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CLIMATE CHANGE AND ARTIFICIAL INTELLIGENCE: ADDRESSING GLOBAL CHALLENGES WITH INNOVATIVE SOLUTIONS

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INTRODUCTION

This paper seeks to explore the emerging macroeconomic trend that exert a significant impact on a global scale. Among these phenomena, climate change stands out as one of the most critical and extensively debated issues. As Sabine Mauderer[1] states, *"Climate change is not a risk of tomorrow"*[2], highlighting how it is already reshaping economies, financial systems, and contemporary society.

The recent catastrophic floods in Spain, the widespread devastation from Hurricanes Milton and Helene in Florida, and the alarming rise in global temperatures—now over 1.5° C above pre-industrial levels—are all stark reminders of the growing vulnerability of our ecosystems, economies, and societies. Prolonged droughts in Kashmir have led to serious water shortages, while Emilia Romagna in Italy has faced disastrous flooding due to relentless heavy rainfall. These events not only highlight the increasing severity of extreme weather but also reveal the systemic risks they pose to our macroeconomic stability and financial resilience.

These examples represent **physical risks** associated with climate change, which directly impact our assets, infrastructure, and human lives.

However, the world has also to face another significant challenge: the "**green transition**". The goal is to achieve carbon neutrality by 2050. Despite global efforts, Global Political Trends show that global CO2 emissions remain stubbornly high, and this situation may persist and may be longer than the expectations. This slow progress raises concerns over our ability to meet climate targets within the expected timeframe.

The complexities of the green transition give rise to **transition risks** linked to the global shift towards a low-carbon economy. These risks stem from regulatory changes, market shifts, and shifting consumer preferences. Industries reliant on carbon-intensive processes may face declining demand, asset devaluations, and increased compliance costs as new environmental policies and carbon pricing mechanisms are implemented.

[1] She currently serves as Vice President of the Deutsche Bundesbank, and in January 2024, she was appointed as Chair of the *Network for Greening the Financial System* (NGFS), a global network of central banks and supervisory authorities committed to promoting a more sustainable financial system. Link available: Dr Sabine Mauderer. https://www.bundesbank.de/en/bundesbank/organisation/executive-board/sabine-mauderer-758366.

[2] https://www.bis.org/events/green_swan_2024/overview.htm

Both **physical and transition risks** have the potential to amplify traditional categories of financial risks, such as credit, market, operational and liquidity risks, thereby posing significant challenges to financial institutions.
The combined impact of physical risk events, the imperative to transition towards a low-carbon, resource-efficient and sustainable economy, as well as other *"environmental, social, governance"* (ESG) challenges, are causing and will cause profound economic transformations that significantly affect the financial sector[3].

In this context, governments, central banks, and financial supervisors are confronted with unprecedented set of challenges[4]. With uncertainty at an all-time high, they find themselves navigating through uncharted waters. To address these complex challenges, the commitment of financial institutions has intensified through the adoption of frameworks and guidelines that focus on incorporating climate considerations into their risk management and policy framework.

In light of this, **Artificial Intelligence** (AI) stands out as a transformative tool that has the potential to address some of humanity's most complex problems such as climate change. This can significantly enhance the ability of financial institutions to assess, monitor, and mitigate climate-related risks. AI addresses these challenges by leveraging machine learning and deep learning algorithms that process vast amounts of structured and unstructured data from diverse sources to generate more accurate and real-time analysis.
AI-driven technologies[5] are already making a tangible impact: predictive models forecast natural disasters with greater precision, allowing communities to better prepare; smart grids optimize energy consumption, reducing electricity waste autonomously; and AI-powered satellites monitor deforestation in real time, supporting efforts to combat illegal logging.

[3]https://www.eba.europa.eu/sites/default/files/2025-01/fb22982a-d69d-42cc-9d62-1023497ad58a/Final%20Guidelines%20on%20the%20management%20of%20ESG%20risks.pdf
[4] https://www.bis.org/events/green_swan_2024/overview.htm
[5] www.devvibe.com/

This thesis is structured as follows.

The **first chapter** describes the regulatory landscape surrounding climate-related risk management at both the International and European levels.

It begins with an analysis of the **Paris Agreement** (2015) that established a global commitment to keep the rise in average temperatures well below 2°C above pre-industrial levels, with a push to limit it to 1.5°C. This agreement did not only lay out ambitious climate goals but also triggered a worldwide momentum towards greater environmental responsibility and transparency, especially in financial markets.

Building on this momentum, the **Financial Stability Board (FSB)** created the **Task Force on Climate-related Financial Disclosures (TCFD)**, which developed a structured framework designed to enhance and standardize how companies disclose climate-related financial risks and opportunities. Having consistent and comparable disclosures about climate-related financial risks is becoming increasingly important for market players and financial authorities, as it gives them the information needed to manage risks and seize opportunities arising from climate change[6]. The TCFD's recommendations have gained recognition as a global benchmark for corporate reporting on climate issues, providing key definitions and outlining the main characteristics of climate change as they affect business operations and financial stability.

At the European level, the **European Green Deal** represents a transformative policy initiative intended to confront the urgency of the climate crisis while reshaping the European Union's economic model. Its goal is to achieve climate neutrality by 2050, all while fostering a sustainable, resource-efficient, and competitive economy. The Green Deal introduces a comprehensive set of strategies and legislative proposals to drive investment into green technologies, enhance energy efficiency, and ensure a fair transition for all sectors and regions.

Consequently, regulatory instruments such as the **EU Taxonomy for Sustainable Activities** and the **Corporate Sustainability Reporting Directive (CSRD)** have been

[6] https://www.fsb.org/work-of-the-fsb/financial-innovation-and-structural-change/climate-related-risks/

established. The EU Taxonomy provides a classification system that helps identify which economic activities can be considered environmentally sustainable. This creates a clear and consistent framework for investors, companies, and policymakers. On the other hand, the CSRD significantly strengthens corporate disclosure obligations by requiring large and listed companies to report detailed information on their environmental, social, and governance (ESG) performance. Together, the EU Taxonomy and CSRD play a strategic role in enhancing market transparency, guiding capital towards sustainable investments, and supporting the European Union's broader sustainability goals.

The regulatory landscape is still evolving. For instance, on 26th of February 2025, the European Commission published the first **EU Omnibus Simplification Package** on sustainability reporting. This package aims to simplify the various directives issued over time to guide companies in their sustainability disclosures. One of the key elements retained in this package is the requirement for a "**double materiality analysis**", which companies across all sectors are expected to conduct.

Double materiality requires companies to assess and report on material issues from two perspectives:

- **Financial materiality**, which considers how ESG factors affect the company's financial performance (e.g., climate risks impacting revenues or costs).
- **Impact materiality**, which focuses on how the company's activities affect people, society, and the environment (e.g., carbon emissions, biodiversity loss, or human rights issues).

The **second chapter** is dedicated to an in-depth analysis of the recommendations issued by the **Task Force on Climate-related Financial Disclosures (TCFD)**, which have become an essential international reference point for companies seeking to enhance transparency around climate-related financial risks and opportunities.

The TCFD framework structures its recommendations across four key thematic areas:

- **Governance**: Organizations are required to disclose the governance structures and processes in place to oversee climate-related risks and opportunities, including the role of the board and management in assessing and managing these factors.
- **Strategy**: Companies must describe the actual and potential impacts of climate-related risks and opportunities on their business model, strategy, and financial planning over different time horizons.
- **Risk Management**: Organizations should explain how they identify, assess, and manage climate-related risks, and how these processes are integrated into their broader enterprise risk management frameworks.
- **Metrics and Targets**: Entities are expected to disclose the metrics used to assess climate-related risks and opportunities, as well as the targets set to manage such risks and track performance against them.

Emphasis is placed on the **energy sector**, which is recognized as being particularly vulnerable to a wide range of climate-induced impacts. These include extreme weather events such as rising average temperatures, prolonged heatwaves, sudden cold snaps and heavy snowfalls, severe drought conditions, intense precipitation, sea-level rise, hurricanes, and wildfires. Given its reliance on stable environmental conditions for production and distribution, the energy sector faces both **physical risks** (e.g., damage to infrastructure) and **transition risks** (e.g., policy shifts, technological changes, market dynamics) linked to climate change.

This chapter also highlights the extent to which **energy companies** are aligning their disclosures with the TCFD recommendations. Through an examination of current reporting practices, it identifies which specific information is typically disclosed by energy firms.

The third chapter focuses on the growing importance of the so-called **"connectivity" between sustainability information and financial reporting**. This concept refers to the need for a coherent, integrated view of how ESG factors — and in particular climate

change — directly or indirectly influence a company's financial position, performance, and prospects.

Connectivity can be of two types:

- **Direct connectivity**, where sustainability factors have an immediate and measurable impact on financial figures (e.g., asset impairments due to regulatory changes related to climate policy).
- **Indirect connectivity**, where sustainability issues affect broader strategic, operational, or reputational aspects of a company, which over time may translate into financial effects.

In the specific context of **climate change**, this connectivity is particularly critical, as climate-related risks — both physical risks and transition risks — can have a profound impact on the **carrying amount of assets** reported in the financial statements.

A key accounting standard addressing this issue is **IAS 36 - Impairment of Assets**, which establishes the principles for testing whether the carrying value of an asset exceeds its recoverable amount. When climate-related factors are expected to negatively affect the future cash flows generated by an asset, companies must recognize an **impairment loss** to adjust the asset's book value accordingly.

The chapter concludes with practical examples of companies in the **energy sector**, which is particularly exposed to climate risks due to its reliance on carbon-intensive assets and long-lived infrastructure, such as **BP**, **Royal Dutch Shell**, and **Vattenfall**, which have historically recorded significant impairment losses attributable, at least in part, to the evolving climate-related risks landscape and regulatory frameworks.

The **fourth chapter** focuses on representing the current process ("**AS IS**") of climate-related risk management within energy sector companies (**A2A** and **Edison**), based on interviews conducted with *Heads of Finance* and *Chief Risk Officers.* These interviews provide valuable insights into how climate risk is presently integrated within corporate **Enterprise Risk Management** (ERM) frameworks.

The findings clearly demonstrate that climate risk is no longer a standalone issue. Instead, it is increasingly analyzed and managed in relation to the companies' **overall strategic** and **financial goals**.

Climate-related risks are thus considered not merely as compliance or reporting issues, but as **strategic drivers** that can materially impact business models, investment decisions, and long-term corporate resilience.

However, the interviews also revealed some **challenges** in the "AS IS" approach:

- Data scarcity and fragmented information make it difficult to consistently quantify and forecast climate risks.
- Traditional risk management tools often lack the sophistication required to model complex, non-linear impacts of climate change across different geographic regions and asset types.

To overcome these challenges, the **role of Artificial Intelligence (AI)** as a transformative tool for enhancing climate risk management emerged. It is analyzed in the **fifth chapter**. AI offers the potential to:

- **Analyze large volumes of historical data** and **climate time series**, enabling more granular and location-specific risk assessments.
- **Simulate complex future scenarios**, including multi-variable interactions between climate phenomena, economic variables, and regulatory developments.

So, this chapter illustrates the process "TO BE" of climate risk management and highlights that **the adoption of AI technologies** represents the next frontier to achieve more **robust, predictive, and strategic** climate risk management practices.

The thesis concludes with **econometric analyses**, aimed at investigating the relationship between corporate financial performance and environmental sustainability, with a particular emphasis on climate-related factors. To build a significant database, data has been collected by looking at MSCI's proprietary indexes. In particular, the chapter is divided into four successive regression models, each aimed at investigating the link between environmental sustainability and economic performance:

- **Baseline Model - Multi-Sector Analysis:** The first regression examines the relationship between economic performance and environmental dimensions of ESG in a heterogeneous sample of industries. This model provides an overview of the association between higher sustainability ratings and higher profitability.
- **Sectoral Impact-Interaction with the Energy Sector:** The second model focuses on the energy sector, including a sectoral dummy variable and interaction terms. The goal is to test whether the effect of environmental performance is significantly different, and potentially more pronounced, for energy firms than for other sectors.
- **Robustness check - Controls over the whole sample:** The third regression introduces control variables such as firm size (proximate by turnover) and firm age. This allows testing the robustness and economic-statistical validity of the observed relationships, considering the structural characteristics of the firms.
- **In-depth sector focus - Controls in the energy sector:** Finally, the fourth model replicates the controlled structure of the previous model but limited to firms in the energy sector. The goal is to test whether the link between environmental sustainability and performance is confirmed-or strengthened-even when isolating a highly regulated and environmentally impactful sector.

In summary, this work aims to highlight how climate change is not just something we need to worry about in the future – it is real and pressing issue that is already having a significant impact on our planet. The effects are becoming more tangible and will continue to intensify in the coming years.

1 Climate Change: Overview

"Climate change is unstoppable"

- Dario Mangili[7], Head of Sustainability and member of the Sustainability Committee at Impact SGR[8].

This statement underlines the severity of the ongoing climate crisis. Former Bank of England Governor Mark Carney has described it as "*the tragedy of the horizon*"[9] as its catastrophic impacts will be felt beyond the traditional horizons of most actors – imposing a cost on future generations.

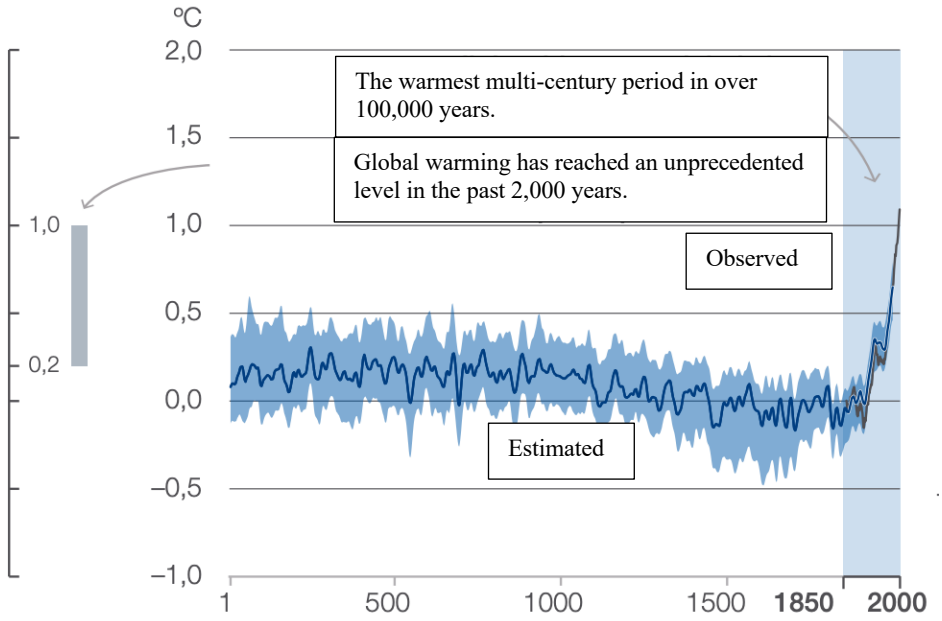

Figure 1- Source: Terna's Climate Change Disclosure 2024

In general, climate change refers to long-term shifts in temperatures and weather patterns[10].

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[7] Article "*Le banche e i rischi fisici del cambiamento climatico*" by aziendabanca- gennaio/febbraio 2025

[8] IMPact is an asset management company specializing in listed impact investing strategies, offering investment solutions that combine financial performance and impact measurement. It aims to generate a net positive impact for people and the environment through innovative investment strategies that measure the net impact generated by investments and their contribution to the achievement of the UN Sustainable Development Goals (SDGs) and the Paris Agreement.
https://www.impactsgr.it/who-we-are/?lang=en

[9] Mark Carney, "Breaking the tragedy of the horizon- climate change and financial stability," September 29, 2015, https://www.bankofengland.co.uk/-/media/boe/files/speech/2015/breaking-the-tragedy-of-the-horizon-climate-change-and-financial-stability.pdf.

[10] https://www.un.org/en/climatechange/what-is-climate-change.

According to the "*Global Climate Highlights 2024"* report by the European Copernicus program, the 2024 was the first year with global temperature more than 1.5°C above the pre-industrial level, with a global average temperature of 15.10°C; 0.12°C higher than the previous highest annual value in 2023[11].

Global temperatures remain consistently among the highest ever recorded, leading to an escalation of extreme climate events and unprecedented environmental transformations. One of the most noticeable impacts is the rise in sea levels, which have increased by approximately 3 mm per year since 1993[12]. This rise poses a serious threat to coastal areas, exacerbating the frequency of flooding and land erosion. At the same time, the accelerated melting of Arctic ice has resulted in the ice sheet's shrinkage rate increasing by 1.5 to 2 times compared to levels recorded between 1950 and 2000.

In parallel, meteorological disasters are becoming increasingly intense and frequent. Since 1970, extreme events like hurricanes, floods, and droughts have risen by approximately 80%, severely testing humanity's resilience.

However, the consequences of climate change extend beyond physical phenomena and impact the socioeconomic sphere[13]. Extreme weather events have severe impacts on various aspects of human well-being, including physical and mental health, as well as higher exposure to allergens.

One of the most critical effects is population displacement: since 2008, approximately 376 million people worldwide have been forced to leave their homes due to floods, windstorms, earthquakes, or droughts, with a record 32.6 million in 2022 alone (European Parliament, 5 October 2023)[14].

Additionally, we are seeing biodiversity loss accelerate at an alarming rate, with estimates indicating that up to one million species could face extinction by the century's end. This would have devastating effects on the ecosystem balance and on the availability of natural resources essential for human survival.

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[11] https://climate.copernicus.eu/global-climate-highlights-2024

[12]https://www.statista.com/statistics/224893/land-and-ocean-temperature-anomalies-based-on-temperature-departure/

[13] https://pmc.ncbi.nlm.nih.gov/articles/PMC9039910/

[14]The sentinel, "Our Role for the Future" of Kieran Doona (2024); Climate_Change_the_Evolving_Role_of_the_OSH_Professional_1740465323%20

From an economic perspective, climate change poses a growing threat to global financial stability. Direct impacts, including infrastructure destruction and damage to production systems, are already causing losses exceeding $200 billion annually. If effective measures are not implemented, global GDP could contract by between 2% and 10% by the end of the century, with would have serious consequences for key sectors such as agriculture, healthcare, and industrial productivity. Developing countries, already struggling with economic and infrastructural vulnerabilities, will be particularly exposed, with climate change potentially irreversibly compromising their growth prospects.
By 2050, it is estimated that the global costs associated with climate change could reach $23 trillion per year, affecting not just infrastructure and the energy sector, but also many other areas crucial for our overall well-being and economic stability.

1.1 International Arena

In response to this increasingly critical scenario, the commitment of countries and supervisory authorities has intensified significantly. This has resulted in the creation of guidelines, directives, regulations, and frameworks[15] aimed at raising awareness and encourage the adoption of strong climate risk management practices (CRM). Through these initiatives, regulatory bodies seek to provide a structured approach for financial institutions and businesses, ensuring that climate risks are effectively integrated into governance, strategy, and decision-making processes.
At the same time, there has been a sharp increase in demand for decision-useful, climate-related information from businesses. Companies are increasingly seeking granular, reliable, and forward-looking data to assess both their exposure to climate risks and emerging opportunities. As highlighted in a KPMG study[16] *"A deeper understanding of one's own climate impacts and exposure to risks and opportunities enables businesses to more accurately assess current and potential impacts. Consequently, this knowledge facilitates the development of effective mitigation and adaptation strategies".*
This growing demand reflects a broader shift in corporate risk management, where climate considerations are no longer peripheral but central to strategic planning and

[15]https://www.eba.europa.eu/sites/default/files/2025-01/fb22982a-d69d-42cc-9d62-1023497ad58a/Final%20Guidelines%20on%20the%20management%20of%20ESG%20risks.pdf
[16] https://assets.kpmg.com/content/dam/kpmg/it/pdf/2020/01/Informativa-rischi-climatici.pdf

financial resilience. The increasing regulatory pressure, combined with heightened expectations from investors and stakeholders, is driving companies to enhance the quality, transparency, and comparability of climate-related information.

1.1.1 Paris Agreement

The Paris Agreement, which has adopted in 2015 during the Conference of the Parties (COP21) [17], marks a significant milestone in the global fight against climate change. It was signed by 195 countries and entered into force on November 4th of the same year, with the aim of addressing the climate crisis in a globally coordinated and equitable manner. Unlike previous treaties, the Paris Agreement involves the universal participation of all nations, regardless of their level of development, establishing common commitments without imposing sanctions for non-compliance. Each country has the option to withdraw from the Agreement three years after its entry into force.

The core element of the Agreement is to limit the increase in global average temperature well below 2°C[18] above pre-industrial levels, while striving to restrict warming to 1.5°C, a threshold considered as vital for reducing the worst effects of climate change. To meet this ambitious target, the signatory countries have committed to reaching a global emissions peak as soon as possible, followed by rapid reductions aimed at achieving a balance between greenhouse gas emissions and removals in the second half of the century. To support these commitments, the Agreement establishes transparency[19] and monitoring systems to make sure that each nation's progress can be tracked and verified. Additionally, every five years, starting from 2020, countries must update and communicate their national climate action plans, setting progressively higher targets. This system ensures the continuous improvement of climate policies.

The Agreement is also based on the principle of "common but differentiated responsibilities", recognizing that developed countries bear a greater historical responsibility for greenhouse gas emissions and must provide financial and technological support to developing nations. Indeed, another key aspect concerns climate finance, which ensures a balance between the commitments required and the financial support

[17] https://unfccc.int/climate-action
[18] https://www.aifirm.it/wp-content/uploads/2020/05/2020-Position-Paper-20-Climate-Change-Risk.pdf
[19] https://www.consilium.europa.eu/it/policies/paris-agreement-climate/#what

provided to the most vulnerable nations. Industrialized countries are required to support mitigation and adaptation projects in less developed nations, thereby enhancing their capacity to respond to climate change challenges[20].

Wealthier countries are expected to support the most vulnerable ones, which have fewer resources to cope with the adverse effects of climate change and limited adaptive capacities. Every two years, more developed nations must submit detailed reports on the financial support provided to less developed countries, including both qualitative and quantitative data. This system not only promotes transparency but also ensures effective monitoring and control of financial flows, contributing to the achievement of global climate goals[21].

1.1.2 United Nations Sustainable Development Goals

Following the adoption of the Paris Agreement, another significant step towards a more equitable and sustainable development model was taken with the approval of the 2030 Agenda for Sustainable Development. On September 25, 2015, during the United Nations Sustainable Development Summit in New York, leaders from around the globe came together to embrace this ambitious agenda. It is part of a broader process of international cooperation aimed at promoting inclusive and sustainable development. This path had already been initiated with the adoption of major global agreements, including the Paris Climate Agreement.

The 2030 Agenda introduces 17 Sustainable Development Goals (SDGs)[22], representing the natural evolution and enhancement of the Millennium Development Goals (MDGs). The MDGs, set up by UN[23] member states in 2000, were designed to be achieved by 2015, but their completion remained only partial, highlighting the need for a broader and more ambitious strategy.

Unlike the MDGs, the 17 SDGs apply to all countries and populations worldwide, making no distinction between developed and developing nations, and thus assuming a universal character. They address a wide range of global challenges, many of which were not

[20] https://www.aifirm.it/wp-content/uploads/2020/05/2020-Position-Paper-20-Climate-Change-Risk.pdf
[21] https://www.consilium.europa.eu/it/policies/paris-agreement-climate/
[22] https://sdgs.un.org/goals
[23] United Nations Organizations

previously included in the MDGs, underscoring the necessity of an integrated and cross-sectoral approach to promote sustainable development. Among the newly introduced themes are climate change, sustainable consumption and production, technological innovation, peace, and justice[24].

A particularly central role within the SDGs is played by Goal 13, dedicated to climate action. This goal is structured around several key actions: strengthening resilience and adaptive capacity to climate-related risks and natural disasters in all countries; integrating climate change measures into national policies, strategies, and planning; and promoting awareness and education among citizens and institutions regarding climate change mitigation, adaptation strategies, and impact reduction[25].

Figure 2 - Source: Department of Economic and Social Affairs - https://sdgs.un.org/goals-

[24] https://www.aifirm.it/wp-content/uploads/2020/05/2020-Position-Paper-20-Climate-Change-Risk.pdf
[25] https://www.urbinati.com/it/17-obiettivi-trasformare-mondo-sdg/

1.1.3 Task Force on Climate-related Financial Disclosure (TCFD)

"***Increasing Transparency makes market more efficient and economies more stable and resilient***"
– Michael R. Bloomberg[26]

In a context of high uncertainty -understood as a condition of limited knowledge where it is difficult or impractical to precisely describe the current state or a future outcome- creditors and investors are increasingly demanding access to risk-related information. These insights must be:

- **Consistent** across industries and sectors.
- **Comparable** allowing investors to assess peers and aggregate risks.
- **Reliable** to ensure trust in the data.
- **Clear** to make complex information understandable.
- **Efficient** to balance costs and benefits.

Since the 2007-2008 financial crisis, there has been a noticeable shift in focus towards how weak corporate governance can negatively affect shareholder value. This has driven increased demand for greater transparency from organizations on their risk management practices, including those related to climate change. When companies do not provide enough information about potential risks, it can lead to mispricing of assets and poor capital allocation, potentially raising concerns about financial stability, as markets can be vulnerable to abrupt corrections[27].

Given such concerns, the G20 Finance Ministers and Central Bank Governors tasked the Financial Stability Board (FSB) with examining how the financial sector should integrate climate-related risks. The Financial Stability Board identified the need for better information to support informed investment, lending and insurance underwriting

[26] https://assets.bbhub.io/company/sites/60/2021/10/FINAL-2017-TCFD-Report.pdf
[27] Mark Carney, "Breaking the tragedy of the horizon- climate change and financial stability," September 29, 2015, https://www.bankofengland.co.uk/-/media/boe/files/speech/2015/breaking-the-tragedy-of-the-horizon-climate-change-and-financial-stability.pdf

decisions and improve understanding and analysis of climate-related risks and opportunities.

To fulfill this need, in December 2015, the FSB established the Task Force on Climate Related Financial Disclosures (TCFD), an industry-led initiative including 32-members[28] from large banks, insurance companies, asset managers, pension funds, large non-financial companies, accounting and consulting firms, and credit rating agencies.

Following extensive consultation, in June 2017, the TCFD released its consultations for climate-related financial disclosure, focusing on four key thematic areas that represent core elements of how organizations operate:

- Governance
- Strategy
- Risk management
- Metrics and targets.

Figure 3 - Source: Recommendations of the Task Force on Climate-related Financial Disclosures, 2017

According to FSB, there are several benefits linked to disclosure including strengthening market discipline, offering data that can be analyzed at a systemic level, and helping authorities assess the materiality of climate-related risks to the financial sector. However,

[28] https://assets.bbhub.io/company/sites/60/2021/10/FINAL-2017-TCFD-Report.pdf

the FSB emphasized that these recommendations should remain voluntary, adhere to the principle of materiality, and maintain a balanced cost-benefit approach.
Greater access to reliable information fosters a virtuous cycle: Better risk assessment for the future, improved pricing accuracy for investors, more informed policy decisions, and a smoother transition to a low-carbon economy.

1.1.3.1 Climate-related Risks

The Task Force divided climate-related risks into two major categories:

1. **Transition risks,** which are linked to the move towards a lower carbon economy.
2. **Physical Risks,** stemming from direct and indirect impacts of climate change[29].

Transition risks

The transition to a low-carbon economy involves significant changes in policy, regulation, technology, and market dynamics, all of which can create financial and reputational risks for organizations.

- **Policy and Legal Risks:** Evolving climate policies aim to either restrict activities that contribute to climate change or encourage adaptation measures. Examples include carbon pricing mechanisms, incentives for renewable energy adoption, energy efficiency initiatives, and sustainable land-use policies. The financial impact of such changes depends on their nature and timing.
- **Technology Risk:** Innovations such as renewable energy, energy storage, and carbon capture technologies can disrupt industries, altering cost structures, supply chains, and consumer demand. Companies unable to keep pace with these advancements may face declining competitiveness[30].
- **Market Risks**: Climate change influences supply and demand dynamics across different sectors. For instance, shifts in consumer preferences and regulatory

[29] https://assets.bbhub.io/company/sites/60/2021/10/FINAL-2017-TCFD-Report.pdf
[30] https://www.aifirm.it/wp-content/uploads/2020/05/2020-Position-Paper-20-Climate-Change-Risk.pdf

changes may reduce demand for carbon-intensive products, affecting companies reliant on fossil fuels.

- **Reputational Risks**: Public perception plays a crucial role in corporate valuation. Companies perceived as lagging in sustainability efforts may suffer reputational damage, impacting their relationships with consumers, investors, and regulators.

Physical risks

Physical risks from climate change can be either **acute**—triggered by extreme weather events—or **chronic**—resulting from long-term shifts in climate patterns—.

- **Acute Risks**: These include immediate, event-driven impacts such as hurricanes, floods, and wildfires, which can cause significant damage to infrastructure, disrupt operations, and lead to financial losses.
- **Chronic Risks**: Gradual climatic changes, such as rising sea levels, prolonged droughts, and sustained temperature increases, can affect resource availability, food security, and overall economic productivity[31].

The growing demand for climate-related transparency reflects a broader awareness that better information management can mitigate uncertainty and strengthen the resilience of the global financial system.

1.1.3.2 Climate-related Opportunities

Climate change is not just a challenge; it also presents significant business opportunities, which can vary based on the industry, market, and region where an organization operates. These opportunities can be strategically categorized into five main areas[32]:

1. **Resource Efficiency**: Companies that optimize energy consumption, material use, waste management, and resource efficiency can significantly reduce costs

[31] https://www.aifirm.it/wp-content/uploads/2020/05/2020-Position-Paper-20-Climate-Change-Risk.pdf
[32] https://assets.bbhub.io/company/sites/60/2021/10/FINAL-2017-TCFD-Report.pdf

while aligning with global sustainability goals. By improving efficiency, they can boost both their financial performance and their positive impact on the environment.

2. **Energy Transition**: The shift towards low-emission energy sources such as wind, solar, wave, and nuclear power is accelerating. Notably, in 2024, for the first time, global investments in the energy transition surpassed $2 trillion[33], highlighting the growing commitment to clean energy solutions.
3. **Products and Services**: Businesses that develop and promote low-emission products and services can strengthen their market position and capitalize on evolving consumer and industry preferences.
4. **Markets**: Proactive organizations can diversify their portfolios by exploring new markets and sustainable investment opportunities. This expansion into green markets allows businesses to tap into climate finance initiatives and benefit from partnerships with governments, development banks, and local enterprises.
5. **Resilience**: Developing adaptive capacity to manage climate risks is crucial for long-term stability. Organizations that invest in climate resilience—whether through supply chain adaptation, infrastructure reinforcement, or risk management strategies—can better mitigate disruptions and seize new opportunities in a rapidly changing environment[34].

1.1.4 United Nations Environment Finance Initiative

The United Nations Environment Programme Finance Initiative (UNEP FI) is a global partnership established in 1992 between the United Nations Environment Programme (UNEP) and the financial sector to integrate sustainability principles into banking, insurance, and investment activities. Acting as a bridge between the financial system and global environmental goals, UNEP FI promotes responsible practices that foster a resilient and low-carbon economy. Today, it collaborates with over 500 financial institutions worldwide, including banks, insurance companies, and investors.

[33] https://about.bnef.com/blog/global-investment-in-the-energy-transition-exceeded-2-trillion-for-the-first-time-in-2024-according-to-bloombergnef-report/
[34] https://assets.bbhub.io/company/sites/60/2021/10/FINAL-2017-TCFD-Report.pdf

UNEP FI has played a crucial role in the development of international regulatory frameworks such as the Corporate Sustainability Reporting Directive (CSRD) [35]which mandates companies to disclose their environmental impact, and the EU Taxonomy[36], a classification system for sustainable investments, both of which are fundamental for "green" finance and CRM. It works closely with governments and regulators to ensure that sustainable finance becomes a core component of global economic policies.
Additionally, UNEP FI leads several major initiatives:

- The **Principles for Responsible Banking (PRB),** adopted by over 350 banks to align their strategies with sustainability goals.
- The **Net-Zero Banking Alliance (NZBA**) and **Net-Zero Asset Owner Alliance (NZAOA),** which commit financial institutions to voluntary efforts in reducing carbon emissions.
- The **Principles for Sustainable Insurance (PSI),** a framework that integrates ESG (Environmental, Social, and Governance) criteria into decision-making in the insurance sector.

Beyond policy development, UNEP FI supports sustainable investment instruments, such as green bonds[37] and sustainability-linked loans, and addresses biodiversity risks that are critical aspects of sustainable finance.

UNEP FI has published different reports and guidelines[38] to support financial institutions in managing climate-related risks. Among the most relevant there is the "*A Practical Guide to 1.5°C Scenarios for Financial Users*"[39], released in January 2025, which provides tools for understanding climate scenarios and evaluating their impact on emissions, energy demand, and financing needs.

[35] For more details, see page 35 of this document.
[36] For more details, see page 33 of this document.
[37] Green bonds are financial instruments that finance green projects and provide investors with regular or fixed income payments – World Bank https://www.worldbank.org/en/news/feature/2021/12/08/what-you-need-to-know-about-ifc-s-green-bonds
[38] https://www.unepfi.org/category/publications/
[39]https://www.unepfi.org/wordpress/wp-content/uploads/2025/01/A-practical-guide-to-1.5C-scenarios-5.pdf

A crucial aspect is UNEP FI's collaboration with the Intergovernmental Panel on Climate Change (IPCC).
The IPCC develops scientific models that help predict how the climate may change under different levels of greenhouse gas emissions. UNEP FI then uses these models in its reports to assess the financial risks and help institutions developing strategies for risk mitigation.

Since April 2024, UNEP FI has launched a program with the Task Force on Climate-related Financial Disclosures (TCFD)[40] to strengthen best practices in climate risk management. This initiative involves over 100 financial institutions in developing tools, frameworks, and methodologies, creating a database of more than 40 tools to improve climate risk assessment, and facilitating dialogue between financial stakeholders and regulators.

UNEP FI is expanding its efforts in new frontiers of "green" finance, addressing biodiversity loss, pollution, and water resource management risks.

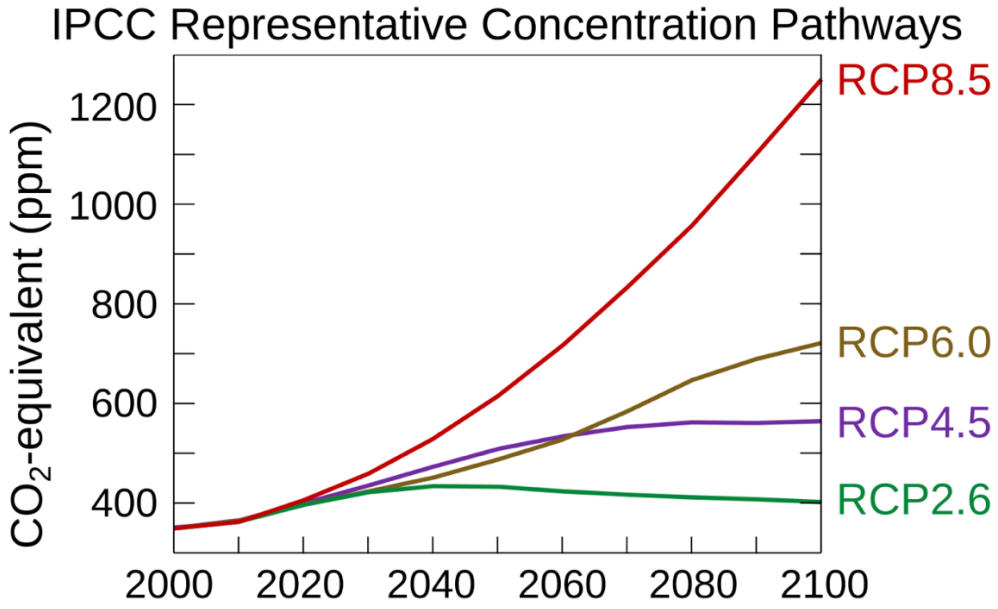


Figure 4 - Source IPCC https://commons.wikimedia.org/w/index.php?curid=87801257.

[40] https://www.unepfi.org/climate-change/tcfd/

Legend:

- **RCP[41] 8.5 (red, worst-case scenario):** high-emission scenario
- **RCP 6.0 (brown, intermediate-high scenario):** delayed stabilization scenario
- **RCP 4.5 (purple, intermediate-low scenario):** moderate stabilization scenario
- **RCP 2.6 (green, best-case scenario):** Low-emission scenario.

UNEP FI includes these scenarios in its reports with the task of helping the transition from high-climate risk scenarios (RCP 8.5) to mitigation pathways (RCP 2.6) through financial instruments, regulations, scenario analysis, and the integration of sustainability into investment and risk management decisions.

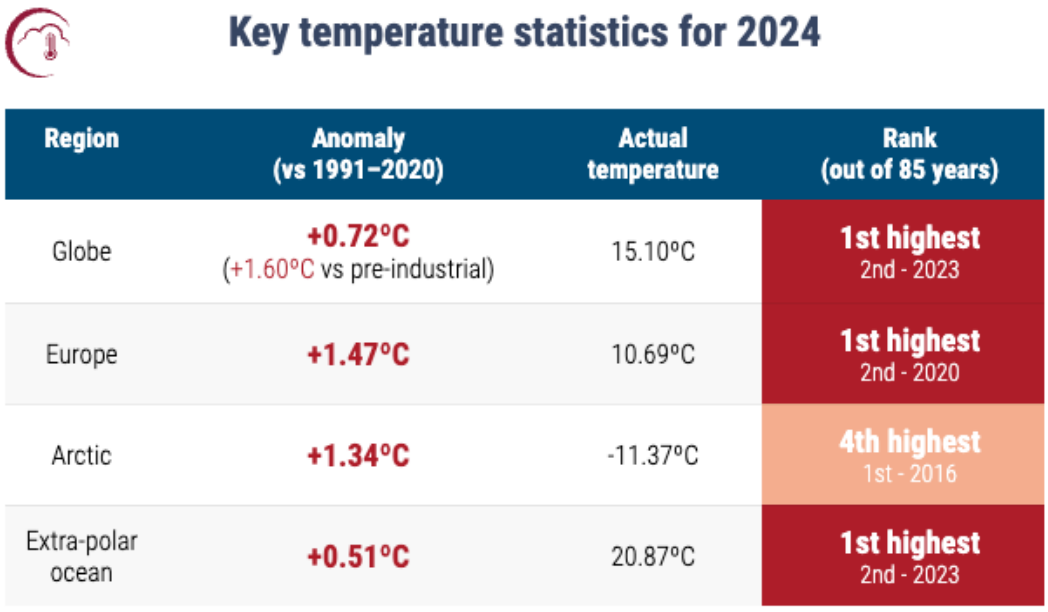
[41] Representative Concentration Pathways (RCP)

1.2 European Arena

Climate change is already affecting Europe in different ways, depending on the region, leading to biodiversity loss, wildfires, declining crop yields, and rising temperatures. The impact extends beyond the environment, posing serious risks to human health.

"***Addressing climate change is one of the European Parliament's top priorities"***[42]

The European Union (EU) is one of the world's largest greenhouse gas emitters.[43] In 2023, the EU ranked as the fourth-largest global emitter, following China, United States, and India[44] . Recognizing its responsibility, the EU plays a key role in international climate negotiations under the United Nations framework, and it is a signatory to the Paris Agreement.



Key temperature statistics for 2024

Region	Anomaly (vs 1991–2020)	Actual temperature	Rank (out of 85 years)
Globe	+0.72°C (+1.60°C vs pre-industrial)	15.10°C	1st highest 2nd - 2023
Europe	+1.47°C	10.69°C	1st highest 2nd - 2020
Arctic	+1.34°C	-11.37°C	4th highest 1st - 2016
Extra-polar ocean	+0.51°C	20.87°C	1st highest 2nd - 2023

Figure 5 - The 2024 Annual Climate Summary "Global Climate Highlights 2024" -

[42]https://www.europarl.europa.eu/topics/it/article/20180703STO07129/le-soluzioni-dell-ue-per-contrastare-i-cambiamenti-climatici#:~:text=Con%20l'accordo%20di%20Parigi,neutralit%C3%A0%20climatica%20entro%20il%202050.

[43] https://climate.copernicus.eu/global-climate-highlights-2024

[44] https://edgar.jrc.ec.europa.eu/report_2022#emissions_table

Under this agreement, the EU initially committed to reducing greenhouse gas emissions by at least 40% by 2030 compared to 1990 levels. However, in 2021, this target was revised to a minimum 55% reduction by 2030, with the long-term goal of achieving climate neutrality by 2050.

Thanks to the consistent policy efforts, Europe has made steady progress, with emissions declining continuously between 1990 and 2023[45].

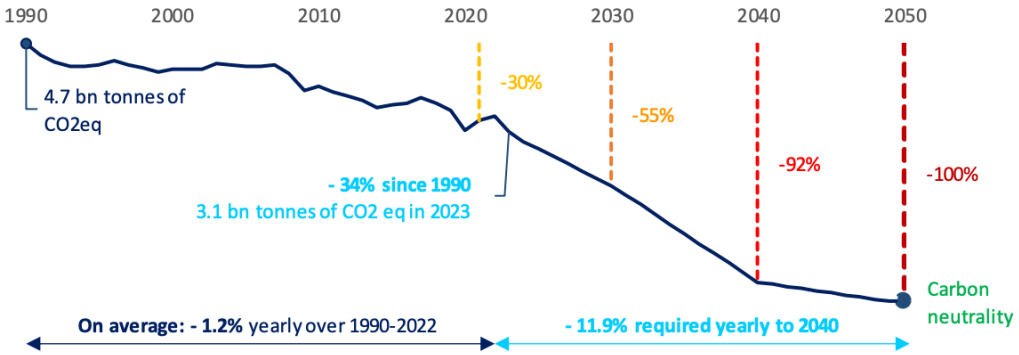


Figure 6 - https://www.aifirm.it/wp-content/uploads/2020/05/2020-Position-Paper-20-Climate-Change-Risk.pdf

1.2.1 European Green Deal: "Fit for 55%" Package

The European Green Deal was introduced on December 11, 2019, by the European Commission under the presidency of Ursula von der Leyen, as a comprehensive strategy to make the European Union the first climate-neutral continent by 2050. It was formally endorsed during the European Council meeting of December 2019, where EU leaders approved the climate neutrality target, marking a significant turning point in European environmental policy. The Green Deal was designed to address the urgency of the climate crisis while transforming the EU's economic model into a more sustainable, resilient, and globally competitive system.

This strategy encompasses all economic sectors, including industrial production, energy, agriculture, transport, finance, and governance.[46]

[45]https://www.europarl.europa.eu/topics/it/article/20180703STO07129/le-soluzioni-dell-ue-per-contrastare-i-cambiamenti-climatici#:~:text=Con%20l'accordo%20di%20Parigi,neutralit%C3%A0%20climatica%20entro%20il%202050.

[46] https://www.europarl.europa.eu/topics/it/article/20200618STO81513/green-deal-europeo-la-chiave-per-un-ue-sostenibile-e-climaticamente-neutrale

Its main goal is to reduce greenhouse gas emissions by at least 55% by 2030, compared to 1990 levels, before achieving full climate neutrality by 2050.

This transformation is based on structural policies aimed at redefining Europe's economic framework. It introduces sectoral strategies focusing on biodiversity conservation, circular economy, zero pollution, sustainable mobility, energy-efficient building renovation, renewable energy promotion, and the development of new technologies such as hydrogen and next-generation batteries.

Figure 7 - https://www.me-factory.eu/ex-post-evaluation-of-cohesion-policy-programmes-work-package-7-european-green-deal/

To support this transition, the EU has allocated unprecedented financial resources through *NextGenerationEU*, the post-pandemic recovery plan that ensures at least 37% of total spending is directed toward the green transition. Additionally, the 2021-2027 multiannual financial framework has been strengthened, with a continuous focus on sustainable finance to unlock private sector investments[47].

[47] https://eur-lex.europa.eu/legal-content/IT/TXT/PDF/?uri=CELEX:52021DC0550

The Fit for 55 legislative package, presented by the European Commission in July 2021[48], translates the Green Deal's goals into concrete measures. It provides the regulatory framework necessary to achieve emission reductions in a fair, competitive, and cost-effective manner, addressing the entire economic and social system of the EU.

One of the key components is the carbon pricing mechanism across various economic sectors through the strengthening of the **EU Emissions Trading System (ETS),** which has been extended to include road transport and buildings. Additionally, the package introduces the **Carbon Border Adjustment Mechanism (CBAM)**, which aims to prevent carbon leakage by imposing import tariffs on goods from countries with less strict environmental regulations.

On the energy side, the package encourages the **greater use of renewable energy** and improvements in energy efficiency, with updates to the relevant EU directives. One of the most significant measures includes the gradual phase-out of fossil fuels and enhanced targets for the development of infrastructure supporting electric mobility and sustainable transport fuels.

Another significant aspect focuses on the automotive sector, introducing a ban on the sale of new internal combustion engine vehicles from 2035, alongside the expansion of the electric vehicle charging network and hydrogen refueling infrastructure. The package also fosters the adoption of cleaner fuels in aviation (***ReFuelEU Aviation***) and maritime transport (***FuelEU Maritime***)[49].

To ensure a fair and inclusive transition, the package establishes the **Social Climate Fund**, which is designed to assist households and businesses most vulnerable to rising energy and fuel prices. Funded through the new ETS for transport and buildings, it will allocate €72.2 billion between 2025 and 2032, helping mitigate the risks of energy and mobility poverty.

Furthermore, the Fit for 55 package reinforces the EU's role as a global leader in the fight against climate change, demonstrating Europe's commitment to upholding the Paris

[48] https://www.europarl.europa.eu/topics/it/article/20200618STO81513/green-deal-europeo-la-chiave-per-un-ue-sostenibile-e-climaticamente-neutrale

[49] https://www.aifirm.it/wp-content/uploads/2020/05/2020-Position-Paper-20-Climate-Change-Risk.pdf

Agreement and encouraging international partners to intensify their efforts. However, EU action alone is not sufficient to achieve the necessary global emission reductions, making international cooperation essential.

The success of this transition will depend on the ability to engage all economic and social actors, from innovators to investors, businesses to cities, and individual citizens. Tackling climate change is something we all need to take on together, showing solidarity across generations. The European Union is stepping up to lead this change instead of just waiting for it to happen.

Clean Industrial Deal

The Clean Industrial Deal was presented, on February 26, 2025, by the President of the European Commission, Ursula von der Leyen. This initiative is a natural extension of the European Green Deal, aimed at enhancing the competitiveness of European industry by accelerating decarbonization and reducing dependence on imported raw materials and energy[50].

A primary goal of the Clean Industrial Deal is the short-term mobilization of 100 billion euros, managed through a new financial instrument: The Industrial Decarbonization Bank (IDB).

This European bank is designed to support energy-intensive industries in their transition towards clean technologies and climate neutrality. The key tools offered by the IDB are:

- Grants and subsidized loans for decarbonization projects.
- Carbon Contracts for Difference (CCfD), which reduce investment risk by guaranteeing a minimum carbon price.
- Reinvestment of revenues from the Emissions Trading System (ETS) to finance innovation and emission reductions in sectors most exposed to international competition.

[50] https://commission.europa.eu/topics/eu-competitiveness/clean-industrial-deal_it

- Support for strategic infrastructure, such as carbon capture and storage (CCS) facilities and renewable hydrogen production.

From a regulatory standpoint, the Clean Industrial Deal is a strategic communication which does not have legally binding force, but it sets new policy guidelines that will significantly influence future EU regulations and investments.

The plan is structured around six main pillars:

1. **Competitive energy**: Reducing energy costs for businesses while promoting the use of renewable energy sources.
2. **Clean technology markets**: Creating new strategic markets and taking the leaf in industry.
3. **Financial instruments**: Setting aside specific resources to modernize industries.
4. **Circular economy and reduced reliance** on non-EU raw materials.
5. **International cooperation**: Promoting fair competition and sustainable trade practices.
6. **Workforce training** to prepare qualified professionals for the green transition.

Specific actions focus on three key sectors:

- **Energy-intensive industries**: Providing immediate support for decarbonization and electrification, safeguarding competitiveness.
- **Clean technologies**: Promoting the development and adoption of innovative technologies, strengthening European leadership.
- **Circular economy**: Reducing imports through recycling and reuse of raw materials[51].

[51] https://commission.europa.eu/topics/eu-competitiveness/clean-industrial-deal_it

Among the most significant measures, there is the Action Plan for Affordable Energy, designed to reduce energy costs for businesses, potentially generating savings of 45 billion euros by 2025.
Additionally, by the end of the year, the Industrial Decarbonization Accelerator Act will be introduced - a binding regulatory measure aimed at accelerating the adoption of clean technologies and significantly reducing greenhouse gas emissions in Europe's industrial sector-[52].

[52] https://commission.europa.eu/topics/eu-competitiveness/clean-industrial-deal_it

1.2.2 Action Plan on Financing Sustainable Growth: EU Taxonomy

After defining the general strategic framework provided by the European Green Deal and the Fit for 55 package, it is essential analyzing the financial instruments that enable businesses to adapt to the transition towards a sustainable economy[53].

On March 8, 2018, the European Commission introduced the "**Action Plan on Financing Sustainable Growth**", a key initiative aimed at directing capital flows towards low-emission activities, managing financial risks associated with climate change, and fostering long-term sustainability in economic activities. As an integral part of the **European Green Deal**, this plan looks to set up a financial system that supports the EU's climate and environmental goals, granting that both private and public investments align with sustainability principles.

One of the most significant instruments introduced by the Action Plan is the **EU Taxonomy**, a classification system that defines scientific criteria for determining whether an economic activity can be considered sustainable. This tool helps investors identify with greater certainty the opportunities that meet the EU's environmental standards, preventing greenwashing[54] and ensuring market transparency.

An economic activity is sustainable or "**green**", when at least one of the following six environmental objectives are satisfied:

- Climate change mitigation,
- Climate change adaptation,
- Sustainable use and protection of water and marine resources,
- Transition to a circular economy, promoting recycling, reuse, and waste reduction,
- Pollution prevention and control,

[53]https://finance.ec.europa.eu/sustainable-finance/tools-and-standards/eu-taxonomy-sustainable-activities_en

[54] "Greenwashing is a communication and marketing strategy through which a company, institution, or organization promotes its activities, products, or services as sustainable, eco-friendly, or environmentally low impact, despite there being no alignment with sustainability criteria. This phenomenon aims to create a misleading image of environmental responsibility, diverting attention from the negative impacts that such activities may generate".
https://www.u2y.io/blog/green-marketing-vs-greenwashing-cosa-devono-sapere-le-aziende

- Protection and restoration of biodiversity and ecosystems.[55]

In addition, an economic activity must comply with the "***Do No Significant Harm***" (DNSH) principle, ensuring that it does not negatively impact any of the other environmental goals.

The EU Taxonomy is applied to three main categories of entities[56]:

1. **Companies subject to the Corporate Sustainability Reporting Directive (CSRD),** which requires large enterprises and listed SMEs to disclose the impact of their activities on sustainability.
2. **Financial institutions**, which must evaluate and classify sustainable financial products according to the Taxonomy criteria, all while making sure their investments are transparent.
3. **EU Member States,** which use the Taxonomy as a reference framework for defining policies, incentives, and requirements for sustainable financial products, ensuring that public funds are allocated to activities aligned with European climate objectives.

In practice, investors must follow a structured assessment process for Taxonomy compliance:

- **Identifying the economic activities** associated with the financed project or company,
- **Assessing their alignment** with the Taxonomy criteria,
- **Conduction of a technical analysis** of environmental metrics to determine whether the activity significantly contributes to climate objectives based on quantifiable parameters, such as CO_2 emission thresholds,

[55]https://www.u2y.io/blog/tassonomia-e-aziende#:~:text=La%20Tassonomia%20UE%20%C3%A8%20un,(TEG)%20sulla%20finanza%20sostenibile

[56] https://www.aifirm.it/wp-content/uploads/2020/05/2020-Position-Paper-20-Climate-Change-Risk.pdf

- **Verifying compliance** with the DNSH principle[57],
- **Assessing adherence** to minimum social safeguards defined by international human rights and labor standards,
- **Prepare transparent documentation** and **disclosures** accessible to stakeholders[58].

In 2023, the investments in Europe aligned with the European Taxonomy reached **250 billion euros**, representing an increase of 34% compared to 2022. About half (125 billion euros) were investments in enabling technologies for decarbonizing other sectors, which grew 40% year-on-year, driven primarily by renewable energy and energy efficiency[59].

1.2.3 Corporate Sustainability Reporting Directive

In addition to the EU Taxonomy, another fundamental pillar of the Action Plan on Financing Sustainable Growth is the **Corporate Sustainability Reporting Directive (CSRD).** This directive was published in the Official Journal of the European Union on 14 December 2022[60] and officially entered into force twenty days thereafter. As previously outlined, the Action Plan aims to redirect financial investments towards sustainable economic activities, accelerating the ecological transition across the entire European Union. Within this context, the CSRD plays a strategic role by providing investors with clear, reliable, and comprehensive information on companies' ESG performance[61].

[57] https://www.aifirm.it/wp-content/uploads/2020/05/2020-Position-Paper-20-Climate-Change-Risk.pdf
[58]https://www.u2y.io/blog/tassonomia-e-aziende#:~:text=La%20Tassonomia%20UE%20%C3%A8%20un,(TEG)%20sulla%20finanza%20sostenibile.
[59] https://www.rinnovabili.it/mercato/economia-e-finanza/tassonomia-ue-investimenti-verdi-34-2023/
[60]https://finance.ec.europa.eu/capital-markets-union-and-financial-markets/company-reporting-and-auditing/company-reporting/corporate-sustainability-reporting_en
[61] https://ollum.it/blog/direttiva-csrd-a-chi-si-applica-quando-entra-in-vigore/

Figure 8 - How to navigate the EU Omnibus Simplification Package-

Specifically, the CSRD mandates that companies of certain sizes and characteristics disclose information on ESG-related risks to which they are exposed, as well as the impacts that their business activities have on the environment and society (double materiality). This directive significantly expands and evolves from the previous **Non-Financial Reporting Directive (NFRD),** substantially increasing the number of companies subject to mandatory sustainability reporting from approximately 10,000 to around 50,000[62].

[62]https://finance.ec.europa.eu/capital-markets-union-and-financial-markets/company-reporting-and-auditing/company-reporting/corporate-sustainability-reporting_en

Main Differences NFRD & CSRD

	NFRD	CSRD
For whom?	Large public-interest entities with > 500 employees: • Listed companies • Banks and Insurance companies Approx. 11,600 companies	All large companies: • 250 employees and/or • €40M Turnover and/or • €20M Total Assets Listed companies Note: small and medium-listed companies get an extra three years to comply. Approx. 49,000 companies Covering > 75% of total EU companies' turnover
When>	FY 2018 – FY 2022	FY 2023 – FY ...
Reporting Requirements	• Environmental protection • Social responsibility and treatment of employees • Respect for human rights • Anti-corruption and bribery • Diversity on company boards (in terms of • age, gender, educational and professional background)	NFRD + Adding additional requirements on: • Double materiality concept: Reporting on both the impact the company has on society and the environment and the sustainability risk the company experiences (e.g., due to climate change and scarcity of resources) • Formulating long-term ESG objectives and policies • Due diligence on its operation and supply chain • Disclose information relating to intangibles (social, human, and intellectual capital) • Reporting in line with Sustainable Finance Disclosure Regulation (SFDR) and the EU Taxonomy Regulation • Integrated reporting and mandatory external assurance
Reporting Format/ Publication	Not set – mainly online/PDFs	European Single Electronic Format ("ESEF" / "XHTML"), data tags, database

Figure 9 - Non-Financial Reporting Directive (NFRD) vs Corporate Sustainability Reporting Directive (CSRD)- https://www.cpmview.com/news/csrd/nfrd-vs-csrd/

In particular, the CSRD applies to:

- All **European companies** listed on financial markets, except micro-enterprises.
- **Large, non-listed European companies** meeting at least two of the following criteria: revenues exceeding €50 million, total assets above €25 million, and an average of more than 250 employees.
- **Non-European companies** generating more than €150 million in annual revenues within the European Union[63].

Subsidiary companies can avoid individual ESG disclosures if they are included in the consolidated report of their parent company.

[63]https://finance.ec.europa.eu/capital-markets-union-and-financial-markets/company-reporting-and-auditing/company-reporting/corporate-sustainability-reporting_en

The CSRD introduces a “phased” approach for implementing the sustainability reporting requirements based on company size and type:

- **January 2025:** Listed companies with more than 500 employees (reporting for fiscal year 2024).
- **January 2026:** Large, non-listed European companies (reporting for fiscal year 2025).
- **January 2027:** Listed SMEs on financial markets (reporting for fiscal year 2026).
- **January 2029:** Non-European companies with EU revenues exceeding EUR 150 million (reporting for fiscal year 2028)[64].

A significant innovation introduced by the CSRD is the requirement to integrate ESG information directly into companies' management reports, in contrast with previous practices permitted by GRI standards, which allowed separate ESG reporting. As a result, ESG disclosures are now given the same importance as traditional financial reporting.

Another key element introduced by the directive is the mandatory assurance (audit) of ESG reports, which must be carried out by accredited independent auditors. This assurance process, initially required at a limited assurance level, may later evolve into reasonable assurance, further enhancing the reliability, transparency, and comparability of ESG information disclosed by companies[65].

To maximize the effectiveness of the CSRD, the European Commission tasked the European Financial Reporting Advisory Group (EFRAG) with developing specific European reporting standards called the European Sustainability Reporting Standards (ESRS). These standards, officially published on 31 July 2023, are mandatory for all companies covered by the CSRD[66]. They build upon key international frameworks (GRI, SASB, IIRC, CDP) and require the disclosure of the following information:

- Principal ESG risks identified by the company.
- Adopted ESG risk mitigation strategies.

[64] https://ollum.it/blog/direttiva-csrd-a-chi-si-applica-quando-entra-in-vigore/
[65] https://www.ibm.com/it-it/topics/csrd
[66]https://finance.ec.europa.eu/capital-markets-union-and-financial-markets/company-reporting-and-auditing/company-reporting/corporate-sustainability-reporting_en

- ESG materiality assessment processes.
- Corporate sustainability targets.
- Environmental, social, and governance policies and procedures.
- Due diligence processes to identify and mitigate ESG impacts.
- Relevant key ESG performance indicators for the company's activities.

These new standards establish a common European language for sustainability, enabling stakeholders to assess companies' genuine commitment more consistently, clearly, and concretely to transitioning towards sustainable economic and social models[67].

1.2.4 EU Omnibus Simplification Package

One of the major strategies to tackle climate change involves enhancing corporate transparency through increasingly comprehensive and rigorous ESG disclosure. Such transparency allows stakeholders to accurately evaluate companies' environmental commitments, encouraging tangible responsibility and reducing the risks of greenwashing.

In this context, the Corporate Sustainability Reporting Directive (CSRD) aims to standardize ESG reporting, facilitating comparability across companies. However, particularly for SMEs and less structured businesses, this regulation may significantly increase bureaucratic burdens and associated costs.

To address this challenge, the European Commission introduced the EU Omnibus Simplification Package with the aim of simplifying and streamlining ESG reporting procedures on the Corporate Sustainability Reporting Directive (CSRD) and the Corporate Sustainability Due Diligence Directive (CSDD)[68], as well as a revision of the EU Taxonomy.

[67] https://ollum.it/blog/direttiva-csrd-a-chi-si-applica-quando-entra-in-vigore/
[68] https://www.esgitalia.it/corporate-sustainability-due-diligence-directive-presto-in-vigore-per-le-grandi-aziende/

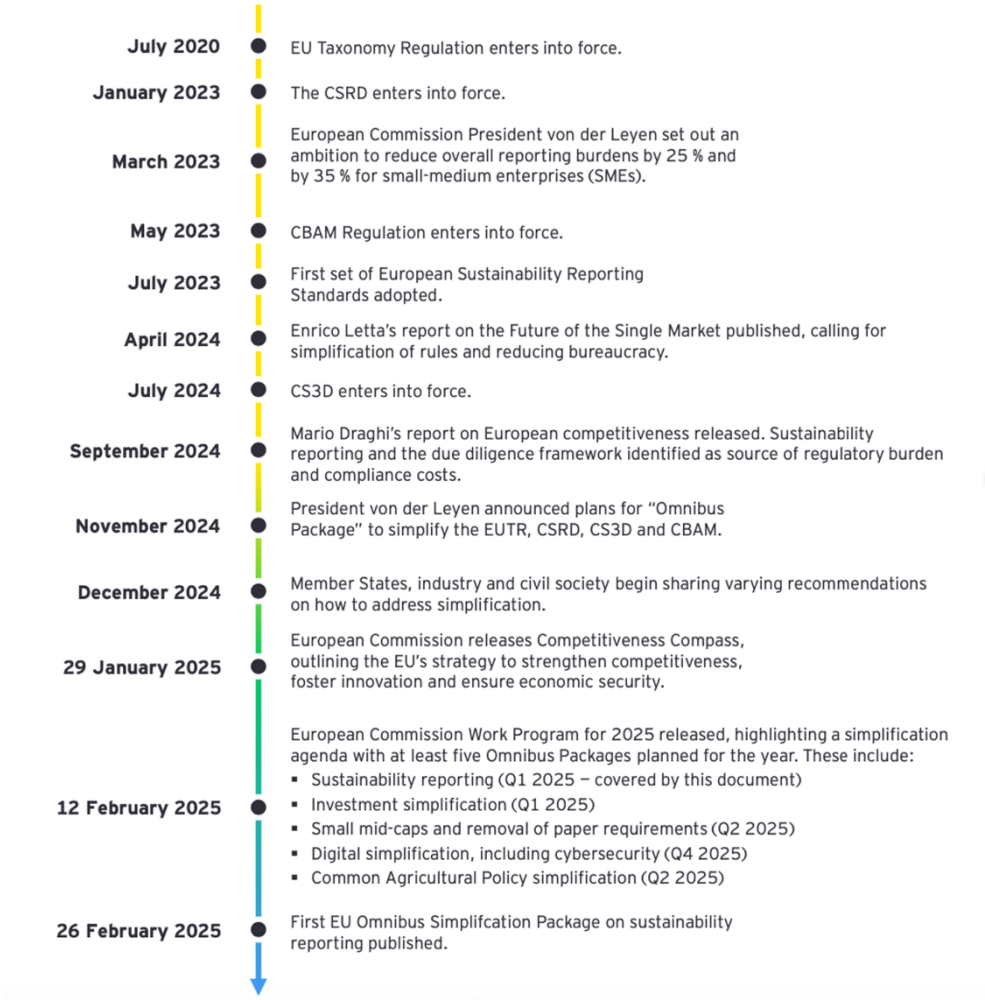


Figure 10 - How to navigate the EU Omnibus Simplification Package -

Specifically, for what concerns the CSRD the mandatory threshold has been raised, limiting its applicability to large companies with over 1,000 employees and a turnover exceeding €50 million or total assets above €25 million. Similarly, for non-EU companies, the turnover requirement within Europe has increased from €150 million to €450 million. Additionally, the implementation timelines for reporting obligations have been adjusted and postponed, such as for large, unlisted companies (from fiscal year 2025 to 2028).

		Before	After
CSRD	Company size	At least 2 of: **250 employees**, **€50M** turnover, **€25M** net assets	**Over 1,000 employees** and one of: **€50M** turnover or **€25M** net assets
	Number of companies affected	Over **50,000**	Less than **7,000**
	Reporting deadlines	**2026** (for 2025 data)	**2028** (for 2027 data)
	Audit of sustainability reports	Gradual move to **Reasonable Assurance**	Transition to Reasonable Assurance **removed** (Limited Assurance only)
CSDDD	Scope of application	**Entire** value chain	Only **direct** suppliers
	Supplier monitoring	**Annual**	Every **5 years**
	Civil liability for non-compliance	**Present** (with sanctions)	**Removed** (no sanctions)
	Financial sector obligations	Maximum fines not lower than **5% of global turnover**	**Removed**
Taxonomy	Companies subject to obligation	**Mandatory** for companies with >**1,000** employees and turnover up to **€450M**	**Voluntary** for companies with **>1,000** employees and turnover up to **€450M**

According to the Commission, these changes will lead to an overall reduction of administrative burdens by approximately 25% and by about 35% for SMEs[69], generating annual savings estimated at up to €6.3 billion. The saved resources can then be redirected towards strategic sustainability investments, mobilizing an additional €50 billion in public and private investments. Moreover, companies can leverage the extended timelines to develop robust ESG processes and implement more effective sustainability strategies. Finally, businesses that voluntarily choose to maintain high ESG reporting standards will have the opportunity to strengthen their competitive position, enhancing their reputation among investors and stakeholders[70].

[69] https://ec.europa.eu/commission/presscorner/detail/it/ip_25_614
[70]https://www.innovationpost.it/attualita/pacchetto-omnibus-che-cose-e-che-cosa-prevede-la-doppia-proposta-dellue-per-semplificare-gli-obblighi-di-rendicontazione/

UK Pension Fund Withdraws £28 Billion from State Street Due to Lack of ESG Alignment

The British pension fund, “The People’s Pension”, has announced the divestment of £28 billion from the U.S.-based asset manager State Street, reallocating £20 billion to Amundi and £8 billion to Invesco, two European asset managers with a strong commitment to climate neutrality ("net zero")[71].
This decision sends a clear signal of the ongoing transformation in institutional finance, where sustainability is no longer a secondary factor but a core element in investment decisions.

Amundi has been entrusted with a £20 billion mandate to build an equity portfolio in developed markets, combining financial return objectives with strict alignment to the decarbonization trajectory needed to limit global warming to 1.5°C.

Invesco has been assigned £8 billion in sovereign and corporate bonds, with a mandate that goes beyond mere capital allocation. The goal is to construct a portfolio aligned with "net zero" objectives, prioritizing issuers that demonstrate a concrete commitment to reducing greenhouse gas emissions.

The People’s Pension’s decision highlights an increasingly relevant issue: The growing divergence between European and U.S. asset managers in their commitment to sustainability.

Dan Mikulskis, Chief Investment Officer of People’s Partnership, emphasized that this move reflects a *strategic* choice aimed at realigning the fund’s investments with the objective of keeping global warming below 1.5°C compared to pre-industrial levels[72].

[71] https://esgnews.it/environmental/fondo-pensione-uk-ritira-28-mld-da-state-street-perche-non-allineato-a-criteri-esg/
[72] https://www.eticanews.it/uk-fondo-pensione-sposta-28-mld-di-sterline-sugli-esg/

This transition is a clear signal that institutional investors are adopting an increasingly proactive approach to climate risk management, shifting capital towards asset managers whose strategies align with sustainable finance and the goals of the European Green Deal.

2 Task force on climate-related financial disclosure recommendations: Focus on the energy sector

"*Sustainability goes beyond mere compliance. It isn't just a set of rules to be followed to align with regulations simply to avoid penalties. Sustainability represents much more: It is a vision, a strategic principle guiding decision-making to ensure that today's prosperity does not compromise tomorrow's well-being*[73] "

-Antonio Schioppi, Manager of Climate Change and Sustainability Services at EY.

Companies that voluntarily embrace robust sustainability practices and transparent reporting gain the trust of investors and stakeholders. Such an approach goes beyond ethical choice; it is a competitive advantage by attracting sustainable capital, facilitating access to green financing, and reducing capital costs. Investing in sustainability today means building tomorrow's future. This strategic vision is underscored by the Mario Draghi Report[74] "*the future of European competitiveness*", which highlights the need for Europe to balance growth, innovation, and sustainability.

In this context of "strategic" sustainability, the recommendations of the Task Force on Climate-related Financial Disclosures (TCFD) represent an essential benchmark, providing concrete guidelines that enable companies to transparently identify, assess, and disclose climate-related risks and opportunities.

[73]https://www.ilroma.net/news/curiosita/847579/la-sostenibilita-non-e-unopzione-una-scelta-imprescindibile-per-il-futuro.html

[74] https://commission.europa.eu/topics/eu-competitiveness/draghi-report_en

Figure 11 - 2021 TCFD Guidance on Metrics, Targets, and Transition Plans-https://osservatorio-economia-circolare.b-cdn.net/documents/bilancio_di_sostenibilita_a2a_2023.pdf

2.1 Task Force on Climate-related Financial Disclosures: Governance

The Task Force on Climate-related Financial Disclosure recommendations focus on four main areas: Governance, Strategy, Risk Management, Metrics and Targets.

Figure 4

Recommendations and Supporting Recommended Disclosures

Governance	Strategy	Risk Management	Metrics and Targets
Disclose the organization's governance around climate-related risks and opportunities.	Disclose the actual and potential impacts of climate-related risks and opportunities on the organization's businesses, strategy, and financial planning where such information is material.	Disclose how the organization identifies, assesses, and manages climate-related risks.	Disclose the metrics and targets used to assess and manage relevant climate-related risks and opportunities where such information is material.
Recommended Disclosures	**Recommended Disclosures**	**Recommended Disclosures**	**Recommended Disclosures**
a) Describe the board's oversight of climate-related risks and opportunities.	a) Describe the climate-related risks and opportunities the organization has identified over the short, medium, and long term.	a) Describe the organization's processes for identifying and assessing climate-related risks.	a) Disclose the metrics used by the organization to assess climate-related risks and opportunities in line with its strategy and risk management process.
b) Describe management's role in assessing and managing climate-related risks and opportunities.	b) Describe the impact of climate-related risks and opportunities on the organization's businesses, strategy, and financial planning.	b) Describe the organization's processes for managing climate-related risks.	b) Disclose Scope 1, Scope 2, and, if appropriate, Scope 3 greenhouse gas (GHG) emissions, and the related risks.
	c) Describe the resilience of the organization's strategy, taking into consideration different climate-related scenarios, including a 2°C or lower scenario.	c) Describe how processes for identifying, assessing, and managing climate-related risks are integrated into the organization's overall risk management.	c) Describe the targets used by the organization to manage climate-related risks and opportunities and performance against targets.

Figure 12 - Recommendations of the Task Force on Climate-related Financial Disclosures 2017 -

With reference to the Governance, it is a fundamental component that all companies, regardless of their sector or size, should carefully consider to effectively manage climate-related risks and opportunities. The TCFD governance recommendations focus on two main aspects: a) Description of the board's oversight of climate-related risks and opportunities, b) Description of the management's role in assessing and managing climate-related risks and opportunities.

a) Description of the board's oversight of climate-related risks and opportunities

Regarding the board, companies should clearly illustrate how and how often the board is informed about climate-related risks. They should also explain how the board integrates these risks into strategic decision-making, annual operating plans, company budgeting, and performance target-setting. Furthermore, the board is responsible for periodically monitoring the company's progress against internally defined climate objectives.

In short, the role of the board is to ensure that climate-risk management is not occasional but systematically integrated into both strategic and day-to-day business decisions.

b) Description of the management's role in assessing and managing climate-related risks and opportunities

Regarding the management's role, the TCFD recommends clearly defining which managerial figures or internal committees have operational responsibility for identifying, assessing, and actively managing climate-related risks. Companies must describe how these managers operate daily, what processes they use to monitor climate issues, and how they regularly communicate with the board.

In summary, the role of management should be clearly organized and embedded in the company's daily operations, with defined responsibilities to ensure effective climate risk management[75].

[75] https://www.aifirm.it/wp-content/uploads/2020/05/2020-Position-Paper-20-Climate-Change-Risk.pdf

2.1.1 Task Force on Climate-related Financial Disclosures: Governance focus on the energy sector

In this paragraph, particular attention is given to the energy sector, which includes all the infrastructures required for collecting, producing, distributing, storing, and consuming energy for residential and commercial use. This sector is highly vulnerable to various impacts induced by climate change, including rising temperatures, heatwaves, cold snaps and snow events, severe droughts, intense rainfall, sea-level rise, hurricanes, and wildfires[76].

Figure 13 - Sea level rise, melting sea ice, and thawing permafrost are all expected to damage oil and gas infrastructure in Alaska, affecting energy production.

Figure 14 - Wildfires due to climate change are more frequent. When a tree encountered electrical distribution lines, it sparked the largest wildfire in California (2021).

The energy sector is the primary contributor to climate change, as it represents the main source of greenhouse gas emissions, accounting for over 90% of carbon dioxide (CO_2) emissions and approximately 75% of total greenhouse gas (GHG) emissions in developed countries. Within the energy sector, CO_2 alone generally accounts for around 95% of emissions, while methane and nitrous oxide constitute the remaining share[77].

Given this "double" materiality[78], the commitment of energy companies to address climate-related challenges has grown significantly in recent years. This shift aligns with the goals established by the Paris Agreement and the United Nations' Agenda 2030. Consequently, energy companies have started adhering to the recommendations issued by the Task Force on Climate-related Financial Disclosures (TCFD).

[76] https://www.epa.gov/climateimpacts/climate-change-impacts energy#:~:text=Warmer%2C%20drier%20conditions%20caused%20by,history%2C%20the%202021%20Dixie%20Fire.
[77] https://unosd.un.org/sites/unosd.un.org/files/session_5_mr._andre_amaro_ipcc.pdf
[78] Double materiality considers both the effects an organization has on the climate and environment and the potential impact of these factors on its financial performance. https://www.manifestclimate.com/blog/what-is-single-and-double-materiality/

To comply with the governance TCFD recommendations, energy companies disclose the following information within, for example, their integrated balance sheet or sustainable report:

1. **Board Composition**

   The Board of Directors (BoD) must be composed of members possessing adequate knowledge of sustainability and climate-related issues to effectively integrate climate risks and opportunities into the company's strategy.
   A survey conducted by the Association of Chartered Certified Accountants (ACCA) [79], which involved over 3,000 finance professionals, found that nearly 25% of respondents cited a lack of professional skills as the main obstacle preventing finance teams from effectively supporting organizations in addressing climate-related challenges. Additionally, a recent global survey of corporate boards found that around 70% of directors perceive themselves as only moderately or not at all effective in integrating climate considerations into corporate strategy and governance. To bridge this gap, companies ought to roll out specialized *induction* programs for their senior leadership. These programs should focus on addressing skill shortages and promote climate literacy at the top level[80].

2. **Roles and Responsibilities**

   Corporate governance can be strengthened by establishing specialized committees with well-defined roles and responsibilities, including:

   - **Sustainability Committee:** Performing investigative, advisory, and proactive roles, this committee supports both the board of Directors and senior executives (Chairman and Chief Executive Officer), ensuring strategic and operational decisions fully incorporate ESG considerations and decarbonization targets.
   - **Risk and Control Committee:** This body integrates climate perspectives into core risk management practices, aligning risk mitigation strategies with industrial planning.

[79] https://assets.bbhub.io/company/sites/60/2023/09/2023-Status-Report.pdf
[80] https://content.gruppoa2a.it/sites/default/files/2022-06/bilancio-integrato-2020.pdf

- **Green Finance Committee:** This committee, acting strategically, ensures corporate investments align with the transition to a low-carbon economy by assessing the sustainability compatibility of projects, acquisitions, and financial transactions.

The Chief Executive Officer (CEO) plays a crucial role in promoting sustainability within the company, while the broader management team is responsible for operational implementation[81]. By adopting a combined governance approach that blends **top-down strategic direction** – where the CEO and committees set the guidelines, investments, industrial plans, and performance metrics- with **bottom-up execution,** where operational management keeps an eye on objectives through risk assessment tools and emission tracking, we can ensure that sustainability principles are embedded across all organizational levels.

3. Incentive Mechanisms

Another crucial aspect is the integration of climate goals into incentive mechanisms. Linking executive and employee compensation directly to the achievement of specific environmental targets, such as reducing emissions or increasing renewable energy production. This practice fosters the embedding of sustainability into corporate culture, creating a tangible connection between business performance and environmental responsibility.

[81] https://content.gruppoa2a.it/sites/default/files/2022-06/bilancio-integrato-2020.pdf

2.2 Task Force on Climate-related Financial Disclosures: Strategy

The strategic recommendations, applicable to every type of companies, cover: a) Description of short, medium, and long-term climate-related risks and opportunities; b) Description of the impacts of climate-related risks on core business, strategies, and financial planning; c) Description of the resilience of corporate strategies, considering various scenarios including a scenario limiting temperature rise to 2°C or lower.

a) Description of short, medium, and long-term climate-related risks and opportunities

Companies should provide the following information: A description of relevant elements over the short, medium, and long-term, taking into consideration both the typical duration of the company's assets or infrastructures and the fact that climate-change impacts often emerge over the medium to long-term; a description of specific climate-related issues that could materialize in each time frame (short, medium, long-term) and have a significant financial impact on the company (distinguishing between physical and transition risks); and a description of the processes used to determine which risks and opportunities could materially impact the company's financials. Additionally, organizations should, where necessary, provide descriptions of risks and opportunities specific to their sector and geographical area[82].

b) Description of the impacts of climate-related risks on core business, strategies, and financial planning

Companies should describe how the climate-related issues they have identified may impact their business, strategies, and financial plans. Companies should assess impacts on business and strategies in the following areas: Products and services; supply and/or value chain; mitigation and adaptation activities; investments in research and development. Companies should describe how climate change affects financial planning processes, the time horizons used, and how these risks and opportunities are prioritized.

[82] https://www.aifirm.it/wp-content/uploads/2020/05/2020-Position-Paper-20-Climate-Change-Risk.pdf

Corporate disclosure should holistically illustrate the interdependencies among factors influencing the company's ability to create value over time. Companies should also disclose impacts on financial planning in the following areas: Operating costs and revenues; capital allocation; acquisitions and divestments; access to capital.
Moreover, if climate-risk scenarios are used within strategy development and financial planning, companies should describe such scenarios.

c) Description of the resilience of corporate strategies, considering various scenarios including a scenario limiting temperature rise to 2°C or lower

Companies should describe how resilient their strategies are concerning climate-related risks and opportunities, considering the transition towards a lower environmental impact economy consistent with a scenario limiting global temperature increases to 2°C, as well as the increasing component of physical risk. Companies should discuss how their strategies might be affected by risks and opportunities associated with climate change; how their strategies might evolve to address these risks and opportunities; and the climate-change scenarios considered along with the related time horizon[83].

2.2.1 Task Force on Climate-related Financial Disclosures: Strategy focus on the energy sector

The second "core" area of Task Force on Climate-related Financial Disclosures recommendations revolves around the strategic approach that companies should adopt to integrate climate-related risks and opportunities into their decision-making processes.

1. Context Description

In accordance with the TCFD recommendations[84], companies are required to include a clear description of the context in their integrated financial statements or sustainability

[83] https://www.aifirm.it/wp-content/uploads/2020/05/2020-Position-Paper-20-Climate-Change-Risk.pdf
[84] https://download.terna.it/terna/Informativa%20di%20Terna%20sul%20Cambiamento%20Climatico%202022_8da6b2fd714984b.pdf

reports. This context setting is crucial to avoid the formulation of strategic objectives that may later prove to be inconsistent with the regulatory or institutional framework within which the company operates. Failing to do so may expose the organization to *reputational risks*, particularly if strategic decisions appear disconnected from the evolving climate and regulatory landscape. To ensure consistency, the context description should cover the current regulatory requirement, institutional and policy frameworks at local, national, and international levels[85].

For instance, considering an energy company operating in Italy, the description of the regulatory context may refer to the twenty-eighth Conference of the Parties (COP28), held in Dubai in December 2023[86], where the Global Stock take highlighted the urgent need to reduce global greenhouse gas emissions by 43% by 2030 compared to 2019 levels, with the objective of limiting the global temperature increase to 1.5°C above pre-industrial levels. Current trajectories remain distant from these targets, prompting international efforts toward phasing out fossil fuels and significantly scaling up investments in renewable energy and energy efficiency.

In the European context, we see this commitment reflected in initiatives like the European Green Deal, the Fit for 55 legislative package, the REPowerEU Plan, and the Carbon Border Adjustment Mechanism (CBAM). These efforts clearly outline targets aimed at achieving climate neutrality by 2050, along with ambitious *interim* goals, such as reducing emissions by 55% by 2030. Italy's National Recovery and Resilience Plan (PNRR) aligns with these objectives by allocating substantial resources to accelerate energy self-production, improve energy storage, and develop innovative Net-Zero technologies[87].

2. Scenario definition

One of the key elements in the TCFD framework is the use of climate scenarios to assess the resilience of strategic decisions against transition and physical risks.

[85] https://www.invitalia.it/chi-siamo/sostenibilita/bilancio-sostenibilita-2023
[86] https://www.isprambiente.gov.it/it/archivio/notizie-e-novita-normative/notizie-ispra/2023/12/conclusa-la-cop28-a-dubai
[87] https://osservatorio-economia-circolare.b-cdn.net/documents/bilancio_di_sostenibilita_a2a_2023.pdf

Energy companies must carefully evaluate these scenarios to identify potential threats and opportunities. To understand the impact of transition risks, companies can use the following International Energy Agency (IEA)[88] scenarios:

- **STEPS (Stated Policies Scenario):** Predicts a global temperature increase of approximately +2.4°C by 2100. This scenario reflects the impact of current and stated policies already in place, indicating a significant gap from the targets set in the Paris Agreement.
- **APS (Announced Pledges Scenario):** Limits temperature rises to about +1.7°C by 2100, if all announced climate commitments made by governments are fully implemented. This scenario is more optimistic but still challenges the net-zero transition goals
- **NZE (Net Zero Emissions by 2050):** Aims to cap the rise at around +1.4°C by 2100, assuming a proactive and accelerated transition to net-zero emissions. This scenario represents the best-case pathway to limit climate impacts but requires substantial global commitment and action[89].

For physical risks, companies should consider the scenarios outlined by the Intergovernmental Panel on Climate Change (IPCC)[90], including:

- **Aggressive Mitigation (RCP2.6):** Targets net-zero emissions by 2100, aiming to stabilize global warming below 2°C. This pathway assumes rapid emission reductions and widespread adoption of low-carbon technologies.
- **Stabilization (RCP4.5):** Emissions peak around 2040 and then decline, leading to moderate warming and partial stabilization of the climate system. It represents a balanced mitigation approach without fully achieving net-zero.
- **Business as Usual (RCP8.5):** Characterized by continuously increasing emissions, significantly exceeding pre-industrial levels. This scenario assumes no

[88] https://www.iea.org/reports/world-energy-outlook-2023/context-and-scenario-design
[89] https://download.terna.it/terna/Informativa%20di%20Terna%20sul%20Cambiamento%20Climatico%202022_8da6b2fd714984b.pdf
[90] https://www.ipcc.ch/site/assets/uploads/2018/03/emissions_scenarios-1.pdf

substantial climate action, resulting in severe climate impacts and extreme weather events.

By incorporating these scenarios, companies can develop robust strategies to withstand the challenges of a changing climate, ensuring that strategic decisions remain resilient under various climate pathways.

3. Definition of the strategic plan

The Strategic Plan is the central component of the company's long-term vision and is developed based on the insights gained from the context description and scenario analysis. It should clearly define the corporate goals and the actions needed to achieve them.

The key objectives for an energy company:

- **Green transition**: Shift from fossil fuel-based energy production to renewable and sustainable sources.
- **Circular economy**: Implement practices to reduce waste and optimize resource use.
- **Decarbonization:** Set ambitious targets to reduce carbon emissions, in line with the Paris Agreement and EU climate policies.
- **Reduction of pollution and waste of resources**.

2.3 Task Force on Climate-related Financial Disclosures: Risk Management

The recommendations made by the TCFD in the risk management area relate to the following areas[91]: a) Description of the organizational processes needed to identify and assess climate risks; b) Description of the organizational processes needed to manage climate risks; c) Description of how the processes of identifying, assessing, and managing climate-related risks are integrated into the overall risk management of the enterprise.

a) Description of the organizational processes needed to identify and assess climate risks

On the first front, the recommendations place particular emphasis on the *transparency* aspects of organizations, which should clearly explain and represent the internal processes related to identifying and managing the climate-related risks to which they are exposed. Describing the organizational and operational ways in which the company oversees these risks can enable the market to understand the focus and emphasis on climate change and its impacts on the company's business.

Particularly, in the description, the enterprise should explain whether and how they take into account existing climate change regulatory requirements (e.g., emission limits) in their processes, the size and scope of potentially climate change-related risks, and existing climate risk terms and definitions (or internal classifications) for identifying climate-related risks[92].

b) Description of the organizational processes needed to manage climate risks

On the second front, the recommendations are addressed to all companies and cover the descriptive aspects of climate-related risk management processes, encompassing within this scope how decisions are made to mitigate, transfer, control and tolerate climate risk. The recommendations also emphasize the need to incorporate, in the description of processes, information on a key preliminary step

[91] https://assets.bbhub.io/company/sites/60/2021/10/FINAL-2017-TCFD-Report.pdf
[92] https://www.aifirm.it/wp-content/uploads/2020/05/2020-Position-Paper-20-Climate-Change-Risk.pdf

related to the company's identification of the priorities to be assigned to climate-related risks, including how such choices are made and justified.

c) Description of how the processes of identifying, assessing, and managing climate-related risks are integrated into the overall risk management of the enterprise

On the third front, the recommendations highlight the need for all companies to describe the choices and ways taken through which the internal processes for identifying, assessing, and managing climate-related risks are integrated into the company's overall climate risk management, including internal mechanisms for aligning and raising *awareness* of corporate behavior with respect to the assumed risk profile.

2.3.1 Task Force on Climate-related Financial Disclosures: Risk Management focus on the energy sector

To align with the recommendations from the Task Force on Climate-related Financial Disclosure (TCFD), effectively identifying, assessing, and managing climate risks calls for a well-organized and systematic approach. Here are the essential steps involved in this process[93]:

1. Identification of climate risks and opportunities

The first and fundamental step in the process is to identify climate-related risks and opportunities that may impact the company's operations and strategic objectives. This identification follows a structured methodology based on two key criteria:

a) Industry Sector:

The industry sector is key in shaping the types and categories of exposure to climate risks. For example:

[93] https://assets.bbhub.io/company/sites/60/2023/09/2023-Status-Report.pdf

- Energy distribution companies may face physical risks linked to temperature variations, extreme wind events, and water scarcity or excess, which could compromise the resilience of energy networks.
- Transition risks, on the other hand, include the dependence on fossil fuels and the need to comply with evolving regulations aimed at carbon reduction and energy transition.

b) Geographic Location:

The geographic location of business activities significantly influences the risk profile, as different regions are exposed to specific climatic and meteorological conditions:

- Floods, droughts, wildfires, and hurricanes are more likely in some areas than others.
- The location also impacts regulatory compliance, as different jurisdictions may enforce distinct climate adaptation and mitigation policies[94].

Alongside identifying risks, it is essential to consider the legal and regulatory environment**.**

2. Scenario Definition and Time Horizons

Once risks and opportunities have been identified, it becomes crucial to define the climate scenarios and time horizons used to assess the resilience of its strategies.

a) Climate scenarios:

Climate scenarios are essential to simulate potential future developments and evaluate the robustness of the company's strategic choice. These can be transition scenarios (e.g., IEA: STEPS, APS, NZE) or physical scenarios (e.g., IPCC: RCP2.6, RCP4.5, RCP8.5).

[94] https://osservatorio-economia-circolare.b-cdn.net/documents/bilancio_di_sostenibilita_a2a_2023.pdf

b) Time Horizons:

Defining time horizons is essential to link strategic planning with anticipated risks and opportunities:

- Short term (1-5 years): Focus on immediate and operational impacts.
- Medium-term (5-15 years): Address strategic shifts and policy changes.
- Long-term (>15 years): Project resilience of long-term investments and decarbonization pathways.

By selecting relevant scenarios and time horizons, the company can strategically align its operations with future climate-related challenges and opportunities.

3. Identification of variables associated with climate scenarios

Once the scenarios are set, it is crucial to pinpoint the key variables that will impact risk assessment and opportunity evaluation. These variables fall into two main categories:

a) Physical variables:

- Predicted average and maximum temperatures: Impact on energy demand.
- Average rainfall and intensity of extreme events: Affect water availability and infrastructure resilience.
- Sea level rise: Particularly relevant for coastal infrastructure and ports.

b) Transition variables:

- Carbon emission prices (e.g., EU ETS allowances): Fluctuations impacting operational costs.
- Energy and climate policies: Including renewable energy incentives and carbon pricing mechanisms.
- Energy prices (commodities, electricity): Directly affecting production costs and profitability.

4. Estimation of risks and opportunities

Following the identification of variables, the company quantifies the potential effects of risks and opportunities, combining qualitative and quantitative approaches:

a) **Qualitative analysis**:
Uses tools like heatmaps to assess the impact and likelihood of each risk, facilitating prioritization of mitigation and adaptation actions.

b) **Quantitative analysis:**

- Employs financial models, as Discounted Cash Flow (DCF) to assess long-term financial impacts, Monte Carlo simulation to evaluate probability distributions and uncertainty.
- Integrates cost-benefit analysis to determine the variability of mitigation actions.

Where quantitative data are insufficient, the company can employ expert judgment, stakeholder consultations, and supplementary qualitative evaluations[95].

5. Climate Value at Risk (VaR) calculation

The last step involves the timely calculation of Climate Value at Risk, i.e., the potential impact on business value of climate risks and opportunities, both under expected conditions (expected impact) and under extreme or stressed conditions (stressed impact). The process includes:
a) Quantification of expected impacts assesses estimated average impacts based on selected climate scenarios (effects on revenues, EBITDA, assets).
a) Quantification of stressed impacts: "Worst-case scenario" analysis, evaluating the financial effect under extreme climate and regulatory conditions[96].

[95] https://osservatorio-economia-circolare.b-cdn.net/documents/bilancio_di_sostenibilita_a2a_2023.pdf
[96] https://assets.bbhub.io/company/sites/60/2023/09/2023-Status-Report.pdf

The TCFD five-step risk management process can be summarized into three main phases:

1. Identification;
2. Valuation;
3. Quantification.

In the next chapter, we will analyze this process in practice by considering companies operating in the energy sector.

2.4 Task Force on Climate-related Financial Disclosures: Metrics and Targets

As described previously, TCFD recommendations are structured around four thematic areas that represent core elements of how organizations operate. While all four recommendations are interrelated, the Task Force views metrics as the "connective tissue" between the recommendations[97].

Relationship between Metrics and other TCFD Recommendations
There is a stringent relationship between "metrics" and the other TCFD recommendations (governance, strategy, and risk management). In particular: **Governance:** Climate-related metrics are fundamental tools for enabling the board of directors and senior management to direct the organization more effectively. By measuring and clearly expressing the effects of climate-related risks and opportunities, these metrics really boost decision-making and strategic oversight. Moreover, climate-related metrics are essential for communicating with external stakeholders—such as investors, lenders, insurance underwriters, and other interested parties—about how senior management monitors and addresses climate-related risks and opportunities. Additionally, metrics related to executive compensation can show how directors and managers are incentivized to meet climate-related targets, reflecting a clear alignment between corporate governance and sustainability objectives[98].

[97] https://assets.bbhub.io/company/sites/60/2021/07/2021-Metrics_Targets_Guidance-1.pdf
[98] https://assets.bbhub.io/company/sites/60/2021/10/FINAL-2017-TCFD-Report.pdf

Strategy: Climate-related metrics allows the quantification and assessment of the impact of climate-related risks and opportunities on the organization's operations, strategic direction, and financial planning. These metrics enable the evaluation of how climate risks may influence business performance, including both short-term and long-term financial outcomes.

Furthermore, metrics help assess the resilience of an organization's strategy under different climate scenarios. By continuously monitoring these metrics, organizations can make data-driven adjustments to their strategies, ensuring they remain robust and adaptive in the face of evolving climate-related challenges.

Risk Management: In the context of risk management, climate-related metrics are invaluable for measuring exposure levels and assessing risks within the organization's comprehensive risk management framework. They contribute to defining risk tolerances, risk appetites, and risk thresholds, thereby informing the degree of climate-related risk the organization is prepared to assume.

These metrics also guide the selection of appropriate risk responses, which may include acceptance**,** avoidance**,** pursuit**,** reduction**,** or sharing/transfer of risks. By integrating climate-related metrics into the broader risk management processes, organizations enhance their capacity to proactively manage potential adverse effects and capitalize on emerging opportunities[99].

[99] https://assets.bbhub.io/company/sites/60/2021/07/2021-Metrics_Targets_Guidance-1.pdf

The TCFD's recommendations on metrics and targets relate to the following areas: a) Disclosure of the metrics used by the company to assess climate-related risks and opportunities, in line with its strategy and its risk management process; b) Disclosure of greenhouse gas emissions (of Scope 1, Scope 2 and possibly Scope 3[100]) and related risks; c) Description of the targets used by the company to manage climate-related risks and opportunities and performance against the targets.

a) Disclosure of the metrics used by the company to assess climate-related risks and opportunities, in line with its strategy and its risk management process

In line with TCFD recommendations, companies should consider incorporating measurement tools for climate-related risks connected, for example, to water, energy, land use, and waste management (provided such assessments are relevant and applicable to their business context). Where formalized, companies should also explain how these metrics are integrated into corporate policies and remuneration systems, promoting individual behaviors aligned with effective risk management.

Additionally, where relevant, companies should disclose their methods for setting internal carbon pricing and the criteria used to evaluate opportunities arising from climate change. According to the recommendations, corporate disclosures should also present data trends derived from these risk measurement metrics, enabling analysis, and forecasting of related phenomena. Therefore, all such information should be included within descriptions of the methodologies employed by companies to calculate or estimate climate-related metrics.

[100] Scope 1 GHG emissions refer to **direct** GHG emissions from sources that are owned or controlled by the company, while Scope 2 GHG emissions are **indirect** from sources that are owned or controlled by the company (e.g., electricity, heat or steam purchased from a utility provider). Finally, Scope 3 greenhouse gas emissions come from sources **not directly** owned or controlled by the enterprise but related to its activities (think of commuting employees, for example). https://assets.bbhub.io/company/sites/60/2021/10/FINAL-2017-TCFD-Report.pdf

b) Disclosure of greenhouse gas emissions (of Scope 1, Scope 2 and possibly Scope 3) and related risks

In this second area, the recommendations refer to the need for companies to provide disclosure about their GHG (i.e., Greenhouse Gases) emissions, referring to the different cases in Scope 1, Scope 2, and possibly related to Scope 3, along with the related risks. The GHG emissions to be reported should be calculated, by the company, in line with the GHG protocol methodology to allow aggregation and comparability between companies even from different countries.

In addition, companies should provide information on the formulation of any estimates and efficiency metrics of their GHG emissions to represent any industry best practices, including over a specified time horizon, and to facilitate the possibility of tracking a trend of sensitivity and effectiveness/efficiency of company behaviors.

c) Description of the targets used by the company to manage climate-related risks and opportunities and performance against the targets

The recommendations in this area aim to promote the description of company information related to targets for: GHG emissions, water consumption, energy consumption, etc., and the constraints that are taken into account in such consumption (standards, markets, benchmarks). To this end, the company should provide-according to TCFD recommendations-its efficiency targets (or economic savings) that it intends to achieve in GHG emission savings, referable, for example, to its production or organizational processes.

In addition, companies should also provide information about the relevance of this target to the overall business strategy, the time frame of reference, and the periodicity with which these results are monitored and calculated in order to show whether or not the expected target is being met. Of course, the company should also explain how the targets are calculated and the results achieved at the overall level are measured and monitored[101].

[101] https://assets.bbhub.io/company/sites/60/2021/10/FINAL-2017-TCFD-Report.pdf

2.4.1 Brief introduction on Metrics and Targets

Metrics are defined as performance indicators that allow to monitor and measure progress against established plans and objectives. The TCFD emphasizes certain fundamental characteristics and principles for effective disclosure and management of climate-related metrics. These include:

- **Decision-usefulness:** Climate-related metrics should be relevant to the organization's risks and opportunities.
- **Clarity and understandability:** Climate-related metrics must be clear and provide the necessary context to enhance understanding.
- **Reliability, verifiability, and objectivity:** Climate-related metrics should be free from bias or value judgments and support controls that enable data verification.
- **Consistency over time:** Climate-related metrics should consider three relevant time horizons: Current, historical, and forward-looking. Forward-looking metrics may be based on methodologies such as scenario analysis and include climate-related targets[102].

While climate-related target refers to a "*specific level, threshold, quantitative, or qualitative goal that the organization wishes to meet over a defined time horizon in order to address its climate-related risks and opportunities"*[103]. A common target organization set is around their commitment to reduce GHG emissions.

As for the metrics also for the targets, TCFD outlines principles and characteristics. These are:

- **Alignment with Strategy and Risk Management goals:** Climate-related targets should be defined in consideration of an organization's strategy and risk management processes.
- **Linked to relevant metrics**: Climate-related targets should be linked to defined metrics, allowing the organization to measure and track progress against targets.

[102] https://toolkit.bii.co.uk/climate-change/tcfd-toolkit/pillar-4-metrics-and-targets/?pdf=3303
[103] https://assets.bbhub.io/company/sites/60/2021/07/2021-Metrics_Targets_Guidance-1.pdf

- **Quantified and measurable:** Climate-related targets should be expressed in quantifiable terms and structured in a measurable way.
- **Clearly specified over time:** Climate-related targets should be defined clearly over time and specify the following elements:

    1. **Baseline:** Clear definition of baseline time period that will be used to track progress, ensuring a consistent base year for all GHG emissions targets.
    2. **Time horizon**: Defined time horizon within which the targets are expected to be met.
    3. **Interim targets:** An *interim* target is a checkpoint between the current period and the target end date in which an organization assesses its progress and makes any adjustments to its plans and targets[104].

Metric category	**Example Unit of Measure**	**Example Metrics**	**Example Climate-related target**
GHG Emissions Absolute Scope 1,2,3 emission intensity	Tons of CO_2 e[105]	Absolute Scope 1, Scope 2, and Scope 3 GHG emissions; weighted average carbon intensity.	Reduce net Scope 1,2,3 GHG emissions to zero by 2050, with an interim target.
Transition Risks Amount and extent of assets or business activities vulnerable to transition risks.	Amount or percentage	Volume of real estate collaterals highly exposed to transition risk; concentration of credit exposure to carbon-related assets; percent of revenue from coal mining.	Reduce percentage of asset value exposed to transition risks by 30% by 2030, relative to a 2019 baseline.
Physical Risks Amount and extent of assets or business activities vulnerable to physical risks.	Amount or percentage	Revenue associated with water withdrawn and consumed in regions of high or extremely high baseline water stress, proportion of	Reduce percentage of asset value exposed to acute and chronic physical climate-

[104] https://toolkit.bii.co.uk/climate-change/tcfd-toolkit/pillar-4-metrics-and-targets/?pdf=3303
[105] CO_2e "*CO_2 equivalents*" includes measuring the impact of different greenhouse gases as methane gas and nitrous oxide.
https://zeroco2.eco/it/magazine/sostenibilita-aziendale/co2-equivalente-co2e/

		property, infrastructure, or other alternative asset portfolios in an area subject to flooding, heat stress, or water stress.	related risks by 50% by 2050.
Remuneration Proportion of executive management remuneration linked to climate considerations.	Percentage, weighting, description, or amount in reporting currency	Portion of employee's annual discretionary bonus linked to investments in climate-related products, weighting of climate goals on long-term incentive scorecards for Executive Directors.	Increase amount of executive management remuneration impacted by climate considerations to 10% by 2025.

Figure 15 - Guidance on Metrics, Targets and Transition Plan - https://assets.bbhub.io/company/sites/60/2021/07/2021-Metrics_Targets_Guidance-1.pdf

2.4.2 TCFD Metrics and Targets on the energy sector

In line with the recommendations of the Task Force on Climate-related Financial Disclosures (TCFD), energy companies typically detail their climate commitments under the "Metrics and Targets" section. A pertinent example is provided by Terna, an energy company committed to significantly reducing its environmental impact.

Terna has set ambitious targets to reach net-zero greenhouse gas (GHG) emissions across Scope 1 (direct emissions), Scope 2 (indirect emissions from energy consumption), and Scope 3 (other indirect emissions) by 2050[106]. As part of its intermediate objectives, Terna aims to reduce emissions by at least 55% by 2030, aligning its goals with broader European community guidelines.

To transparently communicate its progress, Terna's 2023 Integrated Report explicitly outlines targets actions to achieve them, and clear metrics to track and report progress toward meeting these climate-related goals. *(See figure 16)*

[106] https://download.terna.it/terna/Terna_2023_Integrated_Report_8dc5f14f587b168.pdf

This structured disclosure not only enhances transparency but also provides stakeholders with critical insights into how Terna anticipates and responds to potential policy, regulatory, market, and technological developments related to climate change mitigation[107].

SCOPE	ACTION	KPIs	OBJECTIVE
TERNA's ACTIVITY			
Scope 1 emissions	Reduction of SF_6 gas emissions by cutting losses	SF_6 leaks as a percentage of total installed	**- 46%** (2030 vs 2019 – Terna's SBT)
		SF_6 amount	
		SF_6 emissions	
	Greater energy efficiency and reduction of consumption related to offices, substations and plants.	Building and substation consumption	
		Number of buildings and substations monitored through sensors	
	Reduction of vehicle fleet consumption thanks to green vehicles	% Electric and hybrid vehicles	
		Fleet consumption	
Scope 2 emissions	Reduction of emissions associated with grid losses thanks to Development Plan projects	Grid losses in GWh	
		losses as a percentage of energy transported	
		Emissions associated with grid losses	
Scope 3 emissions	Reduction of scope 3 emissions thanks to circular economy projects and green transformers	% of recycled waste	**- 11%** (2030 vs 2021 – Terna's SBT)
		Number of green transformers sold	
		Energy and fuel consumption	

Figure 16 -2023 Annual Report Integrated Report, https://download.terna.it/terna/Terna_2023_Integrated_Report_8dc5f14f587b168.pdf

[107] https://assets.bbhub.io/company/sites/60/2021/07/2021-Metrics_Targets_Guidance-1.pdf

3 The Impairment Test under IAS 36 and climate risks

3.1 Introduction to IAS 36 and key concepts of the Impairment Test

IAS[108] 36 - Impairment of Assets sets out rules to ensure that assets carried on the balance sheet do not exceed their recoverable amount, which is the higher of the fair value less costs of disposal or the asset's value in use. In other words, if the carrying value of an asset exceeds what can be recovered from its sale or use, an impairment loss must be recognized to restore the asset to its recoverable amount[109]. The following are key concepts from IAS 36 that are useful in framing the impairment test:

a) **Recoverable amount:** The higher of fair value less **direct costs of disposal** and value in use.
b) **Fair value less costs of disposal**: The references for estimating fair value less costs of disposal are, in descending order of importance:

   i. Price set in a binding sales agreement
   ii. Current price observed in an active market (for example, the price of the most recent transaction if no significant change in context has occurred, market price)
   iii. Estimation based on technical valuation using the best available information, including recent transactions involving similar assets in sector valuation techniques[110].

Direct costs of disposal include removal costs, brokerage fees, expenses to make the assets negotiable, legal fees, and taxes.

c) **Value in use** is the present value of the net operating cash flows expected to be obtained from the asset during its useful life, plus the final value on disposal.

[108] IAS *"International Accounting Standards"*
[109] https://www.ifrs.org/issued-standards/list-of-standards/ias-36-impairment-of-assets/
[110] https://www.dsg.univr.it/documenti/OccorrenzaIns/matdid/matdid165472.pdf

About value in use estimation, therefore, it requires a financial basis valuation, which consists of two main steps:

- The **projection of future cash flows** generated by the asset.
- The determination of an **appropriate discount rate**, consistent with the nature of the estimated flows.

Future cash flows must be determined on a prudent and realistic basis:

- They must be based on **plans or budgets** approved by the **Board of Directors** that represent the best available management estimate.
- They must reflect the **current condition** of the business, without including future restructuring effects or improvements not yet underway (steady state) [111].
- The explicit projection period should **not exceed five years**, unless justified (e.g., multi-year contracts with guaranteed revenues).
- At the end of the plan period, **a stable or declining growth rate** in line with industry or country expectations is normally assumed.

$$\sum_{t=1}^{n} FC_t(1+i)^{-t} + TV(1+i)^{-n}$$

FC_t: Cash Flow at period t

i: Discount rate

TV: Terminal Value[112]

[111] https://www.fondazionenazionalecommercialisti.it/disknode/get/191/BIL_CPC_Guida_IAS36.pdf?download

[112] https://www.dsg.univr.it/documenti/OccorrenzaIns/matdid/matdid165472.pdf

The discount rate used shall be determined consistently with the flows being discounted. Therefore, if the flows are pre-tax and unlevered, the discount rate must also be pre-tax and free of leverage.

In general, the discount rate:

- It must reflect a **risk-free rate** consistent with the time horizon of the flows.
- It must include an adequate **risk premium** which reflects the specific risk of the asset and operating environment.
- It can be built on the basis of approaches such as **WACC (Weighted Average Cost of Capital)**, appropriately adapted in a non-levered and before-tax form.

This methodological approach ensures that the valuation of the value in use is representative of the real capacity of the asset to generate future economic benefits, maintaining consistency and transparency between the underlying assumptions and the results obtained[113].

d) Cash-generating unit (CGU): The smallest group of assets that generates cash inflows largely independent of those from other assets or groups of assets. When an asset does not generate independent cash flows (e.g., a piece of machinery that is part of an integrated production line), impairment should be assessed at the level of the cash-generating unit to which the asset belongs[114].

e) **Impairment loss:** The amount by which the carrying amount of an asset (or UGF) exceeds its recoverable amount. When identified, the loss has to be charged to the Income Statement and the book value of the asset is reduced to its recoverable amount. Reversals of impairment are permitted only in certain circumstances if there are indicators that the causes of the loss have abated, while reversals of impairment are not allowed once goodwill has been written down.

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[113] https://www.odcec.mi.it/docs/default-source/materiale-convegni/i-principi-contabili-internazionale-ias-ifrs-(28-02-23).pdf?sfvrsn=6214bcf7_2

[114] https://www.ifrs.org/issued-standards/list-of-standards/ias-36-impairment-of-assets/#:~:text=The%20core%20principle%20in%20IAS,generating%20units

The company is obliged to carry out an impairment test every year for the following assets:

a) **Intangible assets with an indefinite useful life (goodwill).**
b) **Intangible assets not yet available for use**.

There are two types of indicators that are symptom of impairment:

External indicators (e.g., a significant decline in the market value of an asset; adverse changes in the regulatory, technological, market, or economic environment; increases in market interest rates that reduce the recoverable value in use; etc.) and **internal** indicators (e.g., obsolescence or physical damage of an asset; economic performance of the business worse than expected; restructuring plans that impact the use of assets)[115].

If indicators are present, it is mandatory to formally estimate the recoverable amount and compare it with the book value.

3.2 Climate Risks as indicators of impairment

Climate change introduces climate risks that can translate into indicators of impairment under IAS 36 because they can significantly alter the environment in which companies operate and the expected cash flows from their assets. In the literature and in reporting practices (e.g., according to the recommendations of the TCFD, Task Force on Climate-related Financial Disclosures), climate risks are typically separated into two categories: **physical and transitional**. Each can signal possible impairment of assets and investments as it affects future cash flows or the market value of assets.

- **Physical risks**: These are the risks arising from the physical impacts of climate change, both **acute** (increasingly frequent and intense extreme weather events such as hurricanes and floods) and **chronic** (gradual changes such as sea level rise, average temperature rise). Such events can cause direct damage to infrastructure and facilities, prolonged operational disruptions, increases in insurance and maintenance costs, and generally a

[115] https://www.odcec.mi.it/docs/default-source/materiale-convegni/i-principi-contabili-internazionale-ias-ifrs-(28-02-23).pdf?sfvrsn=6214bcf7_2

reduction in the useful value or life of assets. For example, an industrial plant located in a coastal area subject to recurring flooding or a power plant that depends on water availability (hydropower) in a region affected by increasing drought may see its ability to generate future cash flows significantly impaired**. According to IAS 36, an adverse change in physical operating conditions or the onset of damage/obsolescence are internal/external indicators of impairment** - physical climate risks fall squarely within these case scenarios. In addition, catastrophic events can reduce the fair value of the asset (e.g., by causing its market value to plummet or making its continued operation burdensome). So, significant exposure to physical hazards (such as the vulnerability of facilities to extreme weather events) is a wake-up call that requires companies to consider whether affected assets should be written down[116].

- **Transition risks**: Relate to the impact of transition processes to a low-carbon economy. They include **regulatory and policy changes, technological changes, market changes and consumer preferences, and reputational changes**. These transition factors can severely affect the expected profitability of certain assets: For example, the introduction of more stringent emissions regulations can increase operating costs (think of industrial plants that have to invest in expensive filters or pay CO_2 emission allowances), while technological developments and falling costs of renewables can reduce demand for fossil fuel-based plants. IAS 36 explicitly counts *"significant changes in the regulatory or market environment with adverse effects on the entity or its assets*" as external indicators of impairment.

[116] https://assets.kpmg.com/content/dam/kpmg/it/pdf/2020/01/Informativa-rischi-climatici.pdf#:~:text=i%20rischi%20di%20transizione%20si,avere%20un%20impatto%20anche%20sulla

3.3 Estimating value in use and fair value in the context of climate risks

Estimating the value in use and fair value of an asset exposed to climate risks presents significant technical complexities and requires major judgments. The reason lies in the high uncertainty associated with possible future climate and energy transition scenarios, as well as the long-term horizon over which these risks manifest themselves. Below we examine how climate risks affect these key elements of the impairment test.

Time horizon of projections and variability of future scenarios: IAS 36 generally allows the use of detailed plans and budgets up to a maximum of 5 years, beyond which cash flows can be extrapolated to reflect stable or decreasing growth rates (subject to justified exceptions). **However, the main effects of climate change and transition policies often unfold over longer horizons (10, 20 or more years).** This implies that limiting oneself to a five-year horizon may be insufficient to fully capture the risk of decreasing flows beyond that period.

In fact, IASB staff have pointed out that some companies risk not adequately incorporating climate risks into their long-term cash flows, for example by stopping at 5-year projections and then assuming perpetual "normality" growth that ignores possible future climate impacts.

IAS 36 allows the use of projections over horizons longer than 5 years if and only if management can demonstrate the **reliability** of the extended forecasts based on past experience and supportable information.[117]

In the current context, this condition can be met by **incorporating credible climate scenario analyses** (e.g., scenarios published by the IPCC, IEA, or NGFS) to assess the impact on demand, prices, and costs in the long run. One suggested approach is to use multiple scenario analyses: e.g., a "**business as usual**" scenario vs. a strong mitigation scenario (e.g., aligned with the Paris Agreement) -each with associated flow projections- and then weight the results or at least perform sensitivity analyses[118].

[117] https://www.ifrs.org/content/dam/ifrs/supporting-implementation/documents/effects-of-climate-related-matters-on-financial-statements.pdf?

[118] https://kpmg.com/kpmg-us/content/dam/kpmg/frv/pdf/2024/handbook-climate-risk-financial-statements.pdf?

Although IAS 36 does not formally require the use of multiple probabilistic scenarios, it does require that the assumptions reflect the "**best estimate**" of the future direction of the economy and industry and consider the full range of reasonably possible economic conditions.

In summary, estimating value in use in the presence of climate risks requires extending the gaze beyond traditional budgeting horizons and incorporating medium- to long-term assessments, using future scenarios that reflect possible transition paths or physical impacts.
The variability of these scenarios is inherently high, which in turn increases the uncertainty of the estimates, which is why IAS 36 requires robust disclosure of assumptions and sensitivity analyses in such cases[119].

Assumptions about future cash flows impacted by climate risks: In calculating value in use, expected cash flows must be based **on management's best estimates** of the asset's future revenues and costs in its current state (i.e., without considering improvements or restructurings that have not yet begun). Climate risks directly impact these assumptions in many ways. Some examples:

- **Reduced demand or prices**: In an accelerated transition scenario, an oil or coal company might expect, based on market evidence, a structural decline in demand for and price of fossil resources. This implies lower future revenues from fields or mining facilities, which must be incorporated into projections[120].

- **Reduction in economic life:** Some climate risks essentially anticipate the end of an asset's economic life. This can occur due to **irreversible physical damage** (example: A coastal plant severely damaged by a hurricane may never return to

[119]https://www.ifrs.org/content/dam/ifrs/supporting-implementation/documents/effects-of-climate-related-matters-on-financial-statements.pdf#:~:text=flows,excluding%20any%20estimated%20cash%20flows
[120]https://www.reuters.com/article/world/uk/bp-wipes-up-to-14-billion-from-assets-with-bleaker-oil-outlook-idUSKBN23M0N2/#:~:text=BP%20said%20that%20the%20aftermath,the%202015%20Paris%20climate%20agreement;
https://ieefa.org/resources/ieefa-update-rwe-uniper-risk-prolonging-dutch-coal-mistakes-compensation-strategy#:~:text=IEEFA%20estimates%20that%20they%20have,by%20the%20end%20of%202029

full operation), or more commonly **earlier obsolescence** due to transition factors. This is exactly what happened in the Netherlands, where in 2019 the government announced a coal phase-out to 2029: Utilities RWE, Uniper, and Engie, which had built new coal-fired power plants only a few years earlier, had to adjust their utilization forecasts to *a de facto* half-life, collectively recording more than €4 billion in write-downs on those plants**.**

3.4 Impacts of climate risks on the energy sector: Cases of impairment

The energy sector is one of the most exposed to climate risks and, consequently, one in which significant climate change-related asset impairments have already occurred. This sector includes both fossil fuel industries (oil, natural gas, coal) and the electric generation and distribution sector.

Climate risks affect these assets in several ways:

- **Physical vulnerability of energy assets**: Infrastructure such as offshore oil platforms, coastal refineries, pipelines, and the power grid are often exposed to extreme weather events amplified by climate change. For example, increased hurricanes and storms can damage offshore platforms and mining facilities; extreme heat waves can reduce the efficiency of thermal power plants or cause blackouts due to grid overload; and periods of drought negatively affect the output of hydropower plants. Although many of these effects result in temporary operating costs or revenue losses, some events may lead to permanent write-downs[121].
- **Transition risks**: In 2020 **BP** announced a radical revision of its long-term oil price forecast (raising Brent from $70 to $55 per barrel as an average through 2050) in response to the twin thrust of the **Covid-19 pandemic and the expected acceleration in the energy transition** ("build back better" post-pandemic in line

[121] https://assets.bbhub.io/company/sites/60/2021/10/FINAL-2017-TCFD-Report.pdf

with the Paris Agreement)[122]. As a result, BP had to write down **$13-17,5 billion** in assets in the second quarter of 2020. BP itself said these adjustments reflect the belief that fossil energy demand will have a lasting decline and that some extraction projects "**may never be developed**" under a scenario of increased climate engagement. At the same time, **Royal Dutch Shell** also made a maxi-devaluation between $15 billion and $22 billion in 2020, citing the collapse in oil prices and the prospects of the energy sector's transformation to lower-emitting sources as reasons.[123] These examples illustrate how transition risk can materialize quickly: Billion-dollar investments that become unrecoverable in less than a decade due to market changes and environmental regulations.

- **Early divestment:** Another impact of climate risks on the energy sector is the acceleration of plans to divest or convert assets. Many companies are deliberately retiring high-carbon assets from service before the end of their technical life, either to follow voluntary environmental commitments or due to decisions imposed by public policy. For example, **Vattenfall** in 2015-2016 significantly wrote down coal-fired power plants in Germany before divesting them[124]; **RWE** wrote down conventional generation assets due to the combined impact of the Energiewende[125] (Germany's transition to renewables) and environmental regulations.
- **Structural changes in energy demand**: Linked to transition risks is the aspect of changes in energy consumption habits. Climate policies and innovations are leading, for example, to a massive penetration of electric vehicles, with the prospect of declining demand for fossil transport fuels as early as the next decade; energy efficiency reduces the growth in demand for electricity and gas; and consumers are more careful and switch to "green" suppliers wherever possible. This creates uncertainty in the long-term forecasts of traditional energy

[122]https://www.reuters.com/article/world/uk/bp-wipes-up-to-14-billion-from-assets-with-bleaker-oil-outlook-idUSKBN23M0N2/#:~:text=BP%20said%20that%20the%20aftermath,the%202015%20Paris%20climate%20agreement

[123]https://insideclimatenews.org/news/02072020/bp-shell-coronavirus-climate-change/#:~:text=term%20outlook%20for%20oil%20and,some%20of%20its%20prospective%20projects

[124]https://group.vattenfall.com/press-and-media/pressreleases/2015/vattenfalls-second-quarter-2015-substantial-impairment-losses-and-continued-low-electricity-prices

[125]https://www.orkestra.deusto.es/images/investigacion/publicaciones/informes/cuadernos-orkestra/Energiewende_English.pdf

companies. For example, **liquefied natural gas (LNG)** companies must assess whether terminals and infrastructure built to last 40 years will still have use in 20 to 30 years if the green transition takes hold. In essence, any systemic shift in demand to a low-carbon economy represents a potential risk of unused or underutilized assets for the industry, with associated write-downs[126].

3.5 Connectivity between Financial and Sustainability Reporting Information

In parallel, a revolution in sustainability reporting is taking place.

In 2023, the first global sustainability standards were issued by the ISSB "*International Sustainability Standard Boards"* (IFRS S1 and S2, with the second dedicated entirely to Climate-related Disclosures), while in Europe **CSRD** came into force, requiring thousands of companies to report in detail on climate-related risks, strategies, and impacts according to European standards. These developments, while affecting non-financial reporting, will also have an indirect but substantial impact on IAS/IFRS financial statements. First, both European standards explicitly incorporate the concept of "**connectivity**"[127] between financial statements and sustainability information, requiring companies to explain correlations and ensure consistency between what is stated in one area and the other.

This means that it will be increasingly difficult, for example, to state in the sustainability report that a certain carbon pricing scenario is expected while simultaneously not reflecting anything similar in the impairment test assumptions. In other words, the two reports will begin to talk to each other.

[126] https://www.mckinsey.com/industries/oil-and-gas/our-insights/the-future-of-liquefied-natural-gas-opportunities-for-growth
[127] https://www.unibocconi.it/it/news/connettivita-perche-bilanci-e-sostenibilita-devono-parlarsi

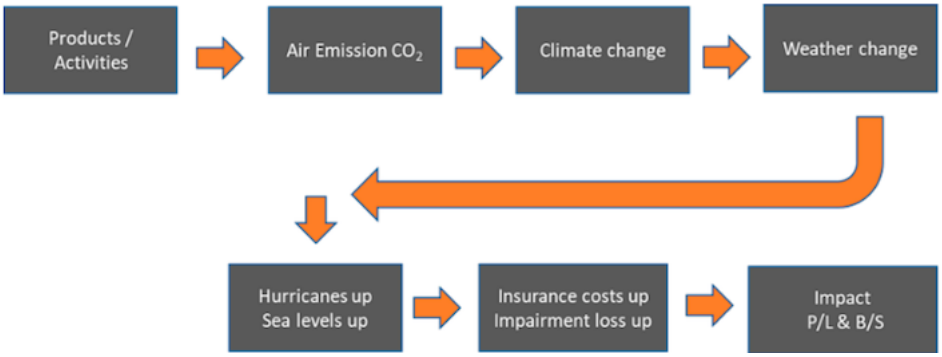

Figure 17 - Example of financial and non-financial interaction and interconnection - https://www.efrag.org/sites/default/files/sites/webpublishing/SiteAssets/EFRAG%20PTF-NFRS_A4_FINAL.pdf

L' EFRAG (*European Financial Reporting Advisory Group*) [128] distinguishes between **direct connectivity** and **indirect connectivity** in reporting.

- **Direct Connectivity:** It is achieved through **cross-referencing**, that is, direct cross-references between information in the ESG report and items or notes in the financial statements. For example, if a carbon intensity indicator (such as CO_2 emissions per unit of revenue) is reported in the sustainability report, the turnover value used to calculate it should be directly linked to the corresponding revenue.

- **Indirect Connectivity:** This is when the link between ESG reporting and financial statements is **less immediate**, that is, the sustainability information is not directly conciliable with a balance sheet figure, but there is still a correlation that must be explained. In these cases, the company must identify the qualitative or consistency links between what it states in the ESG report, and the estimates/values present in the financial statements. An example provided by EFRAG is consistency in the use of certain parameters: If the company adopts an internal price for CO in its decarbonization plans (sustainability disclosure) and in parallel uses carbon price assumptions to estimate possible expenses or impairment on assets subject to carbon regulation (financial reporting), it is

[128] EAFRAG is an independent organization to provide technical advice to the European Commission on financial reporting and sustainability standards for European companies.
https://www.madehse.com/it-it/sostenibilit%C3%A0-rapporto-efrag-su-implementazione-pratiche-esrs.aspx#:~:text=EFRAG%20(European%20Financial%20Reporting%20Advisory%20Group)%20%C3%A8%20un'organizzazione,sostenibilit%C3%A0%20per%20le%20imprese%20europee.

necessary to ensure that these assumptions are aligned. Since it is not possible to reconcile a specific number, indirect connectivity focuses on maintaining consistency of criteria, methodologies and timing between sustainability and financial statements. Indirect connectivity ensures that, even in the absence of a precise numerical connection, the two parts of the report "**speak the same language**" and do not provide inconsistent messages.

Both types of connectivity aim to meet the general principle that any materially relevant monetary or quantitative amount in the sustainability report shall be reconciled with the financial statement: Either by direct reference to the relevant item, or by explaining clearly how that item is derived from (or related to) items in the financial statements and providing reconciliations if necessary.

Accounting and sustainability information provides a **holistic, global,** and **coherent picture** of the climate-related risks facing the company [129].

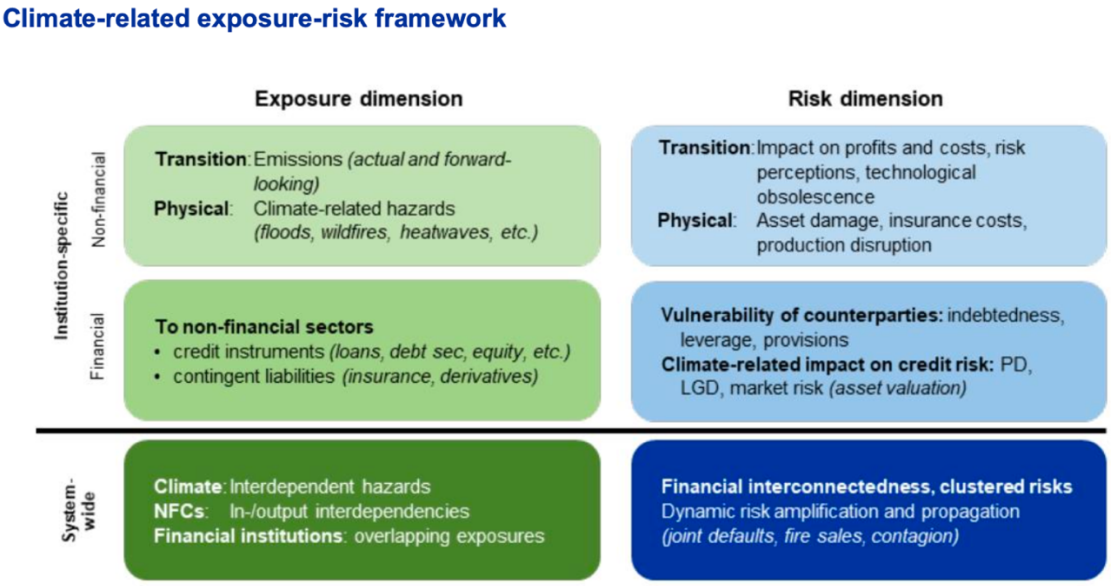

Figure 18- https://www.esrb.europa.eu/pub/pdf/reports/esrb.report202404_climaterelatedrisks~2311dfaee2.en.pdf

In conclusion, the application of IAS 36 considering climate risks represents a rapidly developing field, where best practices and formal rules are evolving together.

[129] https://www.ilsole24ore.com/art/doppia-rilevanza-e-connettivita-sono-sfide-le-imprese-italiane-AFIw1IoB

The application challenges -from scenario definition to the choice of assumptions and disclosure transparency- are significant, but the direction is clear: We are moving toward increasingly integrating climate change into financial assessments.

This means that financial statement will need to be able to tell, numbers in hand, how climate impacts (or potentially will impact) the value of corporate assets. Ultimately, the impairment test under IAS 36, from being a "traditional" accounting exercise, is turning into one of the hubs where sustainability becomes finance: Recognizing climate-related impairments early on is not only a technical obligation, but also a signal of good governance and proactive risk management toward a low-emissions future.

4 “AS-IS” Climate Risk Management process

This chapter aims to explore the climate change issue through an *empirical* perspective. For this reason, a qualitative survey was conducted through interviews with companies operating in the energy sector, that is particularly exposed to climate risks and heavily involved in ecological transition processes.

The main purpose of the survey was to gather opinions, operational experiences, and subjective perceptions regarding the role of the interviewed companies in managing climate risk and implementing adaptation and mitigation strategies. Through discussions with figures such as *Head of Finance*, and *Chief Risk Officer* it was possible to reconstruct in detail the **“AS IS” process** of **identifying, assessing and quantifying climate risks** within organizations.

The interviews made it possible to highlight both the tools adopted and the main challenges in the management of climate-related risks, thus offering a useful contribution to understanding how Italian energy companies are concretely integrating climate risks into their decision-making processes and risk management frameworks.

4.1 A2A

A2A[130] is one of Italy's leading multi-utilities, active in the energy, environment, heat, and networks sectors. It produces and distributes electricity and gas, manages the waste cycle, and offers district heating, public lighting, and sustainable mobility services[131]. Silvana Toppi, *Group Head of Digital Administration, Finance and Control Evolution*, Ferruti Ludovica Anna Mari, *Enterprise Risk Manager focal point ESG,* Stefano Guazzoni, *Head of Strategic Planning, Group Controlling and Revenues Assurance offices*, and Federico Quaglia, *Head of Group Planning & Control*, were interviewed for this company.

[130] https://www.gruppoa2a.it/it/chi-siamo
[131] https://www.gruppoa2a.it/it/chi-siamo/nostra-organizzazione

To outline the process of climate risk identification, the following questions were submitted:

1. What is the process and the steps you follow to identify climate change risks?

Climate risks are integrated within the **Enterprise Risk Management (ERM) process** and are part of the regularly monitored risk portfolio. The process includes the involvement of **risk owners**, i.e., the heads of the different units in the Group. For the materiality analysis of climate risks, A2A has adopted the **recommendations of the TCFD** as a reference since 2015, identifying **physical risks** (thermal overloading of power cables, hydraulics risk, and decreased demand for thermal energy) and **transition risks** (regulatory changes that may affect business operations and profitability).

Subsequently, with the publication of the Taxonomy documents for the sustainable investments, the distinction between physical risks (acute and chronic) and transition risks, according to climatic criteria such as temperature, precipitation, and wind, was deepened. This classification was adopted to carry out comprehensive risk mapping through interviews with risk owners, which provided an assessment of the degree of exposure and riskiness of facilities and activities with respect to climate hazards.

The entire identification and classification process then evolved in parallel with the changing regulatory environment.

The internal process is subsequently translated into **external disclosure**, initially through the integrated financial statements in accordance with TCFD recommendations, and now also in compliance with the new CSRD, maintaining the classification between physical and transitional risks.

2. Which roles are involved?

In addition to **risk owners**, the process involves **process owners**, who are responsible for business units (e.g., asset management); **risk specialists**, who monitor regulatory developments; **management control managers**, who provide data for economic quantification of risks (e.g., expected production vs. variations due to weather conditions); and **scenario experts**, who prepare price and emission forecasts. The

insurance function also participates to assess exposure to extreme risks based on historical claims and deductibles.

3. Do you use software?

Currently the process is managed **manually**, but A2A is considering the adoption of a digital platform to conduct more timely analysis, integrate climate scenarios, and manage risk on an asset-specific basis.

To outline the climate risk assessment process, the following questions were submitted:

4. What is the assessment process?

Climate risk assessment is currently carried out **manually** with climate data from an external platform that provides climate forecasts up to 2100 based on different IPCC scenarios and allows for specific information for municipal areas of interest to the company.
In addition, the company uses the **ISPRA platform**[132] to analyze landslide and flood risk on physical assets.
The medium-term goal is to automate the assessment to systematically estimate the degree of exposure and riskiness of each asset according to different climatic hazards and over different time horizons.
Risk assessment is based on a **5x5 matrix** distinguishing between **economic-financial** and **reputational impacts**. For example, water scarcity for potable uses is considered a reputational risk, while changes in hydraulicity for hydropower generation or changes in CO2 emission permission regulations are seen as economic-financial risks.

[132] ISPRA platform in an Italian platform on adaptation to climate change, promoted by the Ministry of Ecological Transition, aims to favor exchange of information between central administration, local authorities, and all stakeholders. https://www.isprambiente.gov.it/en/archive/news-and-other-events/ispra-news/2022/10/the-national-platform-on-adaptation-to-climate-change-has-been-published

To outline the process of quantifying climate risks, the following questions were submitted:

5. ***What is the quantification process?***

Quantification is based on the difference between the expected impacts of climate risks and the **one-decade business plan** (2025-2035 plan). The expected changes are compared with the expected data and ranked according to a 5-level matrix of economic-financial impact, referring to the company's net financial position **(% of NFP or EBITDA**).

6. ***To what extent is climate risk considered a strategic priority for the company? Do you consider climate risks, possible impacts, investments, and mitigation actions in the budget plan phase?***

Climate risk is considered strategic: It is among the "**top 10 risks**" presented to the Audit and Risk Committee and is specifically disclosed, including in the planning and budget phase, where the possible impacts of climate hazards on industrial plane are analyzed, and mitigation actions are defined.

7. ***As part of your impairment tests, do you consider the potential effects of climate risks on the company's book values?***

Yes, A2A integrates the potential effects of climate risks into its impairment testing process, in line with the requirements of IAS 36. The goal is to assess not only the assets' value in use but also their resilience in the face of external environmental variables.

The impairment test is carried out annually at year-end, as required by IAS 36. However, if *trigger events* occur—such as significantly negative performance by certain CGUs or relevant technological changes—an *ad hoc* update may be requested during the year.

Every six months, discount rates are updated, and the coverage levels identified at year-end are verified through lighter checks, aimed at assessing whether any internal or external events have significantly altered the value of the CGUs.

A2A's main methodology for impairment testing is the **Discounted Cash Flow (DCF)** approach, which compares the value in use with the carrying amount. The assumptions underlying the DCF are consistent with IAS 36, except for the forecasting horizon used, which exceeds the standard five years but is justified and approved by management.

For the past two years, A2A has incorporated climate risk analysis into the impairment testing process. Specifically, two physical variables were selected:

- **Heating Degree Days**, related to the effect of temperature on business performance.
- **Hydraulicity**, related to rainfall and, consequently, to hydropower production.

In the first year, the analysis was managed internally, focusing on how these variables impacted the EBITDA of CGUs subject to impairment testing.

This year, the approach was further refined with the support of Deloitte, adopting an **econometric methodology** based on Monte Carlo simulations.

Using historical data from the past five years, the external expert assessed the statistical significance of the climate variables and calculated the probability of maintaining a positive coverage or incurring an impairment, depending on climatic conditions.

This analysis allowed not only for the evaluation of the direct effect of climate variables on the carrying amounts, but also for the representation of their impact in probabilistic terms, through a Gaussian distribution of the results.

In summary, for each CGU, it was possible to estimate both the percentage of scenarios in which sufficient coverage is maintained and the probability of incurring an impairment.

CGUs with significant initial coverage demonstrated strong resilience even under adverse climate scenarios, whereas for CGUs with thinner margins, the analysis highlighted greater variability, suggesting that management should apply closer monitoring.

It is important to note that, at present, the analysis focuses exclusively on **physical climate risks**, such as heating degree days and hydraulicity, and that no **transition risks** relevant to impairment have been identified.

The integration of climate risks does not automatically result in the impairment of assets. Instead, it is considered as an advanced sensitivity analysis, aimed at testing asset resilience even under unfavorable climate scenarios.

In conclusion, A2A's impairment testing process is based on robust methodologies aligned with IAS 36, enhanced by econometric analyses that strengthen the company's ability to proactively monitor and manage climate-related risks that could impact its assets.

8. How often do you update the risk mapping?

Once every six months. However, there are also *ad hoc* meetings to deepen certain topics.

9. What were the major critical issues in managing climate risks for A2A?

In general, the **Enterprise Risk Management process** manages a large total number of risks -not only climate risks- (**about 200)** that are complex to manage with **manual tools** for filing, updating, sharing such as excel, email, file folders, etc.

To overcome this difficulty, the entire Enterprise Risk Management function has been equipped with a dedicated platform developed through **Power Apps**[133], which has made it possible to **standardize** and **digitize** workflows, improving information traceability and process efficiency.

One of the most significant challenges today is to **perform climate risk analysis with plant-level detail and under different climate scenarios defined by the IPCC**. This need comes from regulatory obligations and standards issued in the context of CSRD and the EU taxonomy on green investments.

[133] Power Apps is a suite of apps, services, and connectors as well as a data platform that provides a rapid development environment to create applications tailored to business needs. https://learn.microsoft.com/it-it/power-apps/powerapps-overview

Given the large number of plants and the variety of processes and facilities in the A2A Group such detailed analysis is very onerous and needs supporting IT tools that A2A is in the process of acquiring.

4.2 Edison

Edison is one of Italy's leading energy companies, active in the production, procurement and sale of electricity and natural gas. It also operates in the development of renewable sources and energy efficiency, with the aim of fostering energy transition and environmental sustainability. Vincenzo Collarino, *Finance Director, and Chief Risk Officer* was interviewed for this company[134].

To outline the process of climate risk identification, the following questions were submitted:

1. What is the process and the steps you follow to identify climate change risks?

Climate risks are identified within the **Enterprise Risk Management (ERM) process**, which is a business process that aims to map all business risks and is based on the **COSO framework**, used globally as a reference point for risk mapping.
Each business unit conducts a self-assessment of emerging risks, considering **impact, likelihood of occurrence, and level of control**. The information is collected by a typically central structure, **Risk Management**, processed according to logic shared by management and validated by the **Board of Directors**.

The COSO framework, among the most widely adopted in the world, promotes an **integrated approach** to risk assessment, overcoming *"silo"* logic and encouraging analysis of the interconnections between different risk categories. Over time, it has become strategically important, as it not only identifies potential risks but also assesses their impact on the achievement of long-term strategic objectives.
Therefore, ESG risks, including climate risks, are considered **cross-cutting** and have a significant weight in the process: For each risk, ESG relevance and correlation with other business risks are assessed, as well as the impact on long-term strategic goals.

[134] https://www.edison.it/it/chi-siamo

For example, a risk such as the failure to develop renewable plants due to complex authorization processes is analyzed for both its ESG relevance and its strategic implications. So, there is also legal at the strategic level.

With the entry into force of the **Corporate Sustainability Reporting Directive (CSRD),** an even more structured assessment of climate risks is required, based on the use of climate scenarios and timely mapping of corporate assets.
Until now, Edison has analyzed climate impacts in a qualitative and general way (e.g., effect of average temperature rises on plant performance or increased flooding on hydroelectric production). Now, however, it is embarking on a detailed analysis project, with the goal of integrating geolocated data, external data providers, and more advanced predictive models to improve understanding and management of climate risks prospectively.

2. Which roles are involved?

The risk identification process involves the **entire** company, so all **business units** are engaged in risk mapping. The results are shared with the **management,** the **CEO,** the **Risk Control and Sustainability Committee**, and finally with the **Board of Directors**. The main results are also published in the **Annual Report**.

3. Do you use software?

Yes, Edison uses **GRC "Governance, Risk and Compliance" software** that collects about 150-170 elementary risks per year. Each risk is described in a sheet containing impact, level of control, ESG nature and assignment to the relevant risk owner.
The software allows aggregation and rationalization into about 20 major risks, including through economic and financial modeling.

To outline the climate risk assessment process, the following questions were submitted:

4. What is the assessment process?

Climate risks are assessed in both **financial** and **reputational** terms, using impact scales that consider the effect on **EBITDA**, **cash flow**, and **corporate reputation**. The principle of **dual materiality** is applied, with thresholds defined to determine the financial significance of the risk.

To outline the process of quantifying climate risks, the following questions were submitted:

5. What is the quantification process?

Risk quantification is done using different models depending on the nature of the risk.
For some ESG risks, such as those related to the development of investments in renewables, the same tools and models used for business planning are adopted to estimate their impact on the business plan.

About physical climate risks -such as an increase in average temperature or a reduction in wind- initial estimates have been conducted through simplified models, but the company is working on implementing more **advanced ones**.
Highly structured external databases are also being used to support this process, allowing for very detailed spatial analysis (down to the individual square meter) of phenomena such as rainfall, wind, floods, and other extreme weather events.

By cross-referencing this data with the geographic location of company assets, the potential impact of climate hazards on specific operational areas and facilities can be more accurately estimated, with the goal of strengthening predictive capacity and enterprise-wide risk management.

6. ***To what extent is climate risk considered a strategic priority for the company? Do you consider climate risks, possible impacts, investments, and mitigation actions in the budget plan phase?***

Climate risk is a **top-level strategic priority** for Edison, as it is relevant under two main dimensions:
- **Regulatory compliance**, in relation to the obligations imposed by the European regulations and directives.
- **Strategic alignment**, consistent with the company's mission, which is based on the development of renewable sources, energy efficiency, and supporting the energy transition of its customers.

Thus, the climate and more generally ESG dimension is not only a regulatory constraint, but a key lever for the implementation of the company's strategy.
Consequently, ESG risks, in particular climate ones, are **fully integrated** into the Group's strategic risk management system.

Even at the budgeting and industrial planning stage, climate risks are considered. A relevant example is the risk of delay in the development of renewable plants, which is one of the central assets of the industrial plan. The assessment of these risks therefore influences not only the definition of investments and operational priorities, but also the planning of possible mitigating actions.

7. ***As part of your impairment tests, do you consider the potential effects of climate risks on the company's book values?***

Currently, there have been no climate risk-related impairments, but as modeling is strengthened and more structured climate scenarios are adopted, these potential effects on asset values and goodwill will also need to be more carefully evaluated.

8. How often do you update the risk mapping?

The process is **annual** in conjunction with the group's business plan. There are also **quarterly,** less structured updates focused on the most critical risks, to keep the analysis up to date between formal assessments.

So, there is a more institutional moment at the conclusion of a structured process, and then quarterly there are periodic updates.

9. What were the major critical issues in managing climate risks for Edison?

One of the biggest challenges Edison faces is the rising average temperatures, particularly during the summer months. This increase can really impact the efficiency of thermoelectric plants. When water is drawn from rivers for cooling, it becomes less effective as temperatures rise, which in turn diminishes the cooling capacity of the machinery. On top of that, there is a decline in precipitation and snowfall, which negatively impacts the water available in reservoirs, leading to a greater reliance on gas for energy production. Another pressing concern is the volatility of energy prices during peak summer demand. Additionally, extreme weather events, like flooding, pose an increasing risk that can directly threaten the safety and operational continuity of the plants.

In this context, Edison has demonstrated a **strong risk culture**, thanks to **a solid corporate structure** and **a methodical approach** to managing critical environmental issues. However, the real issue to be addressed is **the ability to intercept new emerging risks in a timely manner** and, above all, to **allocate adequate resources and investments to mitigate their effects**. The uncertainty associated with so-called "**black swans**" requires continuous updating and strengthening of forecasting and response capabilities.

4.3 Considerations on Climate Risks: Interview-based perspectives

The qualitative analyses conducted through the interviews with A2A, and Edison highlight how energy companies are progressively integrating climate risks into their **Enterprise Risk Management (ERM) systems,** adopting increasingly **structured approaches** in line with major international frameworks such as TCFD recommendations and COSO.

Both companies demonstrate a high degree of **awareness** with respect to the centrality of climate risks, recognizing them as **strategic factors** that influence not only operational resilience, but also the setting of industrial priorities, investments, and mitigation actions. Some key observations:

- **Climate risks have been fully incorporated into the corporate risk map**, no longer isolated in "*silos*" but evaluated in the context of broader strategic and financial objectives.
- Regulatory developments -particularly CSRD- have prompted companies to adopt more advanced tools for identifying, classifying, and communicating climate risks. **Disclosure is no longer optional, but a requirement for transparency to investors and institutional stakeholders.**
- **Climate risk is now a cross-cutting variable**, involving heterogeneous functions and competencies. This has contributed to the strengthening of a more conscious corporate culture geared toward integrated risk management.
- **The need to overcome management fragmentation emerged**, with a decisive push toward digitization of risk management processes.

Given these insights, it can be said that the Italian energy sector is taking significant steps toward **a proactive approach** to climate risk. Future evolution will require:

- Further **standardization** of processes and metrics to promote comparability and traceability.
- **Greater use of enabling technologies (AI)** for asset-based scale modeling.

- Strengthening **internal skills and risk culture**, including through targeted training.
- **Greater connection between risk management and strategic definition**, to transform climate risk from a constraint to an opportunity for sustainable development.

In conclusion, the survey results indicate that managing climate risk is no longer a formal exercise; it is a **vital part of energy companies' resilience, competitiveness, and strategic credibility**.

5 “TO BE” Climate Risk Management Process: Artificial Intelligence as predictive tool

The modern world is significantly shaped by transformative forces like **Artificial Intelligence** (AI). AI stands out as one of the most influential agents of change in our era, with the potential to tackle some of humanity's most complex problems such as climate change.

5.1 Artificial Intelligence

Artificial Intelligence has its roots in the 20th century [135] when visionaries such as Alan Turing began to imagine a world in which machines could “think”. In 1950 Turing wrote a paper entitled “*Computing machinery and intelligence”*, in which he proposed what would become known as the **Turing test**. According to the test, a machine could be considered intelligent if “*its behavior, observed by a human being, was considered indistinguishable from that of a person.”*[136]

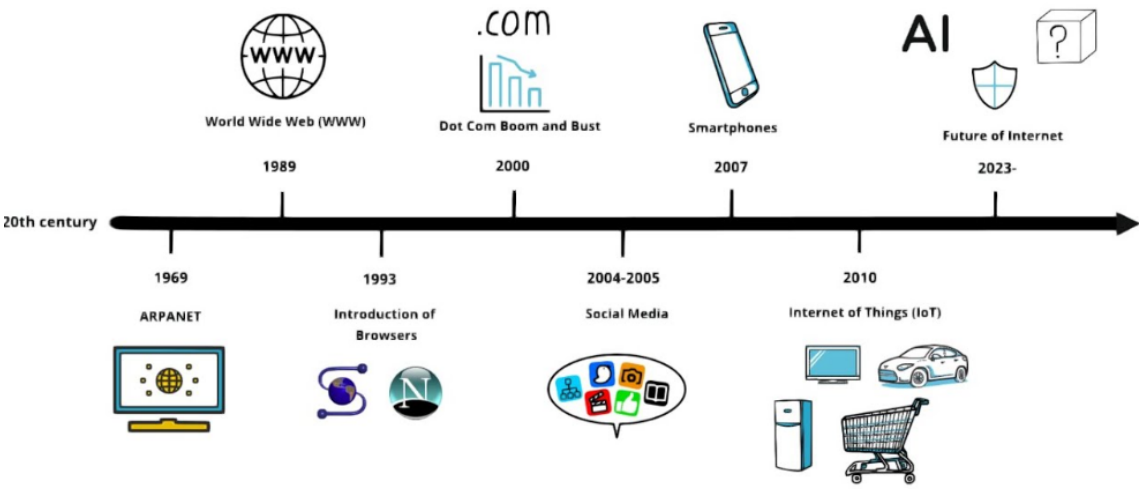

Figure 19 - The History of the Internet: A Timeline -

[135] https://www.seozoom.it/storia-intelligenza-artificiale/
[136] https://blog.osservatori.net/it_it/storia-intelligenza-artificiale

Artificial Intelligence (AI) is a concept that is already part of our actions and decisions, just think of the use we make of it for everyday activities: When we use *Google Maps* to find the quickest route; when we query *Uber* which employs predictive algorithms on passenger demand, prices, and arrival times, when *Facebook* personalizes our news feed making our experience more engaging[137].

Today we talk about **Generative AI**, which differs from traditional AI.
McKinsey gives the following definitions for traditional (or analytical) and Generative AI:

- **Traditional AI** is defined as the tool that works on structured data and can be used to solve analytical tasks such as classifying information, predicting economic trends, generating scenarios, and aggregating information into clusters so that it can be analyzed. Its peculiarity is that it does simple and complex mathematical calculations.
- **Generative AI** is a predictive language model that creates new unstructured content, such as text, images, or audio. Generative AI does not do mathematical calculations but generates written documents, audio conversations, or images. When using it to do calculations, it makes use of AI foundation models[138].

Generative technology is a real change in basic assumptions, because instead of just analyzing data to make predictions or solve predefined problems it focuses on creating new original content that did not previously exist. These advanced models can take different data inputs and discern patterns and structures within them, but instead of stopping there they use the information to generate novel outputs.

Investment in AI technology between now and 2040 is expected to be $40 trillion. Another surprising element is its speed of deployment. **ChatGPT**, launched on November 30, 2022, was the online service that reached **one million users** most quickly—in only a few days. This figure becomes even more impressive when compared to other prominent platforms: for instance, Instagram required several weeks, Facebook

[137] Roberto Prioreschi, *"Intelligenza Artificiale Rivoluzione Competitiva, Qual è il potenziale per l'Italia?",* La rivista dei Direttori Amministrativi e Finanziari (ANDAF), 2024.
[138]https://www.mckinsey.com/capabilities/strategy-and-corporate-finance/our-insights/gen-ai-a-guide-for-cfos

approximately ten months, and Netflix more than three years to achieve the same milestone[139].

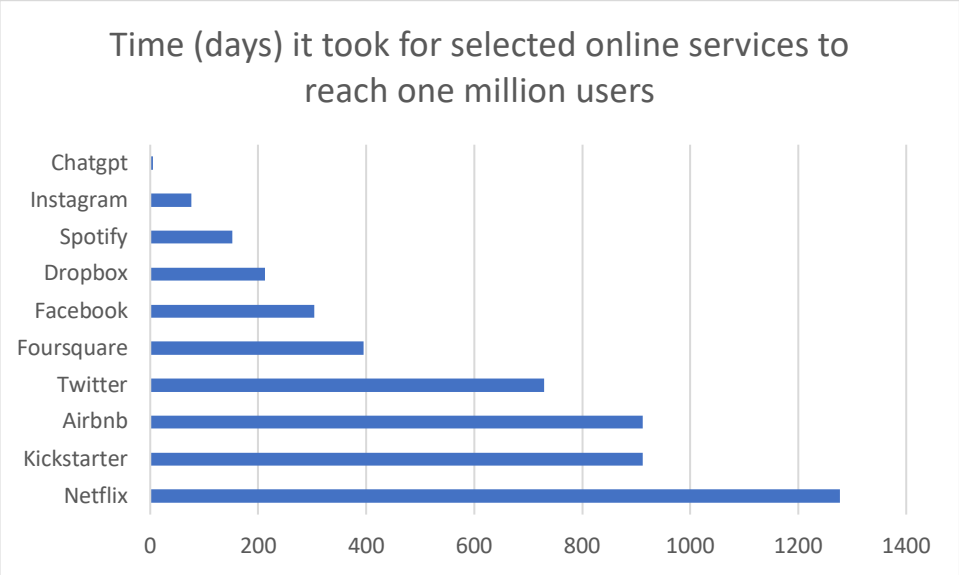

Figure 20 - https://www.digitalinformationworld.com/2023/01/chat-gpt-achieved-one-million-users-in.html

The reality of all economic sectors is rapidly embracing the AI revolution. Further growth of this technology is expected in the coming months: The global AI market is assumed to increase by 166 billion in 2023 to 478 billion by 2027, reflecting a Compound Annual Growth Rate (CAGR) of 30 percent[140].

5.2 Machine Learning

Generative AI is an Artificial Intelligence system capable of producing high-quality content, particularly text, images, and audio.
Some of the best-known Generative AI or GenAI systems are OpenAi's *ChatGPT*, Microsoft's *Copilot* (based on ChatGPT), and *Google*'s Gemini.

[139] Associazione Nazionale Direttori Amministrativi e Finanziari (ANDAF), "*L'Intelligenza Artificiale Come Partner Strategico Per il CFO: Innovazione ed Efficienza",* La rivista dei Direttori Amministrativi e Finanziari (ANDAF), 2024
[140] Roberto Prioreschi, *"Intelligenza Artificiale Rivoluzione Competitiva, Qual è il potenziale per l'Italia?",* La rivista dei Direttori Amministrativi e Finanziari (ANDAF), 2024.

To define it in a more technical way, we can say that Generative AI is a *subset of an AI technique called deep learning, which uses artificial neutral networks to process more complex patterns than is possible with machine learning techniques*[141].

Machine learning allows a system to learn and improve autonomously without being explicitly programmed. Machine learning algorithms work by recognizing patterns and data and making predictions when new data are fed into the system. Three types of patterns are often used in machine learning[142]:

- **Supervised learning**
- **Non-supervised learning**
- **Reinforced learning.**

5.2.1 Supervised Learning

Supervised learning is a technique in machine learning that is commonly used in Artificial Intelligence. It involves training an algorithm on a dataset that has been labeled, helping it learn to make predictions or decisions based on that data. In other words, the model receives inputs accompanied by the corresponding desired outputs during the training phase. The goal is to learn how to map inputs to the correct outputs so that it can make accurate predictions on new, unlabeled data.

5.2.2 Non supervised Learning

Unsupervised learning is a machine learning model that uses unlabeled data (unstructured data). Unlike supervised learning, the output is not known in advance.
Rather, the algorithm learns from the data without human intervention and categorizes it into groups based on attributes.

[141] Associazione Nazionale Direttori Amministrativi e Finanziari (ANDAF), "*L'Intelligenza Artificiale Come Partner Strategico Per il CFO: Innovazione ed Efficienza",* La rivista dei Direttori Amministrativi e Finanziari (ANDAF), 2024
[142] https://www.oracle.com/it/artificial-intelligence/machine-learning/what-is-machine-learning/

5.2.3 Reinforced Learning

Reinforced learning is an automatic learning model that can be described as "*learning by doing*" through a series of trial-and-error experiments.

5.3 Deep Learning

Deep learning is a subset of machine learning that uses artificial neutral networks to process and analyze information. Neutral networks are composed of well-known computational information that is layered within the deep learning algorithm. The algorithms in question are inspired by how the human brain works and are used to analyze data with a logical structure. Deep learning is employed in many tasks that we now consider AI, including image and word recognition, object detection, and normal language processing[143].

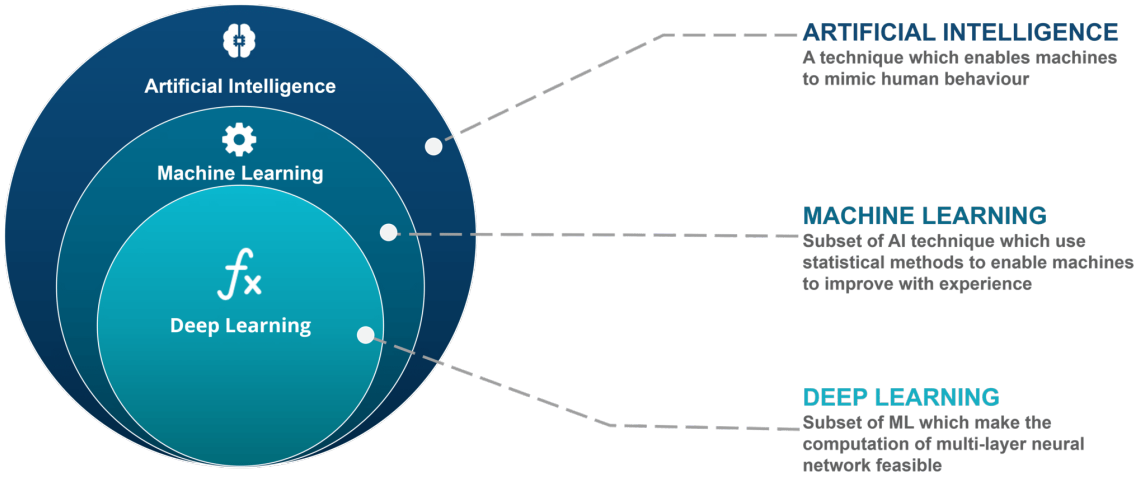

Figure 21 – https://www.edureka.co/blog/ai-vs-machine-learning-vs-deep-learning/

[143] Associazione Nazionale Direttori Amministrativi e Finanziari (ANDAF), "*L'Intelligenza Artificiale Come Partner Strategico Per il CFO: Innovazione ed Efficienza",* La rivista dei Direttori Amministrativi e Finanziari (ANDAF), 2024

5.4 European Artificial Intelligence Regulation: AI ACT

The European Union (EU) plays a leading role in the development, regulation, and ethical promotion of Artificial Intelligence.

The EU's target values for public or private investment in AI were 20 billion euros in total over the 2018-2020 period and 20 billion euros per year over the following decade. The Commission pledged to increase financial investment in research and innovation to €1.5 billion for 2018-2020 and €1 billion per year from 2021 to 2027 [144].

Artificial Intelligence is defined by the European Commission as follows "*an automated system designed to operate with varying levels of autonomy and which may exhibit adaptability after deployment and which, for explicit or implicit purposes, deduces from the input it receives how to generate outputs such as predictions, content, recommendations or decisions that can influence physical or virtual environments*."[145]

The EU is a pioneer in AI regulation, distinguishing itself through an approach centered on fundamental rights, security, and transparency.

Notably, the European Commission officially submitted the proposal for the Artificial Intelligence Regulation, AI ACT, in April 2021. This initiative aims to establish a legal framework that takes a risk management approach to oversee the development, commercialization, and use of AI within the European Union[146]. This Regulation introduces different obligations and restrictions for AI systems, which vary in severity depending on the risk category assigned to AI software. The level of risk is determined by the legislature according to the possible consequences on people's rights and freedoms, dividing systems into three main categories:

a) **Unacceptable risk**: The Regulations impose a categorical ban on practices such as indiscriminate surveillance and biometric

[144] https://www.eca.europa.eu/ECAPublications/SR-2024-08/SR-2024-08_IT.pdf
[145] Associazione Nazionale Direttori Amministrativi e Finanziari (ANDAF), "*L'Intelligenza Artificiale Come Partner Strategico Per il CFO: Innovazione ed Efficienza",* La rivista dei Direttori Amministrativi e Finanziari (ANDAF), 2024
[146] https://artificialintelligenceact.eu/ai-act-explorer/

categorization, classifying them as unacceptable risk. These regulations will become effective six months after the Regulation enters into force, and thus predictably by the end of 2024.

b) **High Risk:** This category includes AI systems used in sensitive areas such as healthcare, transportation, or critical infrastructure management. Where such risks exist, the Regulations require a fundamental rights impact assessment and ensure that systems meet standards of compliance, robustness, and traceability. Specific regulations will be in place within 24 months for sectors such as education and justice, and within 36 months for other sectors.

c) **Low risk:** Refers to less critical AI technologies, such as chatbots, where security and privacy risks are relatively minor. For these systems, regulations are less stringent although following appropriate codes of conduct is strongly recommended. It is also essential, as with all other AI systems, to ensure transparency by informing users that they are integrating with an AI system. [147]

If the risk is unacceptable, it will be necessary to stop using the systems immediately and replace them with compliant solutions; if, on the other hand, the risk is high, it will be necessary to take appropriate technical and organizational measures to ensure compliant use of the software, monitor its operation and inform vendors about any malfunctions, train and educate staff appropriately, and keep the systems up to date; in the case where the risk is minimal, it will be sufficient to ensure transparency by clearly informing users about the use of AI systems.

[147] Associazione Nazionale Direttori Amministrativi e Finanziari (ANDAF), "*L'Intelligenza Artificiale Come Partner Strategico Per il CFO: Innovazione ed Efficienza",* La rivista dei Direttori Amministrativi e Finanziari (ANDAF), 2024

5.5 Artificial Intelligence as Predictive tool

As we have seen in previous chapters, climate risks are a growing challenge for businesses, governments, and society. The complexity of these risks, which can affect physical assets, supply chains, and operations on a global scale, requires new tools for analysis and prediction.

In this context, **Artificial Intelligence (AI)** is emerging as a key ally for gathering and processing climate information with unprecedented depth and speed[148].

Therefore, interest in applying AI to climate risk management is shared by many international bodies, research centers and companies. Bodies such as the **United Nations (UN)** are promoting initiatives to harness AI in climate adaptation: For example, the **UN** has launched the **"Early Warnings for All program"** for every person on the planet to be protected by warning systems by 2027, and experts recognize that AI will play a key role in achieving this goal by enhancing the coverage and effectiveness of early warnings on a global scale[149].

The World Bank and the Global Facility for Disaster Reduction and Recovery (GFDRR) are funding projects that combine AI and geospatial data to strengthen resilience in developing countries, showing how technological innovation can close capacity gaps in the most fragile contexts [150].

On the corporate side, many technology companies and consulting firms have published dedicated white papers and solutions. For example, IT giants such as **IBM and Microsoft** are integrating AI into their corporate climate risk analysis tools[151] . Specialized startups -from **ClimateAI** (agribusiness) to **Jupiter Intelligence** (insurance) are offering AI-driven platforms for assessing physical risks, often in partnership with financial institutions or reinsurers. Consulting and auditing firms such as **Deloitte, McKinsey, and KPMG** have in turn released reports explaining how AI can improve climate risk

[148] https://www.forbes.com/sites/sap/2025/01/20/will-ai-and-climate-risk-management-align-in-2025/
[149]https://www.nature.com/articles/s41467-025-57640-w#:~:text=for%20multi,accuracy%20and%20lead%20time%2C%20advance
[150]https://blogs.worldbank.org/en/sustainablecities/can-ai-help-build-climate-resilience-caribbean-lets-look-housing#:~:text=In%20recent%20years%2C%20the%20World,efficiency
[151]https://www.weforum.org/stories/2025/01/technology-climate-value-chains-risks-adaptation/#:~:text=Forum%20www,and%20AI%20to%20adjust

governance and support compliance with new standards (e.g., climate stress testing, ESG reporting)[152].

As highlighted by the CMCC[153] Foundation, the "*new frontier of machine learning, a branch of AI, [is] serving climate studies and risk assessment"*[154].

In addition, when interviewing **A2A and Edison executives**, they were asked the following question, "**How does AI compare to the traditional risk assessment methods you use today**?" to which they responded as follows:

A2A: Artificial Intelligence (AI) is gradually being integrated into business processes, particularly in database rationalization and advanced reporting.
One of the main advantages of AI, using machine learning models, **is the ability to analyze large volumes of data and provide a predictive assessment of risks** that could affect specific geographic areas where company assets are located.
Thanks to AI, businesses can gain a cleared and more timely perspective on emerging risks, drawing insights from both historical data and current situations.
In addition, integration with cloud solutions allows real-time comparison with similar situations that have occurred in other territorial contexts, enabling analysis by analogy and benchmarking with homogeneous territories.
An additional benefit of AI is the ability to "democratize" access to information. Algorithms can suggest new variables to consider, broadening the view of risk and making analyses more comprehensive and multidimensional. Through the analysis of reports from similar territories, AI helps the management of a greater variety of parameters and enriches the decision-making process related to risk management.

[152]https://zesty.ai/news/in-case-you-missed-it-leader-roundtable-with-mckinsey-and-co#:~:text=In%20Case%20You%20Missed%20It%3A,insurers%20effectively%20manage%20climate%20risk
[153] The CMCC Foundation is an international research centre which studies the interaction between climate change and society. https://it.wikipedia.org/wiki/Centro_euro-Mediterraneo_sui_Cambiamenti_Climatici
[154] https://www.cmcc.it/it/articolo/intelligenza-artificiale-la-nuova-frontiera-per-valutare-i-rischi-legati-ai-cambiamenti-climatici#:~:text=Grandi%20moli%20di%20dati%20e,e%20Universit%C3%A0%20Ca%E2%80%99%20Foscari%20Venezia

To date, the Enterprise Risk Management function uses AI tools as support in the verbalization of risk assessment meetings.

Edison: Artificial Intelligence (AI) is set to be an increasingly relevant enabler in the evolution of risk analysis and management processes, due to its ability to process large volumes of data and generate complex insights quickly.

For Edison, AI will be able to make significant contributions in areas such as:

- The **analysis of historical data** and **climate time series**,
- The **simulation of complex future scenarios**,
- The **integration and enhancement of the risk reporting** and **monitoring system**.

To date, however, the use of AI in business is still in its infancy. Although automated tools such as bots for repetitive tasks are already in use, true generative or predictive AI to support risk assessment has not yet been implemented.

However, the potential stays very high, especially for climate risks, which are characterized by high uncertainty and a considerable amount of environmental, geographic, and operational data to analyze. In this light, AI could become an essential tool for advanced risk modeling, facilitate decision making, and strengthen business responsiveness. In the medium to long term, the contribution of AI is expected to be transversal to all business functions, not only in risk management, but also from the perspective of operational efficiency, innovation, and sustainability.

It can be inferred that AI is and will be increasingly employed in both **scientific-technical** (climate modeling, environmental big data analysis) **and strategic** (decision-making support, resilience planning) fields to improve climate risk management.

Below we will look at the contribution AI can make at different stages of Climate Risk Management.

5.5.1 Identification of climate risks with AI

One of the first steps in climate risk management is to identify hazards and vulnerabilities early. AI is enhancing multi-hazard **Early Warning Systems (EWSs)** by integrating meteorological, geospatial, and socioeconomic data to detect emerging threats. For example, advanced AI models enable the development of EWSs capable of simultaneously monitoring several natural hazards (e.g., floods, heat waves, droughts) and predicting their impacts through meteorological and geospatial foundation models. This makes it possible to move from simply predicting the extreme event to estimating the expected consequences, improving risk communication and crisis decision-making. Indeed, recent studies underscore the transformative potential of an integrated AI approach: Multi-model systems powered by heterogeneous data can increase the localization and personalization of alerts, improve their accuracy, and extend the warning time for communities and businesses[155].

A key aspect is the ability of these algorithms to capture complex relationships. Thanks to machine learning, they can take into account multiple factors – like meteorological, spatial, social elements- that influence the impact of an event all at once. This leads to more reliable predictions even in areas where historical data is scarce, effectively bridging information gaps with satellite observations.

Beyond just predicting **where and when** an extreme phenomenon might occur, AI also helps map **vulnerabilities and exposure** of land and infrastructure. International organizations such as the World Bank are experimenting with using AI and remote sensing to accelerate the collection of critical data in the field.

For example, by combining computer vision algorithms with aerial and satellite imagery, detailed maps of buildings, their structure and condition (e.g., footprints on the ground, roof types) can be generated very quickly, information that is critical for identifying

[155]https://www.sipri.org/sites/default/files/2023-12/2312_sipri_policy_report_ai_for_climate_security_1.pdf#:~:text=weather,This%20capability%20represents%20a%20major

structures vulnerable to climate disasters. This approach, unthinkable with slow traditional surveys, allows decision makers to have an up-to-date database to identify the areas and assets most at risk (e.g., homes to be consolidated or communities to be relocated before the next hurricane).

In summary, AI is transforming how we identify climate risks. It ranges from providing multi-hazard alerts on both regional and global levels to offering detailed assessments of local vulnerabilities. With intelligent automation, we can get a timely and cohesive view of the climate threats that are emerging.

5.5.2 Assessment of the relevance and materiality of risks by AI

Once various climate risks have been identified, managers need to assess their relevance and materiality, that is, to understand which threats deserve **priority** because they are potentially more serious to the organization or area. Artificial Intelligence can support this step by analyzing huge masses of historical data and projections to uncover patterns and drivers of risk that would escape manual analysis. According to UNEP FI, the integration of new data sources and advanced algorithms is already making it possible to identify determinants that increase the severity of extreme events and the likelihood of chain disruptions (e.g., impacts on supply chains)[156].

In practice, AI tools sift through climatic and socioeconomic datasets, highlighting correlations between environmental conditions and seen damages-this helps risk managers understand which climate risks are really material to their operations.
For example, AI analysis can reveal that a certain facility is exposed to recurring flooding in the event of extreme rainfall above a specific threshold, or that a company's critical supply chain could be disrupted if a particular coastal logistics corridor is hit by increasingly frequent marine events. Such insights enable the prioritization of threats with the greatest potential impact.

[156]https://www.unepfi.org/wordpress/wp-content/uploads/2022/03/The-Climate-Risk-Tool-Landscape-2022-supplement.pdf#:~:text=Machine%20learning%20and%20artificial%20intelligence,example%20is%20Jupiter%20Intelligence%2C%20which

From a strategic perspective, organizations recognize the value of AI in distilling decision-useful information. In essence, many leaders see AI as an "essential enabler" for resilient growth, capable of augmenting traditional risk assessment tools with more granular and predictive analyses.
At the same time, precisely because such models will influence important decisions, there is growing attention to the transparency and robustness of AI-based assessments.
For example, in the financial sector, 90 percent of managers believe it is essential for predictive climate risk models to be clear and easy to understand[157].

In conclusion, AI can help focus on the most significant climate risks, but its use requires methodological rigor: Reliable models, quality data, and governance, so that materiality assessments are credible and supported by scientific evidence.

5.5.3 Quantification of potential impacts

AI not only identifies and prioritizes risks, but also enables more accurate quantification of the possible impacts of adverse climate scenarios.

Traditionally, quantification of expected damages (e.g., economic losses, production stoppages) relied on statistical models or stochastic simulations, which were often limited by poorly granular historical data. Today, AI models are trained on heterogeneous data-satellite and drone imagery, IoT sensors, maintenance records, high-resolution climate data, even social media posts -to estimate the effects of extreme events with greater accuracy[158]. For example, in property insurance, deep learning algorithms analyze aerial photographs and building permits to automatically assess the vulnerability of each building (materials, condition, proximity to combustible vegetation, etc.), calculating the risk of forest fire or severe storm for each insured asset. This allows guarantors to estimate potential losses with resolution at the individual property level, rather than relying on area

[157]https://riskandinsurance.com/ai-adoption-grows-for-extreme-weather-risk-assessment/#:~:text=As%20the%20insurance%20industry%20grapples,risk%20models%20should%20be%20transparent
[158]https://riskandinsurance.com/ai-adoption-grows-for-extreme-weather-risk-assessment/#:~:text=,loss%20information%20to%20make%20predictions

averages, improving both risk underwriting and mitigation strategies (e.g., planning interventions on the most critical vulnerabilities).

Another area where AI is improving the quantification of impacts is the logistics-production chain. With the help of AI-driven predictive models, we can simulate how the effects of extreme climate event propagates along the supply chain. Take platforms like Climate AI, for instance; they analyze localized climate forecasts – like shifts in temperature and rainfall- and connect these insights to farmers' planting and harvesting schedules. This allows for predicting potential yield declines before they happen. As a result, everyone downstream, from food processors to distributors, can adjust their plans, avoiding bottlenecks and wastage[159]. Ultimately, with AI, companies are able to translate complex climate data into **actionable intelligence** about the resilience of their value chain.

AI also excels at combining different dimensions of risk to estimate its overall impact. An algorithm can integrate the hazard of an event (e.g., intensity of a hurricane) with exposure (e.g., number and value of assets in the area) and vulnerability (e.g., structural resilience, available contingency plans) to calculate metrics such as expected economic losses, days of plant downtime, or population affected.

Researchers have shown that such AI models are able to quantify the risk of social and environmental impacts more comprehensively than traditional models, precisely because they simultaneously consider many variables previously treated *in silos*[160]. In addition, these algorithms can update estimates in real time as new data flow in (e.g., from sensors in the field during an ongoing event), providing decision makers with a dynamic picture of the situation[161].

[159]https://www.weforum.org/stories/2025/01/technology-climate-value-chains-risks-adaptation/#:~:text=For%20instance%2C%20ClimateAI%27s%20platform%20forecasts,chain%20efficiency%20and%20reducing%20waste

[160] https://www.cmcc.it/it/articolo/intelligenza-artificiale-la-nuova-frontiera-per-valutare-i-rischi-legati-ai-cambiamenti-climatici#:~:text=non%20comprendono%20solamente%20il%20pericolo,determinanti%20nella%20quantificazione%20degli%20impatti

[161]https://www.unepfi.org/wordpress/wp-content/uploads/2022/03/The-Climate-Risk-Tool-Landscape-2022-

A case in point is Jupiter Intelligence's platform, cited in a UNEP report: It combines climate simulations up to 2100 with continuously updated satellite and sensor data, frequently recalculating the physical risk exposure of specific assets. Such tools enable banks, insurance companies and large corporations to understand how risk might evolve for each asset in the short, medium, and long term, facilitating the planning of resilient investments and targeted adaptation measures.

5.5.4 Forecasting and modeling climate scenarios with AI

Climate scenario modelling is a crucial piece of the risk assessment puzzle, and it really benefits from the advanced computing and learning power of machines. Unlike traditional climate scenarios, like those from the IPCC, which rely on complex and static simulations, AI opens up the possibility to explore a much broader range of potential futures in a flexible and speedy manner.

With the help of generative models, such as Generative Adversarial Networks or diffusive models, we can create a wide array of "**what-if" scenarios**. This means we can generate thousands of possible climatic trajectories that align with current uncertainties, allowing us to investigate various combinations extreme events. This is particularly useful for resilience stress tests and long-term planning.
Experts stress the need to push analyses beyond the short term, and this is where AI shows potential yet to be fully exploited.
One group of researchers proposes, for example, to develop decadal warning systems - combining ensembles of global climate models with generative methods - so as to have spatially detailed forecasts over 10 years or more.[162] Such tools would allow anticipating risk trends and planning proactive adjustments, rather than reacting only to the immediate emergency.
In addition, AI can facilitate the construction of **integrated multi-hazard scenarios[163]**.

supplement.pdf#:~:text=analyses%20have%20led%20to%20the,level%20communications%20of%20their

[162] https://www.nature.com/articles/s41467-025-57640-w#:~:text=stress%20the%20need%20for%20responsible,term%2C%20spatially%20resolved%20forecasts%20for

[163] https://www.cmcc.it/it/articolo/intelligenza-artificiale-la-nuova-frontiera-per-valutare-i-rischi-legati-ai-cambiamenti-

In practice, this means simulating simultaneously, for example, a scenario where heat waves, droughts and forest fires occur in succession.

This holistic approach, made possible by AI, is extremely valuable for developing transversal resilience strategies (not focused on one risk at a time) and to inform long-term strategic plans that also comply with disclosure recommendations (such as the TCFD, which encourages the use of 2°C/1.5°C scenarios).

Looking ahead, therefore, **AI is set to become increasingly an integral part of climate risk management processes at all levels**. The key message emerging from scientific and institutional sources is twofold: On the one hand, AI offers **unprecedented capabilities to understand and anticipate climate risks** - improving hazard identification, severity assessment, the quantification of impacts and the development of complex scenarios; on the other hand, it is crucial to ensure that these **new solutions are reliable, fair, and transparent**. As one expert says, "*the real risk is not in the AI itself, but in not exploiting its full potential"*[164]– ignoring the opportunities offered by AI would mean losing valuable tools in the fight against climate change.
At the same time, we need to ensure that AI is used responsibly so that it has a positive net effect on society and the environment.[165].

climatici#:~:text=climatiche%2C%20ambientali%20e%20socio,riduzione%20del%20rischio%20di%20catastrofi%E2%80%9D
[164] https://www.csrwire.com/press_releases/816996-will-ai-and-climate-risk-management-align-2025
[165] https://www.unep.org/news-and-stories/story/ai-has-environmental-problem-heres-what-world-can-do-about#:~:text=There%20are%20high%20hopes%20that,methane%2C%20a%20potent%20greenhouse%20gas

6 Does good Climate Score guarantee better financial performance?

Many studies examine the relationship between ESG *"Environmental, Social and governance"* and financial performance. Those analyses found positive correlations between ESG performance, and operational efficiencies, stock performance and lower cost of capital. During the years, we have seen an exponential growth in ESG investing due in large part to increasing evidence that business strategy focused on material ESG issues is synonymous with high quality management teams and improved returns[166].

The following chapter will look into the study and analysis of the potential correlation between business performance and the "E" component of ESG factors. As discussed in previous chapters, environmental sustainability — and more specifically climate change — is increasingly recognized as a **strategic driver** that shapes corporate decision-making processes and impacts the long-term survival and competitiveness of companies. Understanding the relationship between environmental performance and economic outcomes has become critical, as firms face growing pressure from regulators, investors, and consumers to integrate climate considerations into their business models.

This paper aims to investigate whether environmental dimensions of sustainability – and in particular climate change- impact financial performance.

To pursue this objective, the chapter is structured around four successive regression models[167], each designed to deepen the understanding of the link between environmental sustainability and economic performance:

1. **Baseline Model – Multi-sector Analysis:**

The first regression investigates the relationship between economic performance and environmental dimensions of ESG across a diverse set of industries. This provides a

[166]https://www.stern.nyu.edu/sites/default/files/assets/documents/NYU-RAM_ESG-Paper_2021%20Rev_0.pdf#:~:text=investing%20%E2%80%93%20due%20in%20large,were
[167] The results are expressed in millions of euros.

general overview of whether higher sustainability ratings are associated with better profitability in the overall sample.

2. **Sector-Specific Impact - Energy Sector Interaction:**

The second model introduces a focus on the energy sector. By including a sectoral dummy variable and interaction terms, this regression tests whether the effect of environmental performance is significantly different (and potentially stronger) for energy companies compared to firms in other industries.

3. **Robustness Check – Controls in Full Sample:**

The third regression incorporates control variables such as firm size (proxied by turnover) and firm age. This allows for a verification of whether the observed relationships remain statistically, and economically valid once structural firm characteristics are accounted for, thus testing the robustness and "purity" of the ESG effects across the full sample.

4. **Refined Focus – Controls in the Energy Sector:**

Finally, the fourth model applies the same controlled framework as in the third regression but restricted to firms within the energy sector. This aims to explore whether the environmental sustainability-performance relationship holds (or possibly strengthens) even when isolating a highly regulated, carbon-intensive industry and controlling for internal firm characteristics.

6.1 Data Source and Sample

To build a significant database, data has been collected looking at MSCI's proprietary indexes.

MSCI Inc. (Morgan Stanley Capital International) is a leading global financial services company. It is known for building market indices, such as the MSCI World and MSCI Emerging Markets, providing financial and risk analysis, and evaluating companies according to the ESG (*Environmental, Social, Governance*) criteria. MSCI plays an influential role in the investment world, as its ESG ratings and indices are used by investment funds, pension funds, and asset managers to guide investment choices, especially around sustainable or responsible strategies[168].

As of 2024, MSCI provides ESG ratings for approximately 9,600 companies and covers over 680,000 equity and fixed income securities worldwide. In assessing companies, MSCI typically considers more than 1,000 data points, sourced from publicly available information, third-party databases, and direct company engagement activities[169].

MSCI has developed a highly detailed system for assessing the sustainability and resilience of companies, structuring it around several levels of analysis. Underlying the model are the main pillars, which correspond to the Environmental, Social, and Governance dimensions. Within each pillar, specific relevant issues are identified, which in turn are broken down into concrete key issues, such as water management or carbon emission control.

Each issue is analyzed through precise metrics, consisting of specific and measurable data, which allow for an objective assessment of corporate performance[170].

[168] https://www.msci.com/who-we-are/about-us
[169] https://www.msci.com/our-solutions/sustainability-investing/esg-ratings-climate-search-tool
[170]https://www.msci.com/documents1296102/34424357/MSCI+ESG+Ratings+Methodology+-+Carbon+Emissions+Key+Issue.pdf/bfc8304f-bf60-d4ad-07e4-9f72d2892f79?t=1666182592995#:~:text=are%20determined,the%20carbon%20intensity%20of%20their

Pillar	Themes	ESG Key Issues
Environment	Climate Change	Climate Change Vulnerability Financing Environmental Impact Product Carbon Footprint
	Natural Capital	Biodiversity & Land Use Raw Material Sourcing Water Stress
	Pollution &Waste	Electronic Waste Packaging Material & Waste Toxic Emissions & Waste
	Environmental Opportunities	Opportunities in Clean Tech Opportunities in Green Building Opportunities in Renewable Energy

Figure 22 – MSCI ESG Ratings Methodology: Carbon Emissions Key Issue –

MSCI applies a standardized and sector-specific methodology designed to assess both **Risk Exposure** (the level of ESG risks inherent to a company's business model and industry) and **Risk Management** (the strength and effectiveness of the company's policies and practices relative to industry peers).

Each company's key ESG issues are weighted and aggregated into a final ESG rating, which ranges from CCC (lowest) to AAA (highest). Companies rated CCC and B are classified as *"**laggards,**"* those rated BB, BBB, and A as "***average,***" while AA and AAA denote "***leaders***" in ESG performance. ESG ratings are reviewed and updated at least annually, and more frequently if significant new information becomes available[171].

[171] https://www.msci.com/sustainable-investing/esg-ratings

Building on this methodological framework, the MSCI index was used to identify environmental and, more specifically, climate variables suitable for the goal of the analysis.

6.1.1Variables

Consistent with the purpose of the paper, the independent variables refer to the "**Climate Change Theme Score**" and "**Environmental Pillar Score**" while the dependent variables refer to financial performance namely **EBITDA**.

6.1.2 Independent Variables

The **Climate Change Theme Score** is a score from 0 to 10 [172] that measures a company's resilience to climate change risks and opportunities. In practice, it assesses how effectively the company manages sources of greenhouse gas emissions, its physical vulnerability to climate change, the environmental impact of its financial activities, and the carbon footprint of its products. The goal of this score is to reflect the company's **overall exposure to climate risks** (transition to clean sources, environmental regulations, extreme events) and the **quality of the management strategies adopted**[173].
This index focuses mainly on financial materiality, **outside-in** that is, how ESG factors affect financial performance.
MSCI relies primarily on quantitative data provided by the company or external sources. For example, for Carbon Emissions it uses corporate disclosure of Scope 1, 2 and 3 emissions and official emission intensity data.

In summary, the data include numerical values (tCO_2e, green revenue percentages, etc.), qualitative indicators (adherence to climate mitigation initiatives), and sector information from recognized ESG sources and company reports. The analysis also makes use of

[172]https://bfi.uchicago.edu/wp-content/uploads/2024/10/BFI_WP_2024-138.pdf#:~:text=Taylor%20%282022%29,risks%20related%20to%20climate%20change
[173]https://www.msci.com/documents1296102/34424357/MSCI+ESG+Ratings+Methodology+-+Carbon+Emissions+Key+Issue.pdf/bfc8304f-bf60-d4ad-07e4-9f72d2892f79?t=1666182592995#:~:text=are%20determined,the%20carbon%20intensity%20of%20their

external indices (e.g., climate risk indices) and data on past performance (emissions trends).

The **Climate Change Theme Score** is obtained by **aggregating the scores** of its underlying "Key Issues" (Carbon Emissions, Climate Vulnerability, Financing Environmental Impacts, Carbon Footprint of Products). In each "Key Issue", **an Exposure Score** (based on how exposed the company is to risk or opportunity) and a **Management Score** (based on management practices, policies, and stated objectives) are calculated separately. Then the Climate Change Theme Score is the **weighted average** of these Key Issue Scores, normalized by the sum of the relevant industry weights[174].

As shown in the MSCI hierarchy (*Figures 22*), the Climate Theme includes four "Key Issues" [175]:

- **Carbon Emissions:** Assesses the intensity of the company's operational emissions and the adoption of reduction measures (e.g., energy efficiency, CO_2 sequestration, offset purchase).
- **Climate Change Vulnerability:** Measures the company's exposure to the physical risks of climate change (e.g., hurricanes, drought, sea rise) and management preparedness (adaptation plans).
- **Financing Environmental Impact:** Captures, especially for financial institutions, how exposed the company's lending/underwriting activities are to environmentally risky projects (and able to capture opportunities in green financing")[176].

[174]https://www.msci.com/documents/1296102/34424357/MSCI+ESG+Ratings+Methodology+-+Carbon+Emissions+Key+Issue.pdf/bfc8304f-bf60-d4ad-07e4-9f72d2892f79?t=1666182592995#:~:text=are%20determined,the%20carbon%20intensity%20of%20their

[175]
https://www.msci.com/documents/1296102/34424357/MSCI+ESG+Ratings+Methodology.pdf#:~:text=Environment%20Climate%20Change%20Carbon%20Emissions,Waste%20Packaging%20Material%20%26%20Waste

[176]https://www.msci.com/documents/1296102/34424357/MSCI+ESG+Ratings+Methodology+-+Financing+Environmental+Impact+Key+Issue.pdf/4486c59e-71c1-2dd3-f285-56c8904200bd?t=1666182595573#:~:text=our%20outputs%20are%20determined,a%20Key%20Issue%20in%20the

- **Product Carbon Footprint:** Considers emissions related to the products/services sold by the company and efforts to reduce them along the value chain [177].

These sub-themes reflect both transition risks (e.g., carbon regulation, reduction targets) and opportunities for green innovation.

The **Environmental Pillar Score** is the aggregate score (0 to 10) for all environmental factors in the MSCI ESG model. It represents an overall indication of a company's environmental performance relative to industry peers.

This index assesses both the various environmental risks that may affect the company's economic value over time (***outside-in***) and the various concrete impacts the company may have on the environment such as natural resource consumption **(*inside-out*)**.

According to the official methodology, this score is calculated as a **weighted average** of all "Environmental Key Issues"[178]. The Environmental Pillar Score incorporates **heterogeneous data**.

$$\text{Environmental Score} = \frac{\sum_i (\text{Key Issue Score}_i \times \text{Key Issue Weight}_i)}{\sum_i \text{Key Issue Weight}_i},$$

Where *i* flows on all relevant "Environmental Key Issues". The weights are determined by a sector materiality framework: Each sector has a set of "Environmental Key Issues" considered most important.
MSCI publishes these weights.
The result is between 0 and 10 and then normalized so to be comparable within the sector.

[177] https://www.msci.com/documents/1296102/34424357/MSCI+ESG+Ratings+Methodology+-+Product+Carbon+Footprint+Key+Issue.pdf/1a22f705-889a-b06c-7176-d81f147c8bad?t=1666182601184#:~:text=outputs%20are%20determined,of%20their%20products%20and%20services

[178] https://www.msci.com/documents/1296102/34424357/MSCI+ESG+Ratings+Methodology.pdf#:~:text=Pillar%20Scores%20across%20the%20Environmental,fall%20under%20the%20Environmental%20Pillar

The “Environmental Key Issues” considered are as follows:

- **Climate Change**: As described above, includes Carbon Emissions, Climate Vulnerability, Financing Environmental Impacts, and Product Carbon Footprint.
- **Natural Capital:** Includes Biodiversity & Land Use, Water Stress. Assesses how the company impacts and manages natural resources and habitats (land consumption, critical raw materials, water consumption).
- **Pollution & Waste:** Includes E-Waste, Packaging & Waste, as well as Toxic Emissions & Waste.
- **Environmental Opportunities:** Covers the potential in Clean Tech, Green Building and Renewable Energy. This theme highlights projects and products that have a positive impact on the environment, like generating revenues from renewable energy sources.

6.1.3 Dependent Variables

The financial performance of the companies analyzed was quantified using *Earning Before Interests, Taxes, Depreciation and Amortization* (EBITDA).
This information was obtained by examining public financial statements over the period 2015-2023.

6.2 Baseline Model: Multi-sector analysis

The first analysis sample was constructed by considering a selection of particularly **heterogeneous sectors**: The analysis covers a broad spectrum of industries, ranging from energy to consumer goods, from health care to heavy industry, to the luxury and transportation sectors. To build a significant database, data has been collected looking at the MSCI's proprietary indexes.

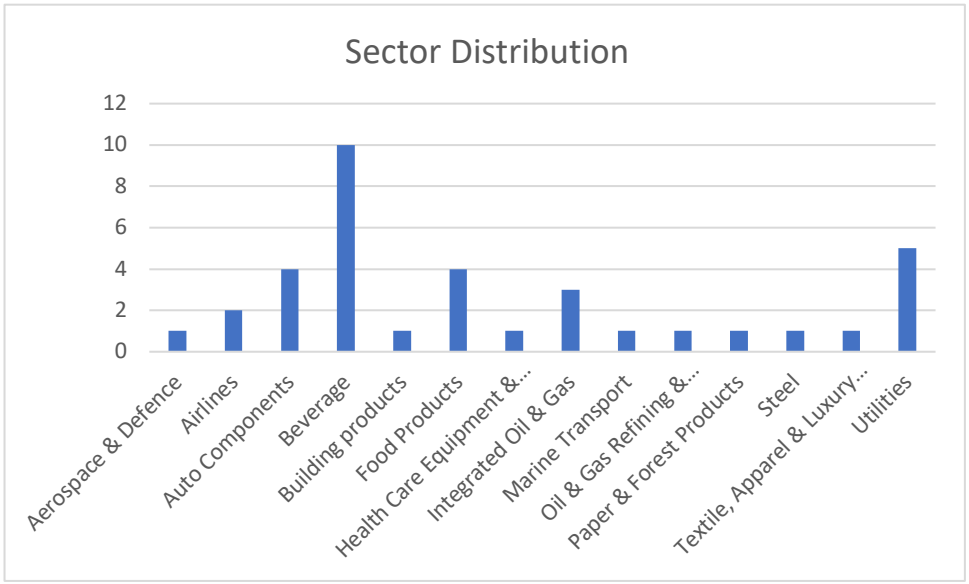

Figure 23

A total of **36 European companies** were selected, spread across the Czech Republic, Denmark, Germany, Ireland, Italy, Netherlands, Portugal, Spain, Sweden, Switzerland, and United Kingdom.

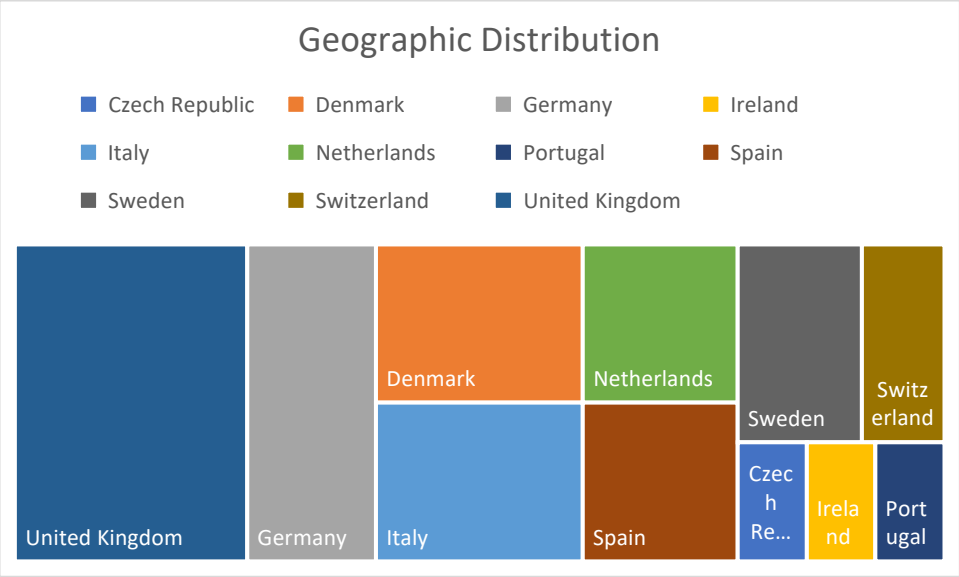

Figure 24

The time horizon of the analysis extends from **2015 to 2023**. The control variables were linked to the independent variables, covering the same time frame. At the end of the data collection and processing phase, a final dataset consisting of **316 observations**[179] was obtained, forming the basis for the quantitative analysis conducted.

For the sectors selected in this analysis, an average score of the Climate Change Theme and the Environmental Pillar was calculated *(figure 25)*.

[179] In order to obtain a robust sample, a "cleaning" activity of the dataset was carried out, with particular reference to the management of missing values, which led to the elimination of companies for which not all scores were available for the period under consideration.

Sector	Average of Climate Change Theme Score	Average of Environmental Pillar Score
Aerospace & Defence	9.711	4.500
Airlines	4.983	4.983
Auto Components	9.476	4.431
Beverage	8.318	6.188
Building products	9.967	6.911
Food Products	3.353	4.081
Health Care Equipment & supplies	8.278	8.278
Integrated Oil & Gas	8.233	6.780
Marine Transport	5.433	4.722
Oil & Gas Refining & Marketing	4.867	4.433
Paper & Forest Products	7.811	6.756
Steel	3.933	3.189
Textile, Apparel & Luxury Goods	9.022	7.378
Utilities	8.828	7.311
Total	**7.5**	**5.8**

Figure 25

Based on the analyzed sample *(figure 25)*, the following observations can be made:

Regarding the **Climate Change Score**, higher values indicate companies that are more resilient to climate-related risks and more advanced in their transition efforts. Industries like **Aerospace & Defence**, **Building Products**, **Auto Components**, and **Utilities** have scored particularly well, with scores exceeding 8. This indicated that, on average, companies operating in these sectors are either effectively managing climate-related risks or are perceived by rating agencies as leaders in adopting low-carbon strategies and emission reduction policies.

In contrast, the **Environmental Pillar Score** evaluates broader environmental performance, encompassing not only climate change but also aspects such as biodiversity conservation, pollution management, resource use, and waste treatment.

Sectors such as **Health Care Equipment & Supplies**, **Utilities**, and **Textile, Apparel & Luxury Goods** achieved relatively higher Environmental Pillar Scores (above 7),

indicating a more comprehensive and proactive approach to managing environmental issues across multiple dimensions.

Conversely, industries such as **Steel** and **Food Products** registered lower environmental scores (around 3–4), reflecting a greater exposure to environmental risks or a relatively slower adoption of best practices in environmental management. These sectors are traditionally more resource-intensive and may face inherent challenges in reducing their environmental footprint due to the nature of their production processes.

Overall, the average score across all sectors was **7.5** for the Climate Change Score and **5.8** for the Environmental Pillar Score. This indicates that, on average, the companies analyzed demonstrate a fairly good level of climate risk management (7.5 out of 10), but a comparatively more moderate and uneven performance in addressing broader environmental sustainability issues (5.8 out of 10).

6.2.1 Model

In order to study the relationship between environment and financial performance, a multiple linear regression model was used, based on the **Ordinary Least Squares - OLS approach**[180]. This type of model was implemented using the **Python programming language**.

$$EBITDA = \beta_{O+} \beta_1 \text{ x } Climate\ Change\ Score + \beta_2\ x\ Environmental\ Pillar + \epsilon$$

[180] The Ordinary Least Squares (OLS) approach is a method used to estimate the coefficients of a linear regression. The main objective is to find the linear model that best fits the observed data, that is, that predicts the value of the dependent variable while minimizing error. More formally, OLS minimizes the sum of squares of the differences between observed and predicted values.
Stock, J. H., & Watson, M. W. (2020). *Introduction to Econometrics* (5th ed.). Pearson.

Where:

- β0 is the intercept,
- β1 and β2 are the coefficients associated with the independent variables,
- ϵ represents the error term.

Thus, the model used is a simple linear regression with two independent variables (Climate Change Score and Environmental Pillar) with EBITDA (MLN) as the dependent variable. Therefore, we assume that EBITDA is expressed as a linear combination of these two environmental indices plus an error term (ϵ).

The output of its functions provides the regression statistics that are functional for our goal and the equation coefficients that allowed us to derive the regression equations.

6.2.2 Regression Analysis

Statistical Summary of the OLS Model

OLS Regression Results

Dep. Variable:	EBITDA (MLN)	**R-squared:**	0.101
Model:	OLS	**Adj. R-squared:**	0.095
Method:	Least Squares	**F-statistic:**	17.49
Date:	Thu, 01 May 2025	**Prob (F-statistic):**	6.30e-08
Time:	16:42:01	**Log-Likelihood:**	-2986.4
No. Observations:	316	**AIC:**	5979.
Df Residuals:	313	**BIC:**	5990.
Df Model:	2		

Figure 26

In the model summary, we first note the **coefficient of determination (R^2)**[181] and the **adjusted R^2.**

[181] R^2 measures the proportion of the variance in the dependent variable that is predictable from the independent variables, while Adjusted R^2 penalizes the addition of irrelevant variables to the model, providing a more accurate measure of model fit.

$$R^2 = 1 - \frac{SS_{residual}}{SS_{total}}$$

where:

- $SS_{residual}$ residual sum of squares
- SS_{total} = total sum of squares[182]

$$R^2 = 1 - (1 - R^2)\, x\, \frac{n-1}{n-k-1}$$

where:

- n = total number of observations
- k = number of independent variables (excluding the constant)

In this case **R² = 0.101** and **adjusted R² = 0.095**. The coefficient of determination represents the fraction of total variance in EBITDA that is explained by the independent variables included in the model (Climate Change Score and Environmental Pillar).
An R² of 0.101 thus indicates that the model explains about 10.1 percent of the observed variability of EBITDA. The adjusted R² also takes into account the number of observations (316) and the number of estimated regressors (2), offering a more cautious measure of fit; in this case it is slightly lower than the gross R², suggesting that the addition of the two explanatory variables contributes only modestly to the increase in explained variance. In practical terms, this means that most of the variation in EBITDA is not captured by the environmental indicators considered alone.
This result **does not invalidate the significance of the estimated coefficients**.

The **F-statistic** of the model is 17.49, with a Prob(F-statistic) = 6.30e-08 (about 0.000000063).

[182] Stock, J. H., & Watson, M. W. (2020). *Introduction to Econometrics* (5th ed.). Pearson.

$$F = \frac{(R^2/k)}{(1-R^2)/(n-k-1)}$$

The overall F-test tests the null hypothesis that all the coefficients of the regressors (excluding the intercept) are simultaneously **zero**.[183] A high value of the F-statistic, with a very small p-value, indicates that at least one of the coefficients is significantly different from zero and that the independent variables as a whole significantly improve the prediction of EBITDA compared to a model without regressors. In our case, the extremely low p-value leads to the rejection of the null hypothesis at any usual significance level (1%, 5%, etc.). This confirms that the model has **overall significance**: The environmental metrics analyzed (Climate Change Score and Environmental Pillar) **are useful in explaining the variability of EBITDA in the sample considered.**

Coefficients

	coef	std err	t	P>|t|	[0.025	0.975]
const	-1318.2676	615.701	-2.141	0.033	-2529.703	-106.832
Climate change score	227.0078	83.559	2.717	0.007	62.600	391.416
Environmental pillar	297.1688	123.432	2.408	0.017	54.308	540.030

Figure 27

Figure 27 gives the coefficient value, standard error, t-statistic, p-value and 95% confidence intervals.

With reference to the **intercept**, the estimated coefficient is -1318.3 with a standard error of 615.7. The t-statistic is -2.141 and the associated p-value is 0.033.
This indicates that the intercept is **statistically significant** at the 5% level (since 0.033 < 0.05). The intercept represents the expected value of EBITDA when both variables Climate Change Score and Environmental Pillar are zero. In practice, this situation is unrealistic especially if they are listed or monitored by ESG rating agencies.

[183] Stock, J. H., & Watson, M. W. (2020). *Introduction to Econometrics* (5th ed.). Pearson.

Theoretically, if a company had zero environmental focus (in both scores), the model would predict a highly negative EBITDA.

The **estimated coefficient for the climate change** score is 227.0078 with standard error 83.559. The t-statistic corresponds to 2.717 with p-value 0.007. The latter is lower than both the 5% and 1% thresholds. This implies that the effect of Climate Change Score on EBITDA **is highly significant**, confirming a **robust positive association** between attention to climate change and business performance.
This positive coefficient (227.0 million) means that, holding the Environmental Pillar constant, a one-point increase in the Climate change score is associated on average with an increase of about 227 million in EBITDA. The 95 percent confidence interval for this coefficient ranges from 62.600 to 391.416, including only positive values; this further confirms that it is extremely unlikely that the actual effect is zero or negative. In practice, the results suggest that firms with higher climate change scores have better economic performance, consistent with the hypothesis that a better climate rating may be reflected in higher corporate profitability.

As for the **Environmental Pillar**, the estimated coefficient is 297.17 with standard error 123.4. The t-statistic is 2.408 with p-value 0.017, indicating significance at 5% ($0.017 < 0.05$). Thus, a one-point increase in the Environmental Pillar corresponds, on average, to an increase in EBITDA of about 297.2 million, all other regressors being equal. The 95 percent confidence interval is [54.308, 540.030], which contains no zero, again signaling a **robust positive effect**. This result also supports the hypothesis that better environmental performance is associated with higher operating profit. However, it should be noted that the p-value (0.017) is less extreme than the Climate change score, indicating a slightly lower (but still robust) significance of the estimated effect.

6.3 Sector Specific Impact – Energy Sector Interaction

The second analysis focuses on the energy sector that is particularly sensitive to climate change issues. In fact, it has a direct and significant impact on the environment, is highly dependent on natural resources and produces high greenhouse gas emissions.

6.3.1 Data Sources and Sample

Data on environmental variables, specifically **Climate Change Theme Score** and **Environmental Pillar Score**, were extracted from **MSCI indices**, while economic data, represented by **EBITDA**, were collected from companies' annual financial statements. The sample consists of **9 European companies** in the **Energy sector**, observed in the period between **2015 and 2023**, for a total of **80 observations**.

The focus is on companies belonging to the following subsectors:

- Oil & Gas Refining & Marketing.

- Integrated Oil & Gas.

- Utilities.

6.3.2 Model

The analysis is based on a multiple linear regression model with **OLS (Ordinary Least Squares**), implemented through **Python language**.

The estimated model is as follows:

$$EBITDA = \beta_0 + \beta_1 \text{ x } Climate\ Change\ Score + \beta_2 \text{ x } EnvironmentalPillar + \beta_3\ x\ Energy\ Dummy + \beta_4\ x\ (ClimateScore\ x\ Energy\ Dummy) + \beta_5\ x\ (Environmental\ Pillar\ x\ Energy\ Dummy) + \epsilon$$

where:

- **EnergyDummy** is worth 1 for firms in the Energy sector, 0 otherwise.
- **ClimateScore × EnergyDummy / EnvironmentalPillar x EnergyDummy** are interaction terms obtained by multiplying the ESG "Climate" and "Environmental" scores by a dummy. These terms measure whether the effect of ESG scores on EBITDA is different for energy companies.

6.3.3 Regression Analysis

OLS Regression Results

Dep. Variable:	EBITDA	R-squared:	0.185
Model:	OLS	Adj. R-squared:	0.172
Method:	Least Squares	F-statistic:	14.10
Date:	Sat, 10 May 2025	Prob (F-statistic):	1.96e-12
Time:	13:00:32	Log-Likelihood:	-2970.8
No. Observations:	316	AIC:	5954.
Df Residuals:	310	BIC:	5976.
Df Model:	5		
Covariance Type:	nonrobust		

	coef	std err	t	P>|t|	[0.025	0.975]
const	-487.0617	668.286	-0.729	0.467	-1802.011	827.888
Climate	202.4692	83.744	2.418	0.016	37.692	367.247
Environmental	88.2115	137.073	0.644	0.520	-181.500	357.923
Energy_dummy	-382.0124	1642.246	-0.233	0.816	-3613.371	2849.346
Climate_Energy_Interaction	460.1263	281.905	1.632	0.104	-94.562	1014.815
Environmental_Energy_Interaction	-182.1127	347.747	-0.524	0.601	-866.355	502.129

Figure 28

- **Intercept**: The coefficient is **not significant** (p-value: 0.467). This indicates that the average value of EBITDA when all independent variables are equal to zero is not significantly different from zero in the energy sector.
- **Climate Change Score**: The coefficient is 212.55, and **statistically significant** (p-value: 0.016.
- **Environmental Pillar:** The coefficient (72.9241) is **not statistically significant** (p-value: 0.566).
- **Energy Dummy:** The coefficient is negative and equal to -382.0124, with p-value 0.816, thus **not significant**. This suggests simply belonging to the energy sector does not result in significant differences in economic performance compared to other sectors when considered in isolation.

- **Climate × Energy interaction**: The estimated coefficient is 460.12, with a p-value of 0.104. This result is marginally **significant** at the 10 percent level.
- **Environmental x Energy interaction**: The estimated coefficient is -182.11, with a p-value of 0.601. This result is not **significant**.

With reference to the **coefficient of determination**, this is **0.185**. This means that about 18.5 percent of EBITDA variability is explained by the independent variables included in the model. Although this value indicates a relatively small explanatory power, as in the previous analysis (17.2%), it is still important to remember that in the context of economic and business data it is common to obtain R^2 that are not high, especially when working with cross-sectional data and not including all possible determinants of performance. In this case, an R^2 of about 18 percent suggests that climate related ESG scores contribute non-negligibly to explaining economic performance, although they are only part of the overall picture.

In conclusion, the hypothesis that the energy sector amplifies the effect of environmental variables on economic performance is not robustly confirmed. The only clue in this direction is offered by the Climate × Energy interaction, the positive effect of which appears potentially significant but statistically uncertain. The analysis therefore suggests that, at least in the data considered, the impact of environmental performance does not differ substantially between energy and nonenergy firms.

6.4 Robustness Check: Controls in Full Sample

The initial analysis showed a positive relationship between environmental sustainability scores—particularly those related to climate change—and economic performance as measured by EBITDA. However, these results can be affected by confounding variables, i.e., factors not considered in the regression models that, when correlated with both ESG variables and economic performance, can distort the estimated effect.

Among these, **firm size**, represented by turnover, and **company age**, defined as the difference between the year of observation and the year the company was founded, are some of the most plausible determinants. In fact, considering firm size for example, larger

firms tend not only to generate higher EBITDA, but also to have more resources to devote to environmental policies, introducing a potential spurious effect.

To address this issue, this chapter proposes an extension of the previous models, including control variables, turnover and age, and comparing the results with those obtained in the absence of such controls. The goal is to test whether the observed impact of ESG dimensions on profitability is autonomous and robust, or whether it is partly attributable to other structural factors.

In the regression model, **turnover reflects the company's revenue level** and is used as a proxy for firm size. **Age**, instead, refers to the number of years the company has been in operation[184]. These variables are included as controls because they may influence both financial performance and potentially ESG ratings. It is a standard practice in the literature to control for firm size when assessing the effect of ESG variables, since larger companies—those with higher revenues—are typically more capable of investing in sustainability initiatives and tend to report higher EBITDA. Similarly, controlling for age allows the model to account for different stages of the corporate life cycle: For instance, distinguishing between naturally low-revenue startups and mature companies that may be declining[185].

In other words, controlling for **turnover and age** is essential to avoid mistaking the influence of structural firm characteristics for the genuine impact of environmental performance.

184 https://ibimapublishing.com/articles/JAARP/2024/145355/#:~:text=financial%20performance,based%20view%20assumes%20that%20large

185 https://webthesis.biblio.polito.it/29687/1/tesi.pdf#:~:text=%E2%80%A2%20Et%C3%A0%20dell%E2%80%99impresa%3A%20si%20%C3%A8,di%20realt%C3%A0%20imprenditoriali%20in%20difficolt%C3%A0

6.4.1 Regression results

OLS Regression Results

Dep. Variable:	EBITDA	**R-squared:**	0.854
Model:	OLS	**Adj. R-squared:**	0.852
Method:	Least Squares	**F-statistic:**	455.5
Date:	Sat, 10 May 2025	**Prob (F-statistic):**	1.25e-128
Time:	10:34:19	**Log-Likelihood:**	-2699.0
No. Observations:	316	**AIC:**	5408.

	coef	std err	t	P>|t|	[0.025	0.975]
const	-307.8510	842.594	-0.365	0.715	-1965.758	1350.056
Climate	-4.8126	34.403	-0.140	0.889	-72.506	62.880
Environmental	239.5922	49.882	4.803	0.000	141.442	337.742
Turnover	0.1793	0.004	40.093	0.000	0.171	0.188
Age	-18.6277	13.871	-1.343	0.180	-45.921	8.666

Figure 29

$EBITDA = \beta_{O+}\beta_1$ x *Climate Change Score* + β_2 *x Environmental Pillar* + β_3 *x Turnover* $+ \beta_4$ *x Age* $+ \epsilon$

This regression estimates the effect of **ESG** -Climate Change Score and Environmental Pillar- on firms' economic performance (EBITDA) by including two control variables: **Turnover** (as a proxy for firm size) and **firm age** (as a proxy for firm maturity or stability over time).

This analysis, *Figure 29*, shows:

- **Significant turnover (p-value: 0.000) and no significant age (p-value: 0.180)** The control variable "turnover" shows a positive and highly **significant** coefficient, confirming that larger firms (with larger turnovers) are associated with higher EBITDA.

This result was expected, as larger firms typically have economies of scale, greater operational capacity and financial resources that enable more efficient business management. The inclusion of this control variable is critical to correctly interpreting the effects of environmental variables, as it helps to distinguish real from apparent (spurious) impacts.

In particular, the key finding is that while **turnover proves to be a highly significant predictor of EBITDA**, the variable **age does not**. This indicates that, holding constant the Climate Change Score and Environmental Pillar, larger firms (those with higher revenues) tend to report higher EBITDA. This outcome reflects the fact that larger companies benefit from scale advantages and superior resources, which translate into stronger operational performance.

By contrast, the effect of **age** is statistically insignificant. This suggests that the **longevity of a company does not, by itself, translate into higher economic performance** once other structural factors are controlled for. Although older firms might theoretically benefit from accumulated managerial experience, established networks, or reputational capital, these advantages do not appear to systematically influence EBITDA in the dataset examined.

Moreover, the lack of significance could suggest that although older companies tend to be more stable, they might also struggle with rigidities, outdated systems, or a reduced capacity for innovation, which can offset any potential advantages. Therefore, **firm age does not emerge as a consistent driver of profitability**, highlighting that dynamic efficiency and operational scale are more decisive factors than historical presence alone.

- **Climate score is no longer significant** (p-value: 0.8)

In the presence of the control variables **turnover and age**, the positive effect initially attributed to Climate score disappears. This shift indicates that the **initially observed positive effect of the Climate score on EBITDA was likely confounded by firm size**. In earlier models—without controls—firms with higher Climate scores appeared to perform better economically. However, this relationship weakens substantially when size and age are accounted for.

This outcome suggests that **larger firms tend to score higher on climate related ESG metrics**, not necessarily because climate strategy directly boosts profitability, but because **larger firms have more resources, infrastructure, and regulatory pressure to develop structured climate policies**. These firms are also more likely to engage in transparent reporting, set formal emission reduction targets, and adopt climate mitigation strategies that increase their ESG scores.

Therefore, the loss of significance indicates that the Climate score may be **more reflective of a firm's scale and disclosure capacity** rather than a direct economic benefit from climate action. When controlling for size and maturity, the climate score **does not appear to exert an independent effect** on EBITDA. This underscores the importance of including structural controls to isolate the true explanatory power of ESG variables and avoid attributing causality where correlation may be driven by underlying firm characteristics.

- **Environmental Pillar remains significant (p-value: 0.000)**

Unlike the Climate Score, the Environmental Pillar variable retains **strong** statistical significance, indicating that the environmental sustainability score is positively associated robustly with EBITDA, even after controlling for firm size and age.

Companies that score higher on the Environmental Pillar tend to adopt more effective and comprehensive environmental strategies across various areas, such as pollution control, waste management, resource efficiency, and mitigating environmental risks. These practices can lead to **tangible economic advantages**, including lower input costs from using energy and material more efficiently, reduced expenses related to regulations or compliance, improved brand value and reputation, and even better access to capital markets, especially for those focused on ESG investments.

6.5 Controls in the energy sector

The fourth model considers the same previous controlled variables, firm size, and age, but restricted to firms within the energy sector.

In particular, the model includes:

- **Climate Change Score**: A score that measures performance related to climate change.
- **Environmental Pillar indicator**: Overall environmental sustainability score.
- **Turnover:** A proxy for firm size.
- **Firm age**
- **A dummy variable** for the energy sector (Energy_dummy, which is worth 1 for energy sector firms and 0 otherwise).
- **Two interaction terms** - one between Climate Change Score and energy sector **(Climate_Energy_Interaction**) and one between Environmental Pillar and energy sector **(Environmental_Energy_Interaction**).

	coef	std err	t	P>|t|	[0.025	0.975]
const	169.9693	856.934	0.198	0.843	−1516.216	1856.154
Climate	12.6704	34.952	0.363	0.717	−56.104	81.445
Environmental	127.6170	56.446	2.261	0.024	16.548	238.686
Turnover	0.1758	0.005	39.028	0.000	0.167	0.185
Age	−20.2556	13.694	−1.479	0.140	−47.202	6.691
Age	−20.2556	13.694	−1.479	0.140	−47.202	6.691
Energy_dummy	−525.4241	683.116	−0.769	0.442	−1869.588	818.740
Climate_Energy_Interaction	−84.5569	116.829	−0.724	0.470	−314.440	145.326
Environmental_Energy_Interaction	284.9156	144.396	1.973	0.049	0.788	569.043

Figure 30

$$EBITDA = \beta_{0+}\beta_1 \text{ x } Climate\ Change\ Score + \beta_2\ x\ Environmental\ Pillar + \beta_3\ x\ Energy\ Dummy + \beta_4\ x\ (ClimateScore\ x\ Energy\ Dummy) + \beta_5\ x\ (Environmental\ Pillar\ x\ Energy\ Dummy) + \beta_6\ x\ Turnover + \beta_7\ x\ Age + \epsilon$$

From the analysis conducted, the results are very close to those obtained previously (*Figure 29*).

Climate change score has a coefficient of 12.67 and is **not statistically significant**: The p-value is 0.717, well above the conventional level of 0.05.
The coefficient associated with the **Environmental Pillar indicator** (overall environmental sustainability) is estimated at 127.62 and is statistically significant at 5 percent (p-value 0.024). This value indicates that, for companies **outside the energy sector** (i.e., value 0 of the energy sector dummy), a 1-point increase in the environmental score is associated on average with an increase of about 127.6 units in EBITDA, all other variables being equal.

Again, looking more closely at the control variables, the regression results for the energy sector show that the **turnover** coefficient is positive and statistically significant ($p < 0.000$), indicating that firms with higher revenues tend to report higher EBITDA.

Conversely, the **age** variable is not statistically significant in the model (p-value: 0.180), suggesting that once turnover and other factors are controlled for, **firm longevity does not exert a systematic influence on EBITDA**. In other words, in the sample analyzed, more mature firms do not show significantly higher or lower levels of profitability than younger firms.
In summary, the data suggest that **firm age is not a relevant driver of economic performance**, especially when already considering firm size and sustainability. What affects operating profitability the most seems to be strategic choices and environmental behaviors, rather than mere corporate seniority.

The Energy dummy variable has a coefficient of -525.4241, which suggests that, given the same Climate Score, Environmental Score, turnover and age, an energy sector firm would have a base EBITDA that is about 525 lower than a non-energy firm. However, it is important to note that this coefficient is not statistically significant (p-value 0.442). In practice, the large uncertainty around this estimate means that we do not have robust evidence of an inherent difference in EBITDA between the energy sector and other sectors once other variables are taken into account.

The negative sign would indicate that, after controlling for revenue and environmental performance, energy firms tend to have lower EBITDA than others-which could suggest

higher operating costs or industry-specific competitive pressures. However, since the effect is not statistically confirmed, we cannot say for sure: Being “energy” per se does not guarantee a distinct effect on EBITDA.

In other words, belonging to the energy sector is neither a significant advantage nor disadvantage on EBITDA if the companies have similar turnovers and sustainability scores.

The **Climate Energy Interaction term** has an estimated coefficient of -84.5569, which is also not statistically significant (p-value 0.470). This interaction coefficient should be interpreted together with the main coefficient of the Climate Score discussed above. In practice, -84.56 represents the difference in the effect of Climate Change Score on EBITDA for firms in the energy sector compared to firms in other sectors.

Specifically, for an energy firm, the total effect of an extra point of Climate Change Score on EBITDA would be given by the sum of the base coefficient (+12.67) and this interaction term (-84.56). This would give a net effect of about -71.9 (12.67 - 84.56) for energy firms. In other words, the model suggests that in the energy sector an increase in climate score could be associated with a reduction in EBITDA, in contrast to the slight positive effect estimated for the other sectors. However, it is crucial to note that this differential effect is not statistically significant.

The coefficient of the **Environmental Energy Interaction term** is +284.9156 and is significant at the 5 percent level (p-value 0.049). This is one of the most significant results of the model with interactions. This coefficient indicates by how much the effect of Environmental Pillar Score on EBITDA differs for energy companies compared to other companies.

Calculating the total effect: For a non-energy firm, as seen before, an extra point of Environmental Score increases EBITDA by ~127.6. For an energy company, one must also add up the interaction: $127.6 + 284.9 \approx 412.5$. So, in the energy sector each additional point in the environmental score is associated with an EBITDA increase of more than 400, compared to ~128 for companies in other sectors. This differential of ~285 is

significant, as confirmed by the 95% confidence interval ranging approximately from +0.8 to +569.0.

This result shows that the positive impact of environmental sustainability on EBITDA is particularly strong for energy companies. In other words, energy companies derive significantly greater economic benefit from improvements in their environmental performance, compared to companies in other industries. This can be explained by several considerations: The energy sector is highly environmentally impactful (emissions, pollution, resource consumption) and highly regulated and under public scrutiny. Therefore, improving environmental performance (reducing non-climate-changing pollutant emissions, improving water and land use efficiency, better managing waste, etc.) can bring immediate and tangible benefits to energy companies. These benefits can manifest themselves in the form of lower operating costs (less waste, more efficient processes, lower disposal costs and penalties), higher revenues (due to a better relationship with communities, better reputation that attracts customers or investors sensitive to sustainability), or lower risks and provisions (fewer environmental incidents mean less extraordinary expenses).

At the same time, non-energy companies are not excluded from the benefit: The Environmental Pillar coefficient was also positive and significant for them, only smaller in magnitude. This suggests that in all sectors sustainable environmental practices contribute positively to performance, but the competitive or operational advantage is amplified in the energy sector.

6.6 Final Considerations

The main objective of this analysis was to investigate the existence of a relationship between the environmental dimensions of sustainability and the economic performance of companies as measured by EBITDA. In particular, the focus was on two indicators provided by MSCI: The **Climate Change Score** and **the Environmental Pillar**. Although both fall under the "E" dimension of the ESG rating, they have different conceptual and structural characteristics, which influence their potential economic impact.

The **Climate Change Score** specifically measures a company's exposure to climate change-related risks and opportunities. It looks at things like greenhouse gas emissions, carbon footprint of products, and vulnerability to physical and transitional climate risks. This score is especially important for industries that are heavily impacted by environmental changes. However, its relevance may also be related to a firm's ability to allocate resources for climate mitigation. In contrast, the **Environmental Pillar** is a broader and more cross-cutting indicator that goes beyond just climate risks. It includes factors related to natural resource management (e.g., water, biodiversity, raw materials), pollution control, waste management, and opportunities related to environmental technologies. This structure makes it potentially better suited to capture widespread management practices and operational impacts that directly influence economic viability.

To empirically assess the relationship between these ESG indicators and corporate profitability, **four OLS regressions were conducted**, constructed using incremental logic. Initially, a heterogeneous sample of companies operating in different sectors was considered, and then the analysis was narrowed down to the energy sector, which is particularly exposed to environmental issues. At a later stage, control variables-specifically, turnover, used as a proxy for firm size, and firm age, understood as operating seniority-were introduced in order to isolate the independent effect of ESG variables on economic performance.

From the **baseline model**, which lacked controls, a positive and statistically significant correlation emerged between both environmental variables and EBITDA. However, the introduction of **turnover** as a control variable profoundly changed the interpretation of

the results. In particular, the **Climate Change Score** completely lost statistical significance, suggesting that its effect was partly explained by company size: Larger companies, having superior economic and organizational resources, are more able to implement climate strategies (e.g., emission reduction targets, low-carbon technologies, adherence to international standards), improving their climate score **without necessarily generating a direct impact on EBITDA**.

In contrast, the **Environmental Pillar** has **maintained its significance even after the introduction of controls**, confirming that the dimensions addressed by this indicator-such as resource management efficiency, waste reduction, emission control, and the adoption of circular practices-directly affect operating costs and management efficiency. Such practices produce concrete and positive economic effects, **not dependent on company scale**, and thus **maintain a significant correlation with profitability even at the same size**.

In the **second model**, focusing on the interaction between environmental indicators and the energy sector, the **Climate Change Score × Energy Sector** interaction is **only marginally significant** ($p = 0.104$), while all other interactions -particularly that with the Environmental Pillar- are **not significant**. This suggests that, in the absence of controls, the effect of ESG variables on profitability does not differ substantially between energy and non-energy firms.

However, in the **fourth model**, which repeats the analysis by restricting to the energy sector only and including the control variables, **the Environmental Pillar maintains a positive and significant impact** on EBITDA[186]. Furthermore, the **Environmental Pillar × Energy Sector** interaction is **significant at 5 percent** ($p = 0.049$), indicating that the positive link between environmental sustainability and economic performance is **still more pronounced** for energy companies than for other sectors. This result highlights that in an industry with a high environmental impact, such as the energy sector, the adoption

[186] The addition of the control variables makes it possible to remove confounding effects and better isolate the specific contribution of environmental sustainability on profitability, bringing out more clearly and statistically relevantly the positive effect of the Environmental Pillar in the energy sector.

of effective environmental practices can translate into concrete competitive and operational advantages.

CONCLUSION

This thesis has examined how climate change constitutes a pressing macroeconomic risk, capable of producing large-scale impacts on economic and financial systems. By discussing concrete examples of extreme weather events – such as exceptional heatwaves, catastrophic floods, and prolonged droughts – the study showed how these phenomena can disrupt entire productive sectors, affect supply chains, and lead to significant financial losses. This evidence emphasizes the urgent need for both governments and businesses to factor climate risk into their assessments of macroeconomic stability and their corporate risk management strategies.

The research delved into the **distinction** between **physical risks** and **transition risks** related to climate change: The former stem from the intensification of destructive weather events and long-term environmental shifts; the latter are associated with regulatory, technological, and market changes accompanying the shift toward a low-carbon economy.

Another key part of this work concerned the **evolution** of the **regulatory framework** on climate and sustainability at both the **international** and **European levels** (*Chapter 1,2)*. The study examined major agreements and initiatives guiding the global response to climate risk: From the **2015 Paris Agreement** – which set ambitious targets to limit global warming – to the **recommendations of the Task Force on Climate-related Financial Disclosures** (TCFD), aimed at improving corporate transparency on climate risks. At the European level, this thesis analyzed the **EU Green Deal** and related regulatory measures, including the **EU Taxonomy** for sustainable finance and the new **Corporate Sustainability Reporting Directive** (CSRD), also considering the recent 2025 "**simplification package**" designed to streamline and enhance sustainability reporting obligations. This policy review clearly underscores the central role of the **double materiality** principle. Companies are now expected to assess and report not only how environmental and social factors affect their financial performance (financial materiality), but also how their business activities impact the environment and society (impact materiality), thereby integrating both dimensions of materiality into corporate strategies.

The research further emphasized the importance of **connectivity** between sustainability disclosures and a company's financial statements (*Chapter 3)*. In particular, with a focus on the energy sector, it showed that environmental and climate-related information must be tightly integrated into financial evaluations – for example, by incorporating potential climate risk effects into asset impairment analyses under the IAS 36 accounting standard. This integrated approach ensures that financial statements adequately reflect the financial impacts of climate change, helping to avoid underestimating potential liabilities or overvaluing assets that are exposed to transition phenomena.

From a managerial perspective, the study (*Chapter 4,5)* analyzed the current ("**AS IS**") and future ("**TO BE**") state of climate risk management in energy companies through direct interviews with Chief Financial Officers (CFOs) and Chief Risk Officers (CROs). These interviews helped outline the practices currently used to identify, assess, and mitigate climate-related risks, as well as the initiatives planned for the future. The insights from the executives revealed the real challenges of weaving climate risk into decision-making processes, along with the necessity of innovating these processes through the use of advanced tools. In particular, the interviews highlighted the transformative potential of **Artificial Intelligence (AI)** in climate risk management: AI techniques can help firms in analyzing complex climate scenarios, monitoring risk indicators in real time, and formulating more effective adaptation strategies.

Finally, the thesis employed **econometric analyses** to explore the connection between corporate performance and environmental sustainability (*Chapter 6)*. The quantitative findings indicate a positive correlation between a company's economic performance – measured by EBITDA – and its commitment to sustainable environmental practices. In particular, a high overall score in the environmental domain (**Environmental Pillar**) is statistically associated with better financial performance. Conversely, a specific climate performance indicator, the **Climate Change Score**, exhibited a less stable and not always significant link with EBITDA.

This discrepancy indicates that while a strong overall environmental profile tends to align with positive economic outcomes, indicators focused exclusively on climate change can

be more difficult to interpret and may not immediately translate into tangible financial benefits in the short term.

The comprehensive analysis conducted in this thesis leads to **several critical reflections.** First, the centrality of sustainability in modern business management clearly emerges climate change and its associated risks are no longer peripheral issues; they have become determining factors that shape strategic decisions, risk management, and the long-term competitiveness of firms. In this context, the evolving regulatory framework serves as both a catalyst and a guide: The different international agreements and European regulations examined in this work not only impose stricter obligations, but also provide companies with a clear direction for orienting their business models toward sustainability.

Moreover, the analysis highlighted the usefulness of advanced tools such as Artificial Intelligence to support these processes: AI methods and data analytics can greatly improve a company's ability to understand complex phenomena, anticipate risk trends, and effectively integrate sustainability considerations into operational and financial decisions.

In conclusion, while recognizing the progress made, several critical issues and future challenges remain.
A primary concern relates to the **quality and standardization of sustainability data**. Although international and European regulatory frameworks are advancing toward greater harmonization of ESG disclosure requirements, **significant discrepancies persist among the metrics and ratings used by different ESG data providers**, such as MSCI, Sustainalytics, Moody's ESG Solutions, and S&P Global.
In particular, seemingly similar indicators—such as the **Climate Change Score**—may be constructed based on very different methodologies. Some are built primarily on disclosure practices and transparency, others on actual performance or forward-looking scenarios; some apply sector-adjusted weightings, while others use absolute or relative scales.
This methodological heterogeneity leads to **low correlations between scores assigned to the same company by different agencies**, generating **inconsistent assessments** and making it difficult to objectively compare sustainability levels across companies or sectors.

These inconsistencies, well-documented in the literature, **can weaken the robustness of empirical findings**: For instance, the **variability observed in the Climate Change Score** within the sample analyzed may help explain why this variable, though theoretically relevant, **proves to be unstable and statistically insignificant in the econometric models**.

This highlights the pressing need to consolidate shared methodologies, harmonized definitions, and standardized parameters. The goal is to make non-financial information not just comparable and reliable, but also fully usable in both corporate and financial decision-making processes.

Another challenge lies in the effective implementation of new technologies: Artificial Intelligence—identified as a promising tool for managing climate risk—will need to be integrated into corporate processes with care, which entails investing in specialized skills and ensuring a solid ethical and regulatory framework to guarantee its reliability and avoid potential biases. Finally, the future of business management hinges on firmly integrating sustainability into the **core business**.

This means moving beyond a mere compliance-based: Environmental and social goals must become an intrinsic part of corporate strategy and value creation models. Only through this cultural and operational paradigm shift can companies effectively mitigate climate-related risks while also seizing the opportunities for innovation and competitive advantage offered by the transition to a sustainable economy.

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