable energy goals, reducing emissions, combating climate change, and ensuring clean energy and a healthy environment for both present and future generations.

Energy plays a crucial role in our daily lives, driving human development and contributing to economic growth and productivity. Transitioning to renewable energy presents a

significant opportunity to combat climate change, but for this shift to secure a sustainable future and meet the energy needs of future generations, it must itself be sustainable. The connection between renewable energy and sustainable development, however, remains an area that requires further exploration. This article aims to evaluate the sustainability of renewable energy sources and examine how transitioning from fossil fuels to renewable energy can help mitigate the impacts of climate change. The study relied on qualitative research, drawing on peer-reviewed papers evaluated by experts in the field. It highlights the potential of renewable energy to enhance energy security, improve access to energy, support social and economic progress, and address environmental and health challenges associated with climate change.

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Appendix A

Type	ISIN	Coupon	Price	Par value	ROI %	YTM %
Green Bonds	DE000A383QR0	3.85%	101	100	2.74	3.8
Green Bonds	FR001400TL81	3.31%	99	100	3.96	3.4
Green Bonds	DE000NRW0PR8	2.50%	100	100	2.62	2.5
Green Bonds	XS2491189408	2.50%	100	100	2.78	2.7
Green Bonds	XS2928133417	4.00%	100	100	4.00	4.0
Green Bonds	XS2932096691	2.63%	100	100	2.82	2.7
Green Bonds	XS2920504292	4.00%	100	100	3.54	3.9
Green Bonds	FR001400TL99	4.25%	101	100	3.70	4.1
Green Bonds	XS2929975071	3.49%	100	100	3.49	3.5
Green Bonds	BE6356934396	2.50%	100	100	2.65	2.6
Green Bonds	XS2922125344	3.63%	100	100	3.73	3.6
Green Bonds	XS2518323584	3.75%	100	100	3.75	3.7

Green Bonds	XS2518323667	3.50%	100	100	3.50	3.5
Green Bonds	XS2919679816	3.08%	100	100	2.74	2.8
Green Bonds	XS2919680236	3.73%	100	100	3.40	3.6
Green Bonds	XS2913069428	2.63%	100	100	2.54	2.5
Green Bonds	XS2916849396	3.15%	100	100	3.15	3.1
Green Bonds	XS2920501868	2.71%	100	100	3.07	2.7
Green Bonds	XS2911217300	4.00%	100	100	4.00	4.0
Green Bonds	XS2908897742	3.70%	100	100	3.39	3.7
Corporate Bonds	XS1103286305	4.50%	98	100	6.22	5.1
Corporate Bonds	XS0134886067	5.75%	101	100	4.21	4.6
Corporate Bonds	XS0097283096	5.75%	104	100	2.09	4.6
Corporate Bonds	XS1614096425	5.00%	100	100	5.00	6.4
Corporate Bonds	XS0340495216	5.75%	103	100	2.82	5.3
Corporate Bonds	XS0140516864	5.25%	103	100	1.74	4.6
Corporate Bonds	XS0184639895	6.00%	102	100	3.79	4.7
Corporate Bonds	XS0085732716	7.25%	106	100	1.10	5.2
Corporate Bonds	XS0174470764	5.38%	100	100	5.38	5.4
Corporate Bonds	XS0121464779	5.88%	105	100	0.55	5.1
Corporate Bonds	XS0148889420	6.13%	103	100	3.33	4.9
Corporate Bonds	XS0221324154	5.75%	104	100	1.60	5.1
Corporate Bonds	XS0105244585	6.00%	106	100	0.33	4.6
Corporate Bonds	GB0002404191	6.00%	100	100	6.00	4.2
Corporate Bonds	XS0181816652	5.63%	101	100	4.48	4.6
Corporate Bonds	XS0158715713	5.90%	105	100	0.54	5.0
Corporate Bonds	XS0214275785	5.38%	98	100	7.14	5.8
Corporate Bonds	XS0178489844	5.75%	100	100	5.75	5.8
Corporate Bonds	GB00B52WS153	4.50%	100	100	4.20	4.5
Corporate Bonds	FR001400TM31	2.63%	100	100	2.88	2.7

Appendix B

Type	ISIN	Coupon	Price	Par value	ROI %	YTM	maturity date
Green	XS2491738352	3.13%	100	100	3.11	3.09%	28/03/2025
Green	XS2554487905	4.13%	101	100	3.05	2.99%	15/11/2025
Green	XS2491738949	3.75%	102	100	1.67	2.97%	28/09/2027
Green	XS2554488978	4.25%	103	100	1.26	3.26%	15/02/2028
Corporate	XS2152061904	3.38%	100	100	2.92	3.23%	06/04/2028
Corporate	XS1082890663	2.25%	99	100	2.91	3.09%	04/12/2025
Green	XS2491738352	3.13%	100	100	3.11	3.09%	28/03/2025
Green	XS2604697891	3.88%	101	100	2.86	3.10%	29/03/2026
Corporate	XS1586555945	1.88%	98	100	3.94	2.77%	30/03/2027
Corporate	XS1910948162	2.63%	99	100	3.60	2.96%	16/11/2027
Corporate	XS1910948329	3.25%	100	100	3.67	3.33%	18/11/2030
Corporate	XS0908570459	3.30%	100	100	3.38	3.31%	22/03/2033