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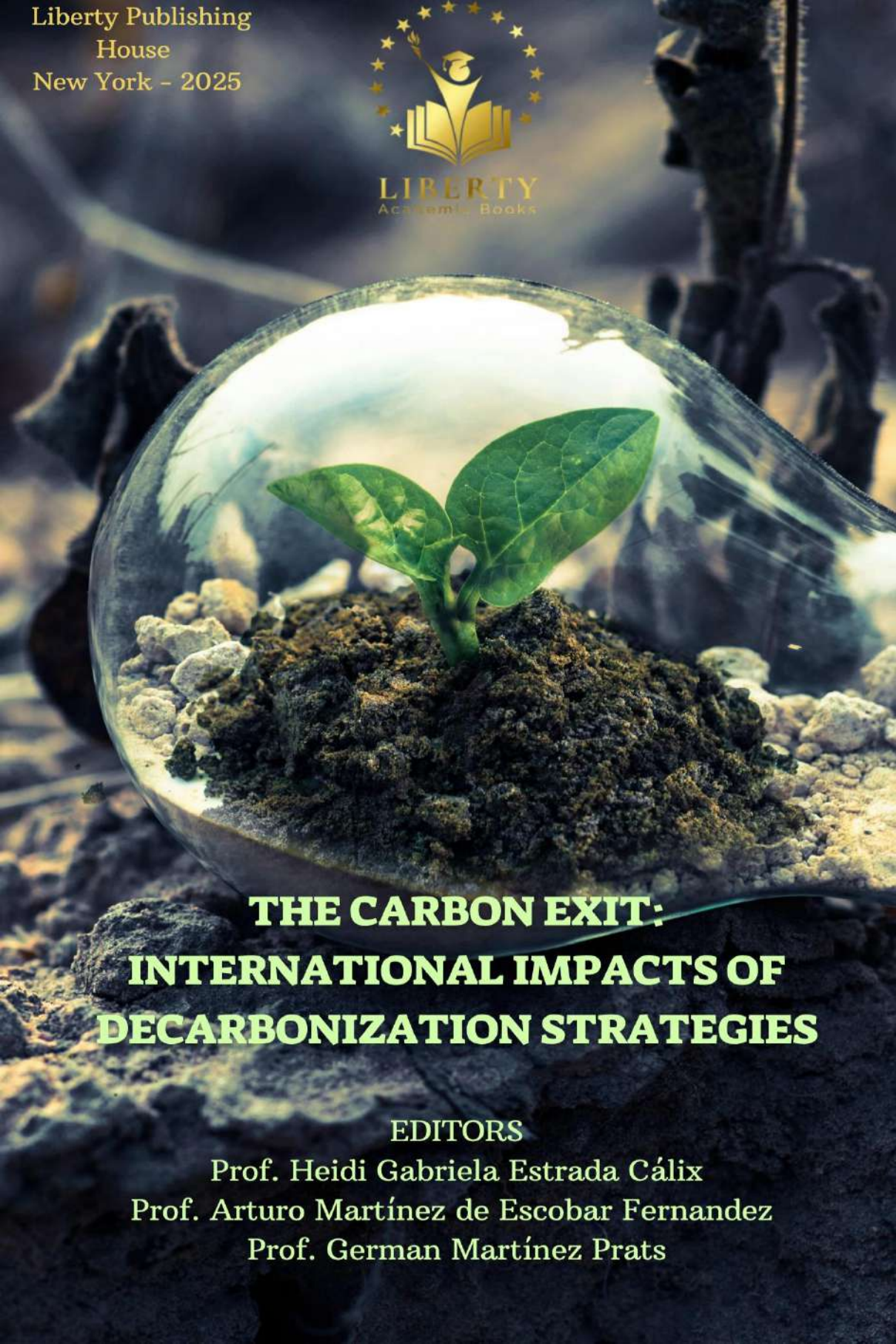

THE CARBON EXIT: INTERNATIONAL IMPACTS OF DECARBONIZATION STRATEGIES

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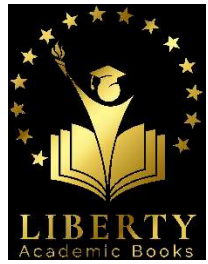

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CONTENTS

PREFACE

In an era defined by accelerating climate crises and the urgent pursuit of sustainable futures, the global community faces a critical juncture: how to effectively transition away from carbon-intensive systems without compromising economic stability, social equity, and technological innovation. This volume, The Carbon Exit: International Impacts of Decarbonization Strategies, emerges as a timely and necessary intervention into that discourse.

The transition to low-carbon energy systems is not merely a technical challenge—it is a profound political, economic, and social transformation that requires coordinated action across borders, sectors, and disciplines. The contributions in this book examine the multidimensional consequences of decarbonization, exploring how scientific advancements, financial mechanisms, governance structures, and ethical imperatives must align to ensure a just and inclusive energy future.

By drawing from a diverse range of methodological approaches and regional perspectives, this work provides an integrative understanding of the evolving dynamics in global carbon governance. It reflects the growing recognition that decarbonization strategies must be informed not only by environmental science, but also by the complex realities of international political economy, development disparities, and socio-technological systems.

This book would not have been possible without the dedication and intellectual rigor of the contributing scholars, whose research advances both academic inquiry and policy relevance. Their collective work demonstrates that achieving net-zero emissions is not an isolated goal, but one deeply embedded in broader aspirations for justice, resilience, and planetary well-being.

I extend my heartfelt gratitude to all authors, reviewers, and partners who contributed to the realization of this volume. May their insights inspire meaningful dialogue and action across the global academic and policy-making communities.

Prof. Germán Martínez Prats
Editorin Chief
New York, July 2025

CHAPTER 4

GREEN FINANCE AND DECARBONIZATION POLICY SYNERGY

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INTRODUCTION

In modern world decarbonization policy is of high priority and is necessary to mitigate the effects of climate change and reduce greenhouse gas emissions resulting from human activities. It provides a set of measures aimed at transitioning to a low-carbon economy and reducing dependence on fossil fuels. Decarbonization is not only important for combating climate change, but also has significant potential to improve the economy, energy security, and quality of life. It has a positive influence on such important processes as:

- Reducing greenhouse gas emissions. The main task is to reduce greenhouse gas emissions, which are the main cause of global warming and climate change.
- Combating climate change. Decarbonization is key to preventing the catastrophic consequences of climate change, such as extreme weather events, rising sea levels, and others.
- Improving air quality and public health. Decarbonization contributes to reducing air pollution, which has a positive impact on human health.
- Modernizing the economy. Decarbonization requires modernizing industry, transitioning to new technologies, and improving energy efficiency, which helps to increase the country's competitiveness.
- Ensuring energy security. The transition to renewable energy sources and increasing energy efficiency reduces dependence on energy imports and ensures a more stable energy supply.
- Stimulating economic growth. Investing in green technologies and developing renewable energy can be a powerful driver of economic growth and job creation.

So, decarbonozation has a great importance on the environment, life quality and economic growth and is important for sustainable development.

The decarbonization process involves restructuring the economy, in particular, modernization of the energy sector, which requires support at the state and international levels in the form of emission reduction policies, state decarbonization programs, etc., as well as significant investments in the modernization of production, transition to green energy, the abandonment of

fossil fuels, etc. In this case green finance helps allocate required resources and shift investments into prioritized areas.

1. LITERATURE REVIEW

In contemporary academic discourse, green finance is regarded as a key instrument in achieving the goals of economic decarbonization, particularly under the intensifying concentration of climate-related risks. The search for synergy between financial instruments and policy measures aimed at reducing carbon emissions has become the subject of numerous interdisciplinary studies. Based on empirical data from China, Lee et al. (2023) argue that green financial policies directly contribute to decarbonization, particularly by supporting technological innovation, restructuring industrial composition, and fostering the development of renewable energy. Similar conclusions are presented in the study by Huang et al. (2024), which emphasizes that the effectiveness of a green financial system lies not merely in its scale, but in the strategic allocation of capital toward energy-saving technologies.

A large-scale international study by Mamun et al. (2022), covering 46 countries, confirms that the impact of green finance on emission reductions is sustainable in both the short and long term, especially in countries with well-developed financial markets and high levels of innovation. The study by Zhu et al. (2024) focuses on the transformation of energy consumption in China, where green capital supports the growth of environmentally oriented industries, particularly in regions with limited public funding for science. Meanwhile, a systematic review by Fu et al. (2024) synthesizes theoretical and empirical approaches to the link between finance and decarbonization, underscoring the need for standardization of green instruments and the harmonization of policy frameworks at the intergovernmental level.

On the other hand, the study by Amolo (2024) highlights the risks in developing countries, particularly limited access to capital, regulatory uncertainty, and the continued dominance of fossil fuel investments. Berensmann and Lindenberg (2016) stress that without clearly coordinated financial and environmental policies; investments in green projects will remain insufficient. Their work also analyzes the role of regulators, particularly central banks, and notes their capacity to reallocate capital flows through monetary

stimuli and prudential supervision. Financial regulators play an equally critical role in shaping the institutional environment for climate-related disclosure and in minimizing the risks of greenwashing.

A novel perspective on policy synergy is introduced in the work of Fichtner et al. (2025), who propose the concept of "impact channels" through which private capital influences ecological transformation, including mechanisms such as climate ratings, litigation, and standardization. An interesting approach is offered by Lazaro et al. (2023), who analyze Brazil's RenovaBio policy as a functioning model of a decarbonization credit market that promotes sustainable agriculture. Adebayo et al. (2024) examine the application of green bonds in the oil industry to support carbon capture technologies and enhance energy efficiency.

The integration of industrial and social innovations into the green transition is addressed in the study by Dhayal et al. (2023), which explores the potential of the transition to Industry 5.0, where green financial capital underpins the development of a circular economy, green logistics, and industrial modernization. A systematic review by Shah et al. (2023) highlights the importance of financial innovations in China and India, which act as catalysts for green technologies through a combination of environmental regulation and market mechanisms. Similarly, Wahyudi et al. (2023) demonstrate that current academic trends focus on the synthesis of finance, digitalization, and climate strategies.

Finally, at the macroeconomic level, the study by Han et al. (2023) shows that combining green financial policy with regional innovation networks creates a synergistic effect that enhances the quality of economic growth. This is echoed in the work of Rochet (2019), which views financial markets as essential infrastructure for internalizing externalities and generating sustainable incentives.

In contemporary academic discourse, it is increasingly emphasized that the effectiveness of decarbonization is determined not only by technological innovation but also by the scale and structure of financial flows capable of redirecting capital toward environmentally sustainable sectors of the economy. The Sixth Assessment Report of the IPCC clearly states that to achieve the 'well-below 2 °C' pathway, global environmental investment needs to at least

triple by 2030 (IPCC, 2022). The International Energy Agency, in its revised 'Net Zero 2050' roadmap, estimates the threshold for annual 'green' capital investment at approximately USD 4 trillion, highlighting that the lion's share must be mobilized from private sources through adequate pricing and effective financial-political linkages (IEA, 2021). A sector-specific analysis presented in the World Energy Outlook 2024 underscores the critical importance of financial incentives in the electricity sector, heavy industry, and transport, where entry barriers for green technologies remain the highest (IEA, 2024).

The magnitude of the "financing gap" is detailed in the study by Kerr et al. (2025), which substantiates an annual financing requirement of ≥ USD 8.4 trillion for the Global South and stresses that without adjustments in carbon pricing policies and the development of appropriate market infrastructure, private capital will exhaust its potential. The Climate Action Monitor 2024 by the OECD further notes that only 9 out of 51 surveyed countries have comprehensive green finance roadmaps integrated with their Nationally Determined Contributions (NDCs) under the Paris Agreement (OECD, 2024). In its Finance and Investment for Industry Decarbonisation report, the OECD emphasizes the necessity for de-risking mechanisms and public-private partnerships in heavy industry (OECD, 2022).

At the regulatory level, the European Union remains a leader, with its Green Deal supported by the "InvestEU" plan and the Just Transition Fund, forming an integrated push-pull mechanism through direct budget support and regulatory implementation of a taxonomic framework (The European Green Deal). Complementing these efforts are the Sustainable Finance Disclosure Regulation (SFDR) requirements for ESG risk reporting in financial products, which have already triggered a reallocation of over EUR 1 trillion in assets during 2023–2024 (European Parliament, 2024). Moreover, the latest technical report from the EU Platform on Sustainable Finance expands taxonomy criteria to hard-to-abate sectors (EU Platform on Sustainable Finance, 2025).

Monetary and supervisory authorities are also shifting the financial paradigm. For instance, the Bank for International Settlements (IFC Bulletin No. 63) notes that central banks across jurisdictions increasingly incorporate climate data into macroprudential and monetary models. Their participation in the "G20 Data Gaps" initiatives fosters the standardization of transformational

risk indicators (Nefzi, D., Noels, J. et al., 2025). The Climate Risk Landscape 2024 review by UNEP FI reports that the share of banks conducting climate stress testing increased from over 30% in 2021 to 65% in 2024 (Carlin, D. & Li, W., 2024).

Progress reports from the Net-Zero Banking Alliance reveal that 57% of participating institutions have already set sector-specific targets for reducing carbon intensity using science-based scenarios (United Nations Environment, 2024). In its GFSR-2025, the International Monetary Fund warns that unbalanced decarbonization policies may elevate the risk of asset stress transformation in high-carbon sectors, necessitating prudential buffers and new liquidity support instruments (Enhancing Resilience amid Global Trade Uncertainty, 2025).

Regarding market-based financing instruments, the global volume of green bond issuances has exceeded USD 3.2 trillion, with empirical studies confirming their capacity to significantly reduce the emissions intensity of issuing entities. Panel data analysis by Nguyen H. & Duong H. (2025) records a 7–10% reduction in fossil fuel consumption by issuing corporations within two years of green bond placement. Khanchel I. et al. (2025) find that these effects intensify with higher levels of institutional ownership, as shareholder oversight of decarbonization discipline increases. Similarly, Tsipas F. et al. (2024) demonstrate that in countries with mature renewable energy markets, green bond portfolios accelerate the deployment of new RES capacities by 12% faster than the control sample.

Additionally, the private sector is gradually institutionalizing decarbonization metrics. The World Bank Climate Finance Roadmap 2025 envisions consortium-based co-financing models with government risk-sharing not exceeding 30% (World Bank, 2024), while the updated Climate Change Action Plan 2021–25 promotes a “country-platform” approach, whereby NDC-related needs are embedded into partnership and lending strategies (World Bank, 2021). Research by the Bank for International Settlements on climate data underscores that the availability of transparent and comparable indicators is foundational for reducing transaction costs and launching new structured products such as transition-linked loans (Fortanier F., 2024).

Thus, the current research unequivocally points to the multi-level and cross-sectoral nature of the synergy between green financial policy and decarbonization strategies. Successful integration is only possible under conditions of coordination, transparency, political will, and institutional flexibility.

2. RESULTS

The constant increase in the use of fossil fuels, the growth of production and consumption lead to an increase in greenhouse gas emissions, which causes significant damage to the environment. Given the limited resources and the need to reduce the destructive impact on the ecology and environment, there is a need to change the structure of energy resources use in favor of renewable energy sources. Different regions have different levels of greenhouse gas emissions and own experience in decarbonization policies implementation. A case of the **European Union** is a good example of constant actions towards emissions reduction. Most leading EU states have a tendency to emissions reduction and move towards the set goals (fig. 1).

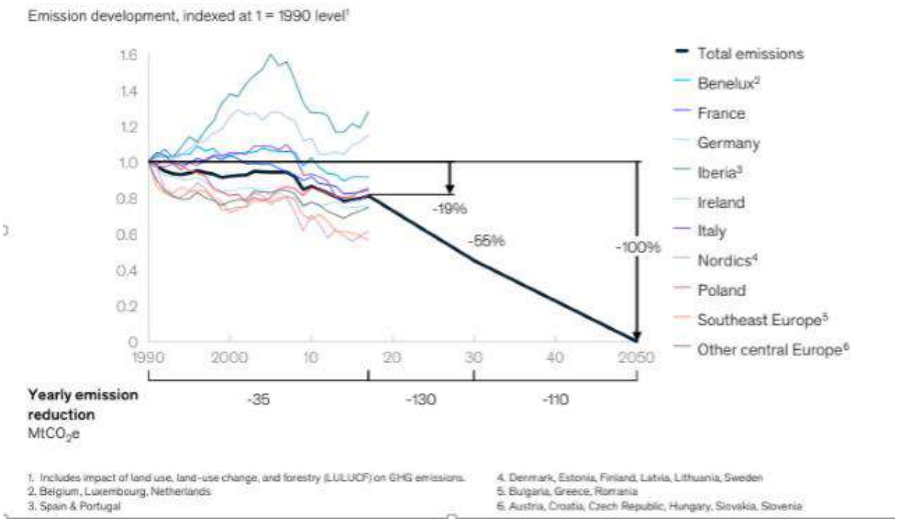

Figure 1. Greenhouse gas emissions dynamics in the EU
Source: McKinsey&Company (2020)

Different sectors of the economy have different volumes of GHG emissions. In the EU industry, power and transportation show the highest level of emissions (fig. 2). It means that these sectors need to be transformed more than others.

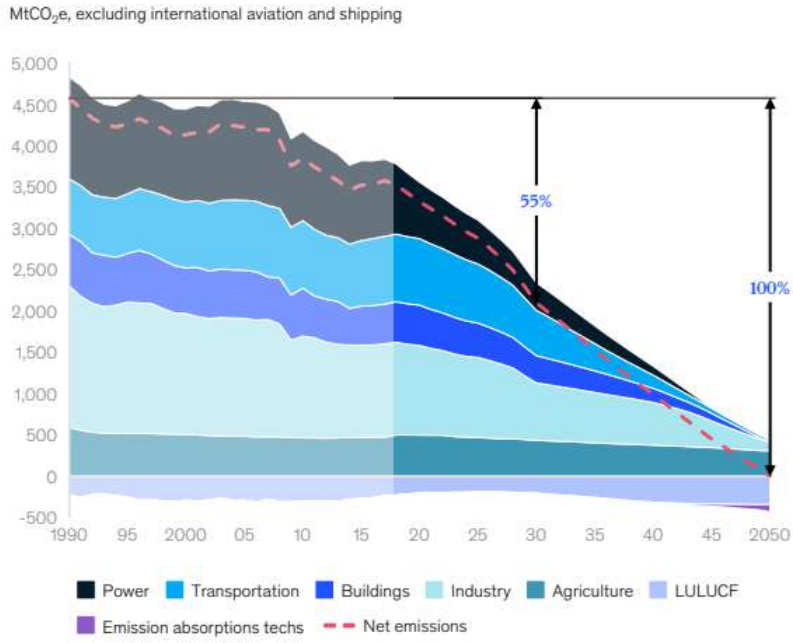

Figure 2. Total emissions per sector for EU-27
Source: McKinsey&Company (2020).

It is worth mentioning that integration groups such as the EU can achieve targeted goals easier than sole states because of compensation mechanism, so they can accumulate their relative advantages and lower transition costs (fig. 3).

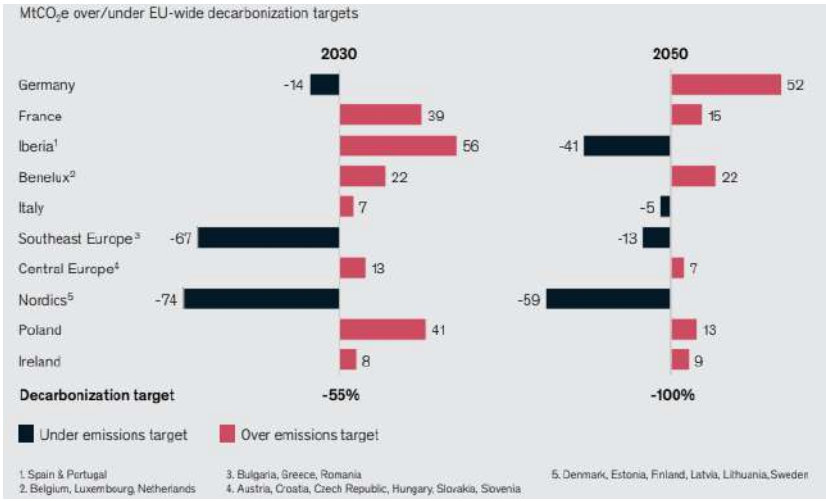

Figure 3. Total emissions reduction for EU-27
Source: McKinsey&Company (2020).

According to McKinsey&Company (2020) on the cost-optimal pathway, some countries' emissions reductions would compensate for others.

It is notable that the European Union has a history of meeting its decarbonization targets:

1. 1997 - Reducing GHG emissions by 8 % by 2012 according to the Kyoto Protocol. The EU over-delivered this target, reducing them by 18 percent.
2. 2010 - Reducing the continent's emissions by 20 percent by 2020. The EU surpassed that goal by 2018.
3. 2019 - the European Commission announced the European Green Deal aiming for climate neutrality. It is a new policy framework intended to accelerate greenhouse gas emissions reduction across the EU.

Among the policies under consideration is a law that would require the bloc to reduce GHG emissions by 55 percent relative to 1990 by 2030 and reach net-zero by 2050 McKinsey&Company, 2020).

3. REGULATORY FRAMEWORK

The European Green Deal serves as the strategic foundation for the EU's sustainability agenda (European Commission, 2019). It outlines the overarching goal of making Europe the first climate-neutral continent by 2050, setting in motion a wide range of legislative and regulatory initiatives.

It is not a law itself, but it catalysed the development of specific frameworks aimed at greening the economy, including supply chains.

This transition will require enormous investment: EU estimates project an additional €350 billion per year in clean energy investments this decade. To finance this, the EU is leveraging both public funds – e.g. dedicating €1 trillion from the 2021-2027 EU budget and NextGenerationEU recovery fund towards green objectives – and private capital, which must fill a remaining investment gap of at least €2.5 trillion (Brühl, 2021). Recognizing that private finance is crucial, the EU has enacted a comprehensive Sustainable Finance Strategy to guide capital toward decarbonization.

A keystone of the EU sustainable finance regulations is the EU Taxonomy for sustainable activities, introduced in 2020. The EU Taxonomy Regulation defines what qualifies as an environmentally sustainable economic activity (European Parliament & Council of the European Union, 2020). This classification system is crucial because it provides the technical basis for other legislative measures. It directly supports the Sustainable Finance Disclosure Regulation (SFDR) by helping financial market participants identify and disclose the sustainability characteristics of their investment portfolios (European Commission, n.d.). It also underpins the Corporate Sustainability Reporting Directive (CSRD) (European Parliament & Council of the European Union, 2022), by offering concrete criteria for companies to report the environmental sustainability of their operations and supply chains.

Instruments such as the EU Taxonomy Regulation, the Sustainable Finance Disclosure Regulation (SFDR), and the Corporate Sustainability Reporting Directive (CSRD) aim to embed sustainability into financial decision-making, enhance corporate transparency, and align private capital with climate objectives. Complementary initiatives, including the Corporate Sustainability Due Diligence Directive (CSDDD), the Carbon Border Adjustment Mechanism (CBAM), and the Deforestation-Free Products

Regulation, further extend these principles into supply chain governance by imposing new reporting, due diligence, and emissions accountability obligations on firms and their suppliers.

While the CSRD focuses on enhancing transparency through standardized sustainability reporting, the CSDDD establishes binding due diligence obligations for companies to identify, prevent, and mitigate adverse human rights and environmental impacts in their operations and supply chains (Corporate Sustainability Due Diligence Directive, 2025). Together, they promote greater accountability and ESG compliance throughout the value chain. The CSRD's entry into application expected in 2025 was postponed. In April 2025, the EU Council and Parliament formally approved the 'Stop-the-clock' mechanism – a directive (part of the "Omnibus I" package) that delays CSRD reporting application for "wave 2" large companies and listed SMEs by 2 years, now effective from 2027 instead of 2025, and postpones CSDDD transposition and initial enforcement (for the largest companies) by 1 year (Council of the European Union, 2025) (fig. 4). The CSDDD was initially expected to apply to the large companies starting from 2026.

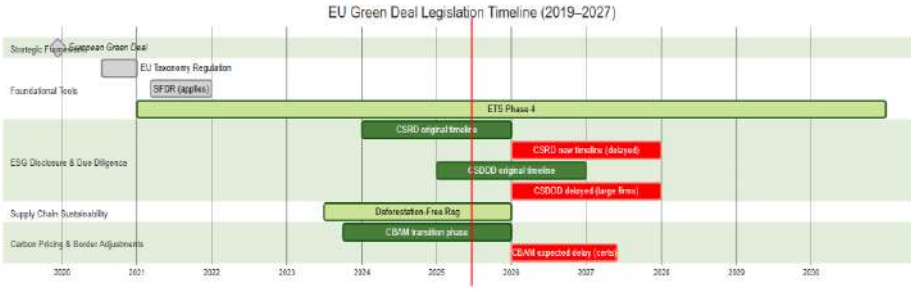

Figure 4. EU Green Deal Legislation Timeline (as of June 2025)
Source: conceptualized by the authors, AI-aided (ChatGPT) (syntax), created with mermaid.js.org

The EU Emissions Trading System (ETS), as a long-standing mechanism for carbon pricing within the EU, lays the groundwork for the Carbon Border Adjustment Mechanism (CBAM) (Corporate Sustainability Due Diligence Directive, 2025). CBAM is designed to address carbon leakage by imposing a carbon cost on certain goods imported into the EU. In essence, it brings carbon

pricing into global trade by requiring importers to buy certificates equivalent to the CO_2 emissions embedded in products such as steel, cement, and fertilizers. By extending the logic of the EU Emissions Trading System (ETS) to imports, CBAM creates a level playing field between EU-based producers and foreign competitors, encouraging manufacturers outside the EU to reduce emissions if they wish to retain access to the European market.

This mechanism compels companies to gain deeper insight into the environmental footprint of their supply chains. It not only promotes emissions tracking and reporting across upstream operations but also incentivizes collaboration with suppliers to implement decarbonization strategies. This aligns closely with broader EU climate goals, particularly in advancing clean energy technologies, upgrading industrial infrastructure, improving energy efficiency, and supporting circular economy initiatives. These areas are also the focus of green finance instruments, with policies like the Sustainable Finance Disclosure Regulation (SFDR) and the EU Taxonomy providing financial incentives or penalties depending on the environmental impact of supply chain activities as captured by CBAM compliance data.

Together with the CSRD and CSDDD, CBAM forms part of a wider regulatory framework that underpins sustainable value chain governance. Financial institutions are increasingly incorporating emissions performance—particularly Scope 3 emissions—into their investment and lending criteria. Tools such as sustainability-linked loans and green supply chain finance offer favorable terms to companies that can demonstrate lower emissions across their supplier base, especially when verified under EU-aligned reporting standards. Although the initial reporting phase of CBAM (2023–2025) remains intact, the start of certificate purchasing is now expected to be postponed until 2027, with actual financial obligations likely commencing in May of that year (S&P Global, 2025). This delay is intended to provide businesses, particularly smaller importers, with additional time to prepare the necessary data systems and compliance processes. While the timing of the cost burden shifts slightly, the core objective remains. The inclusion of a mass-based exemption threshold is also seen as a pragmatic step that eases compliance for smaller firms while still covering the vast majority of emissions, reportedly up to 99 per cent, thus striking a balance between environmental ambition and economic practicality.

The Deforestation-Free Products Regulation complements the CSDDD by targeting a specific environmental risk within supply chains. It prohibits the sale of products in the EU that are linked to deforestation, thus reinforcing corporate obligations to trace and verify the origins of raw materials – a core requirement also addressed under the due diligence framework of the CSDDD (European Commission, 2025).

With regard to these actual and potential delays, the official position of the European Council is that this move aims at cutting red tape, boosting competitiveness, and providing legal certainty. Indeed, it will give companies enough time to implement the systems necessary for the society and climate impact disclosure systems, and align with evolving standards. Further, considering the substantive amendments to CSRD and CSDDD, as well as the related ESRS, the delay is necessary to help avoid confusion from these simultaneous changes in legislation. In addition, it aligns with the broader EU's efforts to simplify legislation and reduce burdens, especially on SMEs.

On the other hand, while the delay eases immediate compliance burdens and helps businesses plan, it also raises concerns about consistency in the EU's green agenda. The 'Stop-the-clock' mechanism risks undermining credibility of the EU's sustainability framework and weakening its global leadership: despite the fact that it should not be regarded by the real sector as a "break" but rather as some additional time granted to streamline ESRS, simplify reporting templates, and clarify the scope, the approval of "Omnibus I" also can serve as an argument to highlight the contradictory nature of sustainable development commitments and the necessity to preserve the competitiveness of the EU industries, and member states at large, in times of global pressures and growing uncertainty.

The expected delay to CBAM will possibly postpone the financial internalization of climate risks across supply chains, and disincentivize early-mover investments in cleaner processes or green sourcing. On the positive side, it gives the time necessary to integrate CBAM data into broader ESG reporting (e.g., CSRD, SFDR), and a chance for financial institutions to align their green finance products (like supply chain transition loans or green trade finance) with upcoming carbon pricing signals. National and corporate strategies must use

the delay to build data pipelines, traceability tools, and incentives for supplier transition, especially in carbon-intensive sectors.

While the core principles and regulatory frameworks of EU sustainability policy were developed during a relatively stable period (prior to the compounded global disruptions of the COVID-19 pandemic and the escalating geopolitical tensions post-2022), their implementation now unfolds under markedly different conditions. The recent EU decisions to delay the enforcement of key regulations, such as the CSRD, CSDDD, and CBAM, are officially framed as efforts to provide companies with the necessary time and clarity to comply. However, this shift raises the question of whether such postponements reflect an underlying tension between the EU's long-term commitments to sustainable development and the immediate imperatives of maintaining industrial competitiveness and economic stability in a volatile global context. Further study is warranted to assess whether these delays indicate a recalibration of sustainability ambitions under pressure, or a strategic realignment that seeks to preserve both environmental goals and economic resilience.

Another novel tool is the EU Climate Benchmarks regulation: since 2019 the EU has created Paris-Aligned and Climate Transition benchmark standards for financial indices, which only include companies on credible decarbonization trajectories, including full disclosure of the index carbon intensity and its alignment with a 1.5°C path. These benchmarks help investors allocate to low-carbon portfolios and encourage companies to reduce emissions to be included (Brühl, 2021).

Together, these policies are reshaping the landscape of supply chain management, where sustainability is no longer a voluntary or reputational concern but a regulated and increasingly financialized imperative. Access to green finance, eligibility for ESG-linked instruments, and participation in EU markets are progressively contingent on an organization's ability to trace, report, and reduce environmental impacts across its upstream and downstream operations.

At the same time, the evolving regulatory and financial environment is intersecting with a wave of technological innovation that is reshaping supply chain management at a structural level. Advanced digital tools, particularly

artificial intelligence (AI), blockchain, quantum computing, and Internet of Things (IoT) technologies, are enabling new levels of transparency, traceability, and predictive decision-making. These innovations are especially critical for meeting the increasing demands of sustainability reporting, emissions tracking, and due diligence required under the CSRD, CSDDD, and CBAM.

For instance, AI-powered analytics can optimize logistics for carbon reduction, monitor supplier compliance in real time, and flag ESG risks across complex, multi-tiered networks. Quantum computing, though still emerging, promises to dramatically enhance supply chain scenario modelling and risk management, particularly for climate-related disruptions and regulatory compliance forecasting (SupplyChainBrain, 2024). Blockchain and distributed ledger technologies offer secure, verifiable records of product provenance, emissions data, and ethical sourcing, which is seen as an essential foundation for robust ESG assurance and green finance eligibility.

Beyond technology, innovations in green finance architecture, including sustainability-linked supply chain finance, performance-based ESG incentives, and dynamic pricing tied to carbon intensity, are helping companies align operational and financial strategies with sustainability goals. These tools not only facilitate compliance with new regulations but also create a competitive edge and market-driven momentum for decarbonization and responsible sourcing.

Together, these advancements position supply chains not just as a locus of regulatory risk, but as a frontier for sustainable innovation and value creation. As the EU refines its regulatory timelines and instruments, the convergence of policy, technology, and finance will increasingly define which firms are able to lead in the transition toward resilient, transparent, and low-carbon global trade systems.

4. GREEN BONDS AND MARKET INSTRUMENTS

Europe also leads in green bond development. The EU and its member states have become major issuers of green bonds (e.g. France and Germany issued sovereign green bonds, and the European Commission itself issued €250 billion in NextGenerationEU green bonds). By 2021, Europe accounted for roughly half of global green bond issuance. To bolster integrity, the European

Commission proposed a European Green Bond Standard (EU GBS). This voluntary standard (expected to be finalized in 2023/24) defines rigorous requirements for green bonds: proceeds must fund Taxonomy-aligned activities, issuers must publish allocation and impact reports, and external auditors supervised by ESMA must verify compliance. These strict criteria are designed to enhance transparency and investor confidence by ensuring bond funds genuinely contribute to decarbonization, thus avoiding greenwashing. Academic and policy analyses view the EU GBS as an important step to standardize green finance products and channel more private capital into high-quality green projects. In addition, EU policymakers have discussed innovative incentives – for example, a debated "green supporting factor" in banking capital rules (reducing capital requirements for green loans) to stimulate lending to low-carbon projects, and possible tax incentives (such as accelerated depreciation for green investments) to further spur private green investment (Brühl, 2021).

Although the EU accounts for only 7 % of global GHG emissions, the benefits of a net-zero Europe would be significant. A Europe on net-zero trajectory would accelerate investment in green technologies, test and refine global industrial strategies and market designs, and encourage other countries to make their own climate change goals more ambitious. Besides, European Commission`s climate change proposals, such as imposing a carbon border tax, would influence the carbon footprint of supply chains around the world.

Another case that is worth to analyse is developing countries` experience. Many developing countries (e.g. India, South Africa, Brazil, Indonesia, etc.) have in recent years begun leveraging green finance to support their decarbonization and sustainable development goals. While these countries contribute far less to historical emissions, they face the dual challenge of growing their economies and shifting to low-carbon pathways. Academic and institutional literature emphasizes innovative financing solutions – from blended finance to **public-private partnerships (PPPs)** – as critical to mobilize the large investments needed in these regions.

4.1 National Policies and Local Initiatives

An increasing number of emerging economies have launched national green finance strategies or institutions. India, for example, created a National Investment and Infrastructure Fund with a focus on green infrastructure and has seen several green bond issuances by public-sector entities for renewable energy. Brazil's central bank integrated climate risk into its banking supervision and encouraged sustainability-linked loans in agriculture. *South Africa* in 2022 released its **Green Finance Taxonomy**, aligned with the EU's framework, to guide investors toward climate-friendly projects and reduce ambiguity (National Treasury, Republic of South Africa, 2021). South Africa also set up a Climate Finance Facility to use concessional funds to de-risk clean projects. Such local efforts often draw on international best practices: for instance, the South African taxonomy was developed with technical support to ensure interoperability with global standards. Developing countries have also experimented with sovereign green bonds – e.g. Nigeria and Fiji were early issuers; by 2020-2022, others like Chile, Indonesia, Egypt, and Thailand sold green bonds to fund solar farms, sustainable transport, or adaptation measures. These issuances are academically notable for building local capital market capacity for green investment, though scholars call for rigorous impact tracking of the funded projects.

4.2 Blended Finance and PPPs

Given limited public coffers, *blended finance* (mixing public, philanthropic, and private investment) has gained traction as a way to fund decarbonization in developing countries. A Stanford review analyzed blended finance vehicles and found they are increasingly deployed to support clean energy transitions (National Treasury, Republic of South Africa, 2021). Key themes include the importance of structuring funds to provide first-loss capital or credit enhancements that attract private investors by reducing risk. For example, the **Global Energy Efficiency and Renewable Energy Fund (GEEREF)** – an EU-sponsored fund-of-funds – and the **Climate Public-Private Partnership (CP3)** program – backed by the UK and Asian Development Bank – both use public money to catalyze much larger private flows into renewables and energy efficiency projects in Africa, Asia, and Latin

America. Case studies of these funds show some success in raising private-to-public investment multiples, though also highlight issues like measuring "additionality" (whether projects would have happened without blended finance) and ensuring transparent impact reporting. Similarly, public-private partnerships have been employed for green infrastructure – for instance, PPP models are financing mass transit and wind farms in countries like India and Vietnam, often with multilateral development bank support. Academic assessments stress that well-designed PPP contracts can allocate risks appropriately and deliver projects on time but require robust governance to achieve environmental outcomes. Overall, blended finance and PPPs are seen as essential for scaling climate investment in developing markets but need to be greatly expanded to bridge the trillions in funding gap.

Based on the analysis of innovative green financing instruments and policies, a matrix was created "Policy Lever – Financial Channels" Matrix (table 1).

Table 1. 'Policy Lever – Financial Channels' Matrix

№	**Policy lever**	**Financial channels**	**Principal financial instruments & structures**
1	Carbon pricing and phase-out of fossil-fuel subsidies	A predictable carbon price (ETS, carbon tax) increases future cash-flows of low-carbon projects, raising their internal rate of return. Redirected subsidy savings expand fiscal space for green incentives.	– Emissions Trading Schemes (ETS) with free-allocation phase-down. – Carbon Contracts for Difference (CfD) guaranteeing a strike price. – Termination of tax rebates on diesel, coal, gas.
2	Targeted concessional and blended finance	Public lenders (DFIs, climate funds) accept first-loss or below-market returns; private lenders capture senior tranches, cutting weighted-average cost of capital (WACC) by 300-600 bp. Every public dollar can attract ≥ 5 private dollars ("crowd-in" effect).	-Blended-finance platforms (e.g., IFC's MCPP, GCF's Private Sector Facility). -Syndicated loans with pari-passu DFIs. -Risk-sharing facilities.
3	Capital-adequacy reform and MDB alignment	Lower green risk-weights and higher limits for long-tenor lending enlarge balance-sheet capacity. Multilateral Development Banks (MDBs) align portfolios to Paris	– Revised Basel III/IV risk-weight tables for climate-positive assets. – Hybrid capital instruments for MDBs.

		goals and recycle callable capital faster.	– Portfolio guarantees provided by donor trust funds.
4	Green taxonomies, data standards and mandatory ESG disclosure	Clear eligibility criteria reduce due-diligence costs and information asymmetry. Mandatory Task-Force-style disclosure (TCFD, ISSB) penalises "green-washing", redirecting investor demand to verified assets.	– EU Taxonomy, ASEAN Taxonomy, China CSRC Green Catalogue. – Sustainable Finance Disclosure Regulation (SFDR) art. 8/9 funds. – Climate transition benchmarks.
5	National climate strategies integrated into budget processes (NDC tagging)	"Green tagging" of public expenditure creates an investable project pipeline with sovereign guarantees. Medium-term expenditure frameworks anchor private expectations.	– Climate-budget tagging systems (e.g., Indonesia, France). – Sovereign green bonds linked to tagged capital spending. – Public-private project preparation facilities.
6	Innovation support: R&D grants and tax credits	De-risks early-stage technologies (TRL 4-6) and bridges the "valley of death" to demonstration and first-of-a-kind (FOAK) plants. Lowers technology learning curves, enabling private equity entry.	– Competitive R&D grants (ARPA-E-type programmes). – Production tax credits (e.g., US IRA section 45X). – Milestone-based innovation prizes.
7	Credit enhancement: guarantees, insurance, first-loss capital	Public or philanthropic first-loss layers shift the loss-distribution curve, making projects bankable. Guarantees unlock local-currency financing in emerging markets.	– Partial risk guarantees (PRG) and political risk insurance (MIGA, ATI). – Green guarantee facilities (EIB, KfW). – Collateralised loan obligations with subordinated public tranche.
8	Sovereign transition frameworks: sustainability-linked bonds (SLB) and debt-for-climate swaps	Links coupon step-ups or face-value reductions to measurable climate KPIs, incentivising ambitious policies. Debt swaps free fiscal space for adaptation and mitigation investment.	– Sovereign SLBs with emissions-intensity targets (e.g., Chile 2023). – Debt-for-nature/climate swaps (e.g., Belize, Barbados). – Performance-based buy-down facilities.

Source: Conceptualized by the authors on the basis of Naran et. al., 2024

Hence, an “adaptive synergy” is forming between financial and political mechanisms, as regulatory signals—such as carbon pricing, taxonomy, and SFDR disclosures—enhance the attractiveness of green instruments, while their success in capital mobilization reinforces political trust and supports more ambitious climate objectives. A comparative analysis across over 40 countries identifies four typical configurations: budget-driven, market-de-risked, monetary-active, and hybrid. The highest environmental effectiveness at the lowest budgetary cost is demonstrated by states that combine taxonomical regulation with an active role of central banks and institutional investors. This typology serves as a foundation for the roadmap of regulators and financial institutions, aiming to optimize green finance portfolios, develop transition finance products, and implement resource-efficient incentives for sustainable development.

The results demonstrate that green finance policies have a positive impact on decarbonization through several key channels: 1) stimulating innovation in the field of green energy; 2) restructuring of industrial capacities; 3) increasing energy efficiency and supporting circular economy projects.

So, a mix of regulatory standards, strategic public funding, and market development is considered as a model for mobilizing finance at scale for decarbonization, albeit one that must continue evolving. Its effectiveness will ultimately be measured by how rapidly capital flows shift from high-carbon to low-carbon sectors, a trend that early data and disclosure reports are beginning to track.

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