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Cleantech Innovation in Europe: driving Sustainability through Startups, Policies and Venture Capital

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La fortuna aiuta
gli audaci.
(Virgilio 29 a.C.)

Ai miei Genitori, che mi hanno donato
le radici per crescere e le ali per volare.

A mia Sorella, indispensabile linfa del mio cuore.

Ai miei Nonni, guida preziosa
e presenza costante durante il mio percorso.

A Sharon, dolce respiro che rasserena la mia anima.

A chi lotta per ciò che ama.
A quelli che ce la mettono tutta per riuscirci.

Alla mia parte fragile come un cristallo
e alla mia parte dura come il cemento armato.

Contents

EXECUTIVE SUMMARY

This thesis provides a comprehensive overview of the dynamics influencing the cleantech sector in Europe, highlighting the potential of startups and the need for support through investments, innovation, and public policies.

CONTEXT ANALYSIS

The definition of cleantech companies, their distinctive characteristics and the different sectors in which they operate enables the delineation of the importance of these start-ups in technological innovation and their segmentation provides an understanding of the different areas of specialisation. The academic literature accounts for the factors that contribute to the development of the growth dynamics of start-ups, for which it is necessary to implement a holistic approach that takes into account the variables and operational dynamics as well as the reference context related to the expansion process. In this perspective, the variables at play include internal growth dynamics, entrepreneurial skills and innovation capacity, and external ones, such as the influence of social networks, financial resources and public policies, aspects that deserve adequate attention (Gilbert et al., 2006).

The parameters for creating a favorable business ecosystem for the growth of the cleantech sector are part of an overall framework that is characterised by a number of interdependent factors. In this context, Green Deal policies provide a favourable regulatory framework for cleantech companies, supporting innovation and research in green technologies and providing for investment in sustainable projects and green infrastructure, stimulating the economy and offering companies access to funds and resources to develop their solutions.

Europe positions itself as a global leader in energy transaction and sustainability, fostering the export of cleantech technologies and know-how.

Sustainability indicators are essential tools for measuring and monitoring progress in the cleantech sector as they provide concrete data that can guide strategic decisions. Reference is made to the measurement of environmental performance, assessment of energy efficiency, economic sustainability, social impact, innovation related to patents and innovation investments, and regulatory compliance.

RESEARCH POINTS

A crucial role in the development of cleantech businesses is played by venture capital as a tool that provides the capital needed to support innovation and growth in this sector. Key aspects of its impact include:

- The financing of innovation: especially in the early stages, companies need significant investments, and VC enables the development of innovative technologies and products;
- Scaling support: the VC helps finance the growth and expansion of cleantech companies through production optimisation, expansion into new markets and the creation of strategic partnerships;
- Access to expertise and networks: venture capitalists bring not only capital but also expertise and networks, which are crucial for start-ups in the cleantech market landscape.

The combination of data on cleantech companies, extracted from the Orbis database, with information on VC investments provided by VICO 4.0, provides an interesting overview to analyse the role of VC in the advancement of cleantech in Europe, highlighting a high percentage of investments in technologies mainly related to sustainable energy production, but also recognising the importance of innovative solutions to pollution and waste management issues.

In this context, a key role is played by patents, which also increase the attractiveness of companies for potential investors by signalling the innovative potential of the patenting company. This is also true for green technologies (Belucci et al., 2021).

The correlation between financial support and patent innovation suggests that not all companies receive the necessary impetus to develop new patentable technologies, therefore, the importance of venture capital is emphasised not only as a source of financing, but also as a catalyst for innovation in green technologies.

The intensity of venture capital investments, expressed as the percentage of cleantech companies that received such funding, shows considerable variation across countries. These data not only reflect current trends in the startup world, but also offer insights into the economic and social dynamics that influence entrepreneurs' choice of cities. Cities that emerge as innovation hubs tend to have a favourable ecosystem,

characterised by support networks, access to funding and a vibrant entrepreneurial community (European Startup Monitor, 2023; Startup Genome, 2023).

The emergence of new cleantech companies is influenced by several environmental indicators, particularly in relation to research and development (R&D) and patents. In recent years, there has been a significant increase in the number of patents covering technological innovations oriented towards environmental sustainability and the transition to cleaner energy sources, prompting many companies and institutions to invest in research and development of eco-friendly technologies. This phenomenon was documented in a recent report by the European Patent Office, which not only underlines the emerging opportunities in this field, but also highlights the critical issues related to these developments, including barriers to entry for small and medium-sized enterprises, which may have difficulty competing with large market players, and the need for an adequate infrastructure to support the implementation of these technologies.

Analysing the interconnections between patents and market dynamics is important for understanding the investment decisions and development strategies of start-ups. The implications of environmental indicators on the emergence of start-ups, together with disparities in investments in sustainable technologies and barriers to commercialisation, provide a comprehensive view of the challenges that start-ups face in the current environment.

Finally, there is a focus on digital transformation and sustainability, key elements that are reshaping the contemporary business landscape. The discussion on sustainable innovation and the Twin Transition, together with the analysis of regulations and investments, highlights how companies can exploit these synergies to develop innovative and sustainable solutions.

CONCLUSIONS

Although, Europe emerges as a key player in the global landscape geared towards the goal of achieving zero net greenhouse gas emissions, and establishes itself as a leader in the field of green technologies, supported by a substantial number of patents reflecting its commitment to innovation and research in this field, it is competing with countries such as China and the United States that are rapidly advancing in the field of green technologies, implying the need to invest in research and development (R&D) as well as to adopt appropriate policies to support the innovation and commercialisation of sustainable technologies.

A long-standing and well-documented challenge is the funding gap that characterises the innovation environment on the continent. This gap is a major obstacle for start-ups and emerging companies in the field of sustainable technologies, limiting their ability to grow and expand their activities. A robust single market offers opportunities for collaboration and partnership between companies, institutions and research centres, facilitating the exchange of knowledge and expertise (European Investment Bank, 2021).

In this context, a key role is played by patents, as they enable European companies in the field of environmentally friendly technologies to safeguard their competitive advantages in an ever-changing field. Furthermore, patents can facilitate access to finance, which is particularly significant for small and medium-sized enterprises (SMEs) in the field of sustainable technologies, which often face capital constraints (European Patent Office, 2020). Synergetic collaboration between different actors, research centres, companies and academic institutions, is a key step in the Climate-Tech context precisely because technological challenges necessarily require a collaborative effort and a sharing of intentions involving both investors and entrepreneurs.

This requires an integrated approach that combines public and private investment, research and development, and incentive policies that stimulate the adoption of green technologies (Baker et al., 2022). Europe's ability to address these challenges will have a decisive impact on its competitive position in the global climate-tech market.

Introduction

Climate change has been increasingly recognized as one of the most important challenges for the future of humanity. Many factors, now more than ever, are impacting our lives, from environmental to social impacts, including rising sea levels, an increased frequency and severity of natural disasters, pollution of rivers and seas, and shifts in the distribution of plant and animal species.

Actions for mitigating the effects of climate change require international cooperation and coordinated actions.

The cleantech sector is emerging as a crucial element in addressing global environmental challenges and supporting the transition to a sustainable economy.

Cleantech technologies are essential not only for reducing the environmental impact of human activities, but also for promoting economic growth, creating jobs, and attracting investments. These technologies encompass innovative solutions in areas such as renewable energy, energy efficiency, waste management, and sustainable mobility.

The European Union, recognizing the importance of Cleantech technologies, has adopted the European Green Deal, an ambitious package of policies aimed at transforming Europe into the first climate-neutral continent by 2050. This commitment represents a historic turning point, outlining a clear path towards environmental sustainability and stimulating innovation in the Cleantech sector.

However, the success of Cleantech companies largely depends on an ecosystem of policies and regulations that facilitate their development. These policies must provide a stable regulatory framework, economic incentives, and access to adequate financing. In this context, it becomes crucial to analyze the enabling factors that can support and accelerate the growth of Cleantech companies in Europe.

This thesis is set within this context, focusing on a country-level analysis of the dynamics of the cleantech sector, with the aim of finding new research gaps on previous studies conducted at the European level and adapting them to the individual countries.

The European Union and its member states have introduced in the last years many green laws and regulations, which aims to transform the EU's economy into a more sustainable one while ensuring that the transition is fair for all parties involved.

A starting point of our work involves leveraging insights from the CLEU project (Cleantech in the European Green Deal: policy challenges and the finance landscape for SMEs), supported by the EIBURS funding program of the European Investment Bank (EIB). This project has provided valuable frameworks for categorizing cleantech firms into innovators and ecosystem. We will employ a methodology based on identifying cleantech firms through the Orbis database by Bureau van Dijk, integrating financial and investment data with patent and technological innovation information. This approach will allow us to gain an in-depth understanding of the sector, identifying national peculiarities and the growth dynamics of cleantech firms.

We will examine whether and how national policies, financial support, and other enabling factors contribute to the increase or decrease in the value of cleantech firms, providing an empirical basis for improving strategies to support these innovative technologies.

Our study will focus on key states and specific sectors, selected based on their relevance and contribution to the European cleantech landscape. The goal is to delve deeper into the factors at the country level that influence the creation and development of cleantech companies and startups through a comparative analysis. By identifying and analyzing these factors, we hope to provide valuable insights into the conditions that foster innovation and growth in the cleantech sector, ultimately contributing to the broader goal of achieving a sustainable and climate-neutral future, while identifying best practices and specific challenges characterizing each national context and sector.

The thesis is structured as follows: Chapter 1 is dedicated to a systematic review of the literature and analysis of the reference framework in the cleantech context, providing a theoretical foundation on which to build the subsequent arguments. This phase provides the necessary context to understand the market dynamics and the interactions between startups and sustainable technologies. Chapter 2, we will explore the dynamics of interaction between start-ups and sustainability, analysing how these new companies can contribute to an effective ecological transition; we will discuss the role of start-ups in clean technologies, and provide an overview of the existing database on cleantech companies in Europe, an important resource for understanding the entrepreneurial landscape and investment opportunities in this sector. Finally, the focus is on sustainability indicators, offering a general overview of the tools and metrics used to assess the environmental impact of companies.

Chapter 3: focuses on Venture Capital, a crucial element in the financing of innovative start-ups, exploring the European Venture Capital context, highlighting trends and investment opportunities on the continent. Finally, we will focus on the specific situation of cleantech in Italy, analyzing the challenges and prospects for start-ups operating in this sector.

The topic of patents and market analysis emerges as a crucial field of study. The protection of intellectual property, through patents, not only allows innovators to safeguard their discoveries, but also serves as an indicator of the level of technological maturity and growth potential of start-ups. Chapter 4 aims to explore the interconnections between patents and market dynamics; an assessment of the level of technological maturity represented in patents will be carried out, analyzing how this maturity may influence the investment decisions and development strategies of start-ups. In addition, attention will be paid to the implications of environmental indicators on the emergence of start-ups, in relation to research and development (R&D) expenditures and patents, examining how sustainability policies can incentivize or hinder innovation.

Furthermore, attention is paid to disparities in investment in sustainable technologies, analyzing regional and sectoral differences and their impact on the competitiveness of start-ups, and to barriers to commercialization, with a focus on access to finance, a crucial element for the success of start-ups in today's market.

The last chapter focuses on digital transformation and sustainability, two forces that are redefining the contemporary business landscape. Sustainable innovation and its role in promoting a circular and inclusive economy will be discussed. The concept of the Twin Transition, and the link with innovation and patents, will be explored, highlighting how companies can capitalize on these synergies to develop innovative solutions, within a context influenced by investments and regulations as key elements for the development and growth of industrial supply chains.

Keywords: Cleantech, Environmental Innovation, National Policies, Venture Capital Investments, Country-Level Analysis

Chapter 1: Background and context

1.1 Definition of cleantech companies: characteristics and sectors

Cleantech, or clean technology, companies refer to those companies that develop products, services and processes using sustainable technologies to reduce environmental impact. These companies operate in various sectors, including renewable energy, waste management, energy efficiency, sustainable transport and water treatment technologies. They are characterized by a number of key features that shape their identity and operations, such as technological innovation, economic and environmental sustainability, and the ability to adapt to changing regulations.

The term clean technology (or "clean tech") refers to a complex and rapidly changing field, whose boundaries can sometimes be blurred. It is not uncommon, in fact, that "clean tech" is used interchangeably with "green technology" ("green tech"), reflecting an overlap in their meanings and applications. This terminological confusion can be attributed to the increased investment in eco-innovations, stimulated by growing global environmental awareness.

Since the 1970s, there has been a significant change in corporate perceptions of sustainability due to a growing awareness on the part of companies to adapt to a new consumer orientation, increasingly sensitive to environmental issues, which has led them to favour companies that demonstrate a commitment to ecological and sustainable practices, thus influencing marketing and corporate image strategies.

In addition to the ethical and social drive, companies are also motivated to invest in clean technologies for economic reasons, as the transition to more sustainable business models can lead to significant operational cost savings and improvements in energy efficiency. The increasing demand for environmentally friendly products and services has turned the clean technology sector into a significant opportunity and, at the same time, a strategic necessity for companies aspiring to thrive in the current economic landscape.

In the current context of start-ups and technology transfer projects, "clean tech" refers to a sector of investment which encompasses a wide range of innovative technologies mainly oriented towards:

- Renewable energy production, which includes resources such as biomass, wind energy, solar energy, electricity and biofuels;
- The implementation of recycling techniques, which can cover household waste, municipal waste and waste materials from industrial processes;
- The development of environmentally friendly transport solutions, including electric and hybrid engine technologies, green chemistry, new lighting systems and grey water treatment.

In a global context of growing energy demand, the creation of sustainable energy production technologies - capable of reducing emissions and improving efficiency - is one of the most significant business challenges for the near future (Kirkpatrick, 2020; Smith & Jones, 2021). Innovation in this sector not only promotes sustainable economic growth, but also contributes to mitigating the negative effects of climate change (Johnson et al., 2022).

1.1.2 Diving into the Cleantech startup sector

The increasing global emphasis on sustainability and environmental responsibility has led to the birth and rapid growth of the Cleantech sector, made of cleantech companies. The most common and used definition for the cleantech comes from Pernick and Wilder (2007), stating in their article that “cleantech refers to any product, service, or process that delivers value using limited or zero nons.” The cleantech sector embodies many different industries, including renewable energy, energy storage, water purification, waste management, and sustainable transportation. Their innovations often involve leveraging advanced materials, digital technologies, and novel engineering approaches to create solutions that are both economically viable and environmentally beneficial. As the global economy transitions toward a low-carbon future, cleantech startups are

positioned at the forefront of this transformation, offering groundbreaking solutions that align with international climate goals.
Several key elements drive the growth of cleantech startups:

• **Increasing Investment**: Venture capital and private equity funding in the cleantech sector have seen substantial growth, with venture capital being the major source of funding for early-stage cleantech startups. Investors are increasingly recognizing the potential of cleantech innovations to generate significant returns while contributing to sustainability goals. For instance, according to a report by Cleantech Group, global cleantech investments reached 46 billion dollars in 2022, highlighting robust investor interest in green technologies (Cleantech Group, 2023). As widely expected, energy and energy efficiency technologies represent about 70 percent of all cleantech funding (PWC, 2015). Other forms of financing are also growinng up in this sector, such as crowdfunding.
• **Supportive Policies**: Government policies and international agreements, such as the Paris Agreement and the European Green Deal, create a favorable regulatory environment for cleantech innovations. These policies not only provide financial incentives but also establish ambitious targets
for reducing greenhouse gas emissions and transitioning to renewable energy sources (European Commission, 2019).
• **Technological Advancements**: Rapid advancements in technologies such as artificial intelligence, blockchain, and advanced materials are accelerating the development and deployment of cleantech solutions. These technologies enable more efficient and scalable solutions for managing resources
and reducing environmental impact (International Energy Agency, 2022).
• **Consumer Demand**: Growing awareness among consumers about environmental issues has increased demand for sustainable products and services. This shift in consumer preferences drives companies to adopt cleantech solutions that align with their sustainability goals and meet market expectations (McKinsey Company, 2023).

The factors that promote new technology-based firm growth can roughly be divided into three categories: individual, firm-specific and external factors (Gilbert et al.,2006). Individual factors represent the individual characteristics of entrepreneurs, their skills

and background. Firm-specific factors include firm partners and network, as well as the riskiness of the firm's mission. External factors include policies and regulations, which will be investigated in this thesis.

1.1.3 Cleantech Segmentation

The cleantech sector is diverse, encompassing a wide range of technologies and industries dedicated to environmental sustainability. In the research conducted by Ambrois et al. (2023), a segmentation of the European Cleantech sector is proposed by the authors, since no comprehensive list of this sector has been done before. Therefore the segmentation of cleantech companies is crucial to better analyze and understand their specific characteristics and contributions. The segmentation is based on a comprehensive methodology, combining supervised machine learning (ML) and manual classification

1. Supervised Machine Learning Algorithm: A supervised ML algorithm was utilized to classify companies based on their extended business descriptions from the Orbis database. This initial step involved training the model with a labeled dataset, where companies were manually identified as cleantech or non-cleantech. The algorithm learned to recognize patterns and indicators of cleantech activities, such as keywords related to sustainability, renewable energy, energy efficiency, waste management, and pollution reduction.
2. Computer-Aided Filters: Following the ML classification, computer-aided filters were applied to eliminate false positives. These filters refined the classification by cross-referencing additional criteria and datasets to ensure accuracy.
3. Manual Checks and Ecosystem Segmentation: The final step involved manual verification and classification. Companies were categorized intotwo primary segments:

• Cleantech Innovators: These are companies that develop new clean technologies. This includes firms engaged in the research and development of innovative solutions aimed at reducing environmental impact, such as advanced renewable energy technologies, energy storage systems, green chemistry, and sustainable materials. Examples include companies working on next-generation solar panels, hydrogen fuel cells, and cutting-edge recycling technologies.

• Cleantech Ecosystem: These companies adopt clean technologies, sell services based on clean technologies, or provide inputs for the development of clean technologies.

They are further distinguished into:

Experimenters: Companies involved in performing experimental tasks that can lead to discoveries and advances in the science of the cleantech supply chain, both private and public. These firms may also engage in manufacturing activities.

Manufacturers: Companies involved in the cleantech supply chain, dealing with manufacturing, fabrication, and production of necessary and auxiliary components or raw materials for clean technology. They handle ancillary services concerning actual innovation.

Distributors: Companies that distribute or are involved in the commercial provision of cleantech products or technologies. Their primary role is to make clean technologies available on the market.

Integrators: Companies involved in the cleantech supply chain, dealing with engineering, installation, procurement, design, conception, and planning. Their prominent role is to make the clean technology ready to use for adopters.

Operators: Companies involved in the cleantech supply chain that deal with the construction, implementation, and maintenance of facilities where clean technology is used. This category also includes adopters who use technology as the primary tool to achieve their output, such as energy production.

This rigorous process reduced the initial dataset from over 537,000 companies to a refined list of 23,858 cleantech companies, with 2,990 classified as innovators and 20,868 as part of the broader cleantech ecosystem.

1.2 Literature review

Based on the above, it is necessary to conduct a review of the literature that accounts for the factors that favor business development based on new technology, as well as the regulatory factors related to the European Green Deal and its four fundamental principles.

With regard to the growth dynamics of start-ups, it is interesting to distinguish how the relevant literature focuses mainly on the reason for their development, sometimes neglecting the geographical and sectoral context. Therefore, it is considered crucial to implement a holistic approach that examines not only the motivations behind growth, but also the variables and operational dynamics as well as the context related to the expansion process.

With respect to established firms, in fact, the academic literature accounts for the parameters at play with respect to internal growth dynamics, including entrepreneurial skills and innovation capacity, and external ones, such as the influence of social networks, financial resources and public policies, aspects that deserve greater attention (Gilbert et al., 2006).

Numerous articles can be found in the ISI Web of Science database, which provides a wide selection of leading cleantech journals, offering an interesting overview of cleantech start-up companies. An integrated search was carried out based on specific reference keywords, such as ‘growth’, ‘determinants’ and ‘company performance’.

A number of academic articles were selected to serve as reference points for a systematic literature review in relation to the criteria to be examined concerning the above-mentioned factors.

A study carried out by Bjornalia, ES, & Ellingsen, A. published in the journal Energy Procedia, entitled Factors Affecting the Development of Clean-tech Start-Ups: A Literature Review, outlines the general variables that determine growth factors in New Technology-Based Firms (NTBFs), presenting the relevant descriptive results, focusing on American companies.

Research data show that in the energy sector, the two main groups focus on the adoption of sustainable technologies and the use of renewable energy sources. These groups tend to consider the entire energy technology landscape, rather than focusing solely on specific technological solutions or their individual progress. In particular, solar and

wind energy stand out as the two predominant industries in the clean technology arena, excluding hydropower in this case. The increasing focus on these renewable sources is fueled by the need to reduce greenhouse gas emissions and promote a low-carbon economy.

A more recent study published in the International Journal of Energy Economics and Policy accounts for how improved natural resource use, green investment, digital finance, industrial use, energy efficiency and renewable energy consumption contribute significantly to sustainable development (Abdullah, et al., 2024) by examining the role of these factors in 20 Belt and Road Initiative (BRI) countries in particular. The analysis was conducted based on data from 2010 to 2020, applying the Driscoll-Kraay (1998) standard error model in order to make a robust and reliable empirical estimate.

In accordance with the emerging evidence, the research proposes that the surveyed nations can gain significant benefits from the adoption of digital financial inclusion strategies in conjunction with the increased use of renewable energy sources. These findings not only highlight the economic and social development potential of these practices, but also provide a useful framework for public policy makers. The latter can thus formulate more effective and targeted strategies to achieve the goals outlined in the 2030 Agenda for Sustainable Development, the so-called Sustainable Development Goals (SDGs). These directions are part of a broader context of research and analysis of the synergies between technology, sustainability and social inclusion, as discussed in the literature (Ocampo, 2020; Mazzucato, 2018).

In an article in Venture Capital: An International Journal of Entrepreneurial Finance, titled Financing green innovation startups: A systematic literature review on early-stage SME funding, the authors (Mukherjee et al., 2024) provide an interesting analysis of the current landscape by implementing a systematic literature review methodology that investigates the issue of early-stage green startup financing, taking into consideration the types of investors and financial models available, highlighting how the green finance ecosystem can best support early-stage investments. The results of the analysis show a significant lack of data regarding the financing of green start-ups, with a marked bias towards established ecosystems in North America and Europe.

This scenario is further complicated by the increasing variety of private funding sources that have emerged in the wake of the global financial crisis (GFC), including instruments such as grants, venture capital and crowdfunding. However, dependence on

public funding remains high, and there is a lack of empirical evidence to clarify their actual impact. The peculiarities of green technologies, characterized by high initial investment requirements, long payback time horizons and their innovative nature, pose the need to develop state-of-the-art public financing instruments and policies to mitigate the associated risks and to stimulate private capital inflow into the sector.

In this context, it is crucial to consider the existing literature analyzing the dynamics of financing green innovations. For example, research by Ghosh et al. (2019) and Hall et al. (2020) highlighted the importance of an integrated approach combining public and private resources to support sustainable innovation. Furthermore, the work of Hockerts and Wüstenhagen (2010) highlights how public policies can influence the funding landscape, fostering a more favorable environment for the emergence of green solutions.

They emphasize the importance of an interdisciplinary approach in research and policy collaboration to improve the policy mix in support of the green economy through quantitative economic analysis research and qualitative studies that aim to create a framework that will not only foster public-private co-financing, but also improve stakeholder engagement while providing solid evidence for policy decisions.

The literature suggests that synergy between different disciplines can generate more effective solutions to current challenges. For example, Mazzucato's (2013) research highlights the crucial role that public policies play in innovation, highlighting the need for constant interaction between public and private actors. Studies such as those by Agrawal et al. (2019) show how the integration of behavioral approaches can improve financing strategies for sustainable technologies by addressing psychological and cognitive barriers to investment.

Green finance is academically and politically relevant in relation to climate change, as also emphasized in the final synthesis report by the Intergovernmental Panel on Climate Change (IPCC, Citation2023) of the United Nations with the goal of reducing greenhouse gas emissions and facilitating the transition to a sustainable economy. This is in line with the global targets set by the Paris Agreement (2015) to reduce greenhouse gas emissions to zero by 2050. Furthermore, this study highlights the existing disparity in funding, estimating an annual gap of more than $100 billion between private and public resources allocated to these causes (IPCC, 2022; 2023).

The economic difficulties that innovative SMEs face with respect to accessing the financing necessary to develop green solutions and to support the long and complex process of commercialization, implies the creation of entrepreneurial finance ecosystems capable of integrating financial offers with sustainability policies and a network of professional actors. Nanda (2020) highlights the presence of a persistent market failure for investments in deep-tech technologies, characterized by high capital requirements and long-time horizons, sometimes exceeding 10 years, before generating economic returns.

This occurs because SMEs struggle to clearly present the value of their innovations, which can lead to underestimation by the market (Carpenter & Petersen, 2002).

The literature review in the context of sustainability technologies is significantly intertwined with the strategies outlined in the European Green Deal, which aims to promote the innovation and adoption of green technologies as key tools for achieving climate and environmental goals.

In accordance with European climate legislation, the targets defined in the EDG are legally binding for the European Union and its 27 Member States. This will entail the need to introduce new regulations and revise the EU's current legislative framework in order to facilitate the transition to a more sustainable model.

The Industrial Plan for the Green Deal, presented in Brussels on 1 February 2023 by the European Commission, aims to address the need to achieve European climate standards by creating a favorable environment for the expansion of EU production capacity in technology and zero-emission products (European Commission, 2023).

Europe has the opportunity to take a leadership role in the development and implementation of sustainable technologies, as stated by the President of the European Commission, Ursula van der Leyen, who optimistically expressed this concept on this occasion, highlighting how the clean technology revolution needs a leaner and faster regulatory framework:

«We have an opportunity, unique for our generation, to show the way with speed and ambition, bearing in mind our goal of ensuring EU industrial leadership in the fast-growing sector of net-zero technologies. Europe is determined to lead the clean technology revolution. For our businesses and citizens, this means turning skills into quality jobs and innovation into mass production, thanks to a simpler and faster

framework. Better access to finance will enable our leading clean technology industries to grow rapidly».

The European Green Deal mapped out a clear path to implement a profound transformation, which will bring with it numerous benefits, ranging from the creation of new opportunities for innovation and investment to the emergence of green jobs and improved health and well-being of populations. Member states have committed to making the EU the first continent to achieve climate neutrality by 2050 by setting a target to reduce emissions by at least 55% by 2030, compared to 1990 levels.

Currently, the European Union has adopted legally binding climate targets affecting all major sectors of the economy. In general, the package of measures includes:

- Emission reduction targets in different sectoral areas
- A target for increasing natural carbon sinks
- An up-to-date emissions trading scheme, aimed at limiting emissions, putting an economic value on pollution and stimulating investment in the transition to a green economy
- A social support for citizens and businesses.

1.2.1 The Green Deal Industrial Plan

To ensure industrial innovations and clean technologies, the Green Deal business plan develops four basic principles:

1. **A predictable and simplified regulatory environment**

The first pillar of the strategic plan focuses on the regulatory environment, with the aim of outlining an environment that is not only simplified, but also quicker and more predictable for industry players. The main intent is to ensure the availability of an adequate amount of raw materials, as well as to ensure that users have access to affordable forms of renewable energy. In support of this commitment, three key initiatives are articulated:

■ **Zero net emission industry regulation**: this initiative is designed to set clear targets for industrial capacity oriented towards zero net emissions, as well as to create a regulatory framework that facilitates the rapid deployment of such capacity. By setting standards and regulations, it is intended to incentivize companies to invest in clean and sustainable technologies, thereby promoting a transition to a low-carbon economy (European Commission, 2021).

■ **Critical raw materials legislation**: this component of the plan aims to ensure adequate access to essential raw materials, such as rare earths, which are crucial for the production of advanced and sustainable technologies. The implementation of specific legislation is crucial to reduce dependence on external suppliers and to ensure a stable and sustainable supply of materials that are indispensable for technological innovation in the renewable energy sector (European Commission, 2020).

■ **Electricity market structure reform**: this reform aims to structure the market in such a way that consumers can take advantage of affordable forms of renewable energy. The aim is to create a competitive environment that stimulates innovation and lowers prices for end consumers, while facilitating the integration of renewables into the energy mix (International Energy Agency, 2022).

The Organization for Economic Co-operation and Development (OECD) defines regulation as a set of incentives established by legislative, governmental or administrative bodies, which oblige or prohibit certain actions by citizens and enterprises. Regulatory measures are accompanied by clearly defined sanctions that can be applied in the event of non-compliance. The content of regulations can be a significant resource for innovation, but at the same time can be a major obstacle for innovative activities (OECD, 1994) (Swann, 2005).

An example of this dynamic is provided by antitrust regulation, which shows a positive impact on research and development (R&D) intensity (Koch et al.,2004). This observation is consistent with the positive correlation between the level of competition and innovative activities (Geroski, 1991). However, a negative correlation has also been

found between the intensity of product market regulation and R&D expenditure in OECD member countries (ECO/WKP, OECD, 2002).

Uncertainties associated with regulation and taxation emerge as major barriers to investment in climate-related projects as they often lead companies to postpone or reduce their innovation efforts. In contrast, regulatory frameworks that promote flexibility through incentives and performance standards prove more beneficial in stimulating innovation, enabling companies to implement solutions that are both economically viable and commercially sound (Knut Blind, 2016).

Another critical aspect is over-regulation, which is emerging as a barrier to the survival and growth of small and medium sized enterprises (SMEs) that are particularly vulnerable to bureaucracy, because they have fewer resources and expertise to manage the complexity of regulations, and cannot spread compliance costs over a larger volume of operations than large companies can.

2. **Speeding up access to finance**

Accelerated access to finance is a key element in the context of the second pillar of the European plan, which aims to significantly boost investment and financial resources for the production of sustainable technologies on the continent. As part of the competition policy strategy, the European Commission's primary objective is to ensure a level playing field in the European single market, while simplifying the procedure for Member States to grant aid, which is necessary to promote a rapid and effective ecological transition.

To achieve these objectives, the Commission undertook a number of strategic actions. First, it launched a consultation process with the various Member States, leading to a modification of the temporary crisis and transition framework for State aid in order to adapt to the new needs emerging from the climate crisis. In addition, the General Block Exemption Regulation was revised considering the guidelines of the European Green Deal, which outlines an ambitious path towards environmental sustainability.

In parallel, the Commission intends to facilitate access to existing European funds, including REPowerEU, InvestEU and the Innovation Fund. These financial resources are intended to support innovation, production and dissemination of clean technologies.

Finally, the creation of a European Sovereignty Fund is envisaged, which would be a structural and medium-term response to the growing need for investment in sustainability.

These initiatives are in line with international policies for sustainability and energy transition, highlighting the importance of a coordinated approach at European level to address contemporary environmental challenges (European Commission, 2021; European Parliament, 2022).

In the field of research, one third of the world's most prestigious institutions are located in the European Union, along with one third of international patents and more start-ups in the field of climate technologies than the sum of the US and China. Although Europe holds a leading position in the early stages of research and development, the United States surpasses it in terms of availability of financial resources, particularly now, thanks to the Inflation Reduction Act (IRA), a set of policies that provides clear incentives for investors and companies, facilitating investment choices.

Europe has become aware of the importance of supporting environmentally friendly technologies in response to the US IRA. To address this challenge, the second pillar of the European Green Deal will focus on accelerating funding for sustainable technologies in Europe. Hence, a range of financing mechanisms will be developed.

In the figure below, a graphical representation of public funding sources dedicated to these technologies is shown. In particular, the European Commission's estimates of the investment needed to promote clean technologies in the EU up to 2030 foresee a total investment of EUR 92 billion, of which between EUR 16 and 18 billion should come from public funds.

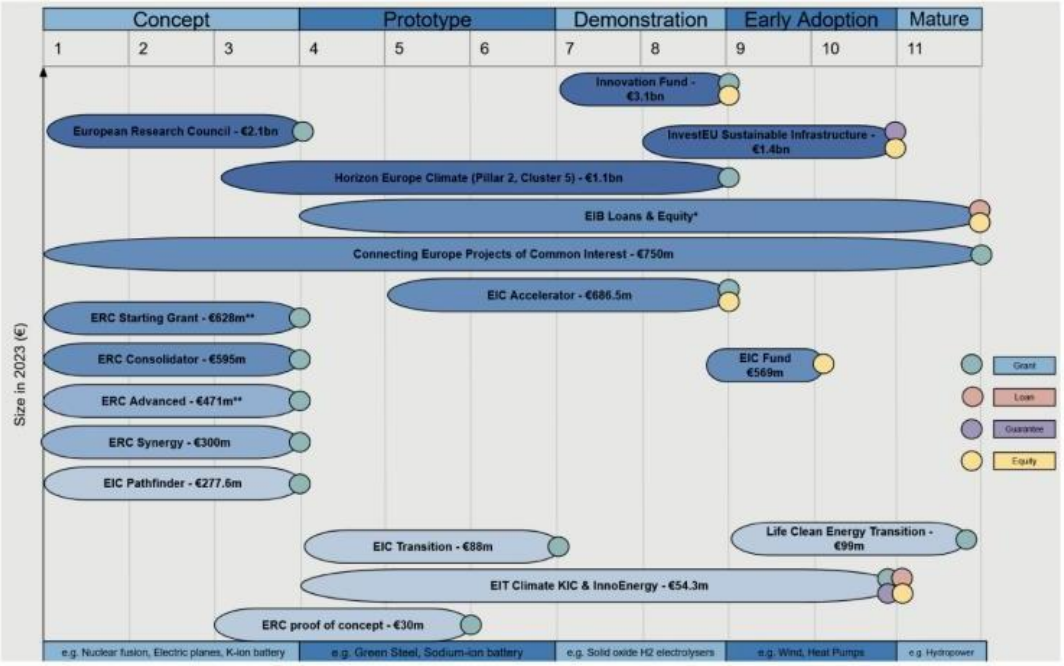

Figure 1. : EU public finance landscape for cleantech. (Source: Institute for Climate Economics)

The figure shows several EU funds and financial initiatives that support innovation and research in advanced and sustainable technology areas. Each of them has a specific focus:

1. Innovation Fund: focuses on demonstration projects that test new technologies before they are commercialized;
2. European Research Council (ERC): supports start-ups in innovative sectors such as cleantech, deeptech and biotech;
3. InvestEU: aggregates various financial instruments to support different categories of companies and projects;
4. Horizon: is a global research and innovation initiative addressing several thematic challenges;
5. STEP Platform: this is a recent initiative, presented by the European Commission in 2023, which aims to channel investments in strategic technologies by introducing a label to facilitate access to funds for significant projects through a “Sovereignty Seal”.

However, although the EU has a good availability of financial instruments to support research and innovation in the area of clean technologies, it lacks adequate financial resources to support their large-scale production. Innovative small and medium-sized

enterprises (SMEs) need long-term financing and high capital investment, but also face significant technological, market and regulatory risks. Therefore, facilitated access to finance is of paramount importance to enable them to invest in new technologies, improve their processes and develop innovative products, all of which enable them to be competitive both nationally and internationally.

Globally, bank financing continues to be the main mode of access to external funds for small and medium-sized enterprises (SMEs). However, it is important to note that the use of traditional debt is particularly inappropriate for innovative and high-growth start-ups, especially in their early stages. Indeed, these companies often lack a solid credit history and tangible collateral, and operate in contexts characterized by rapid change and uncertainty.

In contrast, venture capital emerges as the most suitable solution for financing companies in the Cleantech sector. Innovations in this field require significant investment from the early stages of research and development, which makes venture capital a crucial source of support. This is not just a purely financial aspect; venture capitalists not only provide the necessary funds, but also offer strategic advice that considers the triple bottom line: economic, social and environmental. This integrated approach is crucial for Cleantech companies, as it contributes not only to their economic growth, but also to their positive impact on society and the environment. Moreover, venture capitalists provide valuable support in terms of networking, helping companies to connect with other actors in the sector and build strategic relationships that can prove crucial for long-term success (Bocken, 2015).

3. **Enhancing skills**

The exponential expansion of new technologies, particularly in the context of the transition to a low-carbon economy, requires significant skills development and appropriate training for workers in the sector. According to the European Commission, in order to meet this challenge, it is crucial to implement strategies that foster the development of the skills needed for the green transition (European Commission, 2021). Firstly, the proposal to establish net-zero industry academies is a crucial step towards implementing programs aimed at retraining and improving skills in strategic industries.

These academies would be tasked with training professionals capable of addressing environmental challenges and innovating in a sustainable context (OECD, 2020).
Secondly, it is essential to combine an approach that emphasizes practical skills with existing qualification systems, in order to recognize the actual skills of workers and facilitate the integration into the labor market of individuals who possess skills that are not always formally certified, but highly valued in the work context (European Centre for the Development of Vocational Training, 2019).
Furthermore, the Commission intends to explore ways to facilitate the access of third-country nationals to EU labor markets, especially in sectors that require specific skills and are considered priorities for the green transition. Such a strategy would not only help fill gaps in the labor market, but also foster greater diversity and inclusion in the European labor context (Eurofound, 2021).
Finally, it is crucial to promote an alignment between public and private funding for skills development. Coordinated investments could ensure adequate resources for training and retraining, thus facilitating the creation of a labor ecosystem that can effectively respond to the challenges of the green transition (World Economic Forum, 2020).
In summary, ensuring an effective and sustainable green transition requires an integrated approach combining training, labor market access and strategic funding, supported by a shared vision between institutions, industry and civil society.
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4. **Promoting open and fair trade**

The fourth pillar of the European strategy focuses on promoting open and fair international trade, emphasizing the importance of global cooperation in fostering an ecological transition. This approach is based on the principles of fair competition and trade, in line with the EU's commitments and the activities of the World Trade Organization (WTO).
To ensure a transition towards a more sustainable economy, the European Commission intends to expand its network of free trade agreements and develop further forms of cooperation with international partners. Furthermore, it will be crucial to protect the EU

single market from unfair trade practices, which could undermine efforts towards sustainability and competitiveness.

Academic literature argues that fair and open trade not only facilitates access to foreign markets, but also helps to promote innovation and sustainable economic growth (Stiglitz, 2002; Rodrik, 2018). International cooperation, in this context, should not be limited to trade, but should also include a commitment to environmental and social standards to ensure that the benefits of trade are shared fairly (Piketty, 2014).

The European Commission conducted an in-depth analysis highlighting the EU's dependence on external suppliers for a total of 137 strategic products. Of these, about a quarter, corresponding to 34 products, show significant vulnerability, characterized by low diversification potential and limited possibilities of substitution by domestically produced alternatives. Interestingly, China is the main source of supply for almost half of these goods, at 52 %. Other significant suppliers include Vietnam, which contributes 11%, and Brazil, with a 5% share (European Commission, 2021).

A further remark by the Commission concerns the interdependent relationship between the EU and the US, emphasizing how both share important vulnerabilities to China. This is particularly relevant for critical raw materials, which play a key role in the transition processes towards more sustainable and digitized economies (Ibid.).

This highlights the need to develop more resilient and diversified supply strategies in order to mitigate the risks associated with such dependence and ensure a sustainable and independent economic future for the EU (European Commission, 2023; European Parliament, 2023).

The fragility of global supply chains, previously affected by events such as natural disasters and political instability, has been further highlighted in recent years by the COVID-19 pandemic, showing, however, remarkable resilience. This has led to a greater understanding of current and future strategic dependencies affecting the core interests of the EU (European Commission, 2021). Through effective strategies, the European Commission is committed to consolidating a resilient supply chain through the fourth pillar of the European Green Deal (EGD). which includes, in particular, the creation of the Critical Raw Materials Club, a platform dedicated to connecting raw material consumers with resource-rich countries. In addition, to stimulate economic growth and foster the adoption of elevated environmental standards, The EU aims to facilitate the diffusion of green technologies and sustainable practices through the

expansion of Free Trade Agreements and the creation of trade alliances (European Commission, 2020; European Commission, 2021).

1.3 The market for clean technologies in Europe

Based on an analysis by the International Energy Agency (LEA), a report titled Energy Technology Perspectives 2024 shows that the rapid expansion of sustainable energy technologies represents a major opportunity for nations to develop and commercialize them (ETP-2024). However, this phenomenon simultaneously places governments in the position of facing significant challenges due to the critical issues and complexities associated with the industrial and commercial policies they decide to adopt. Indeed, the need to promote innovation and the adoption of clean technologies clashes with the economic implications and resulting social impacts, including effects on the labor force, industrial competitiveness and international trade relations.

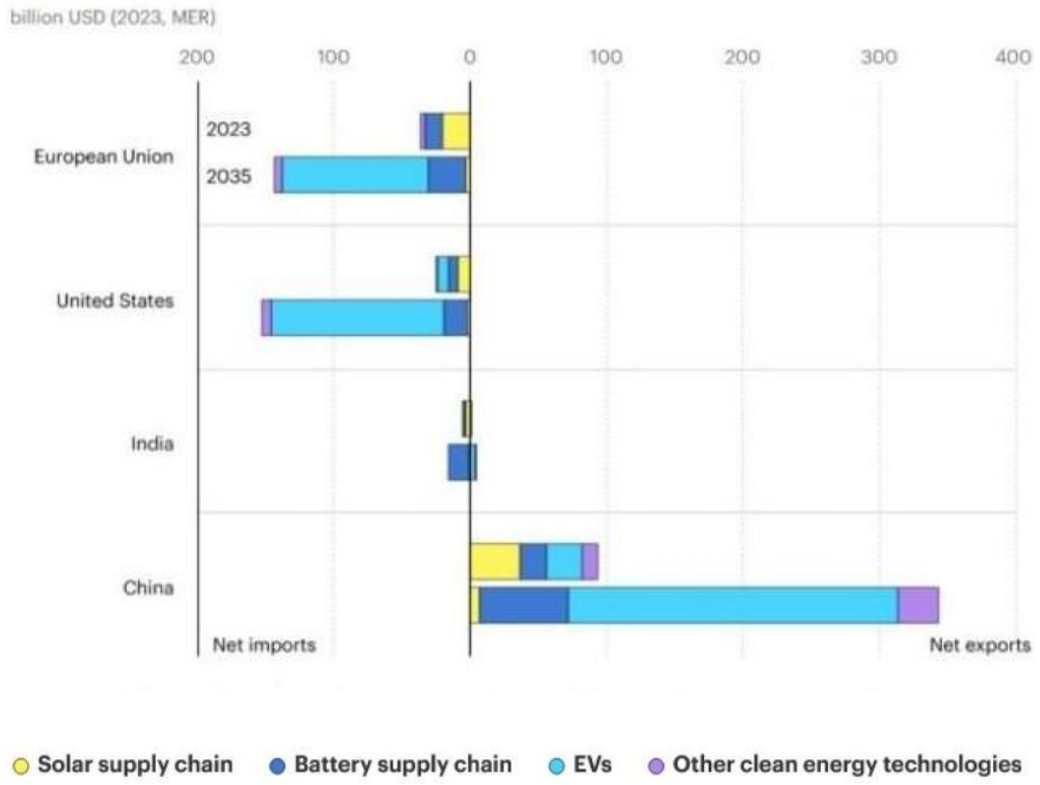
The data emerging from the report account for the current policy scenario that projects the global green technology market to grow from $700 billion in 2023 to more than $2 trillion by 2035. This projection rivals the value of the green technology market to that of oil, with a prediction of significant growth in the coming years, with estimates indicating a $575 billion increase within a decade.

This value would represent more than three times the current volume of global natural gas trade, setting in place a substantial shift in the global energy landscape.

Fatih Birol, executive director of the IEA, points out that as nations try to define their position in the context of the new energy economy, three key sectors--energy, industry and trade--are becoming increasingly interdependent. This interconnectedness means that policy decisions can no longer be considered in isolation, but must take into account the interactions between the different areas (ETP-2024).

The significant increase in the expansion of the global market for low-carbon technologies is the result of an unprecedented wave of investment that combines the need for nations to strengthen their energy security and maintain a high level of competitiveness by reducing greenhouse gas emissions. Much of this investment has

been directed to already advantaged regions, such as China, the European Union, the United States and India, as established players in the green sector. Among them, China is confirmed as a leader in the manufacturing sector worldwide (IEA, 2021; World Bank, 2020).

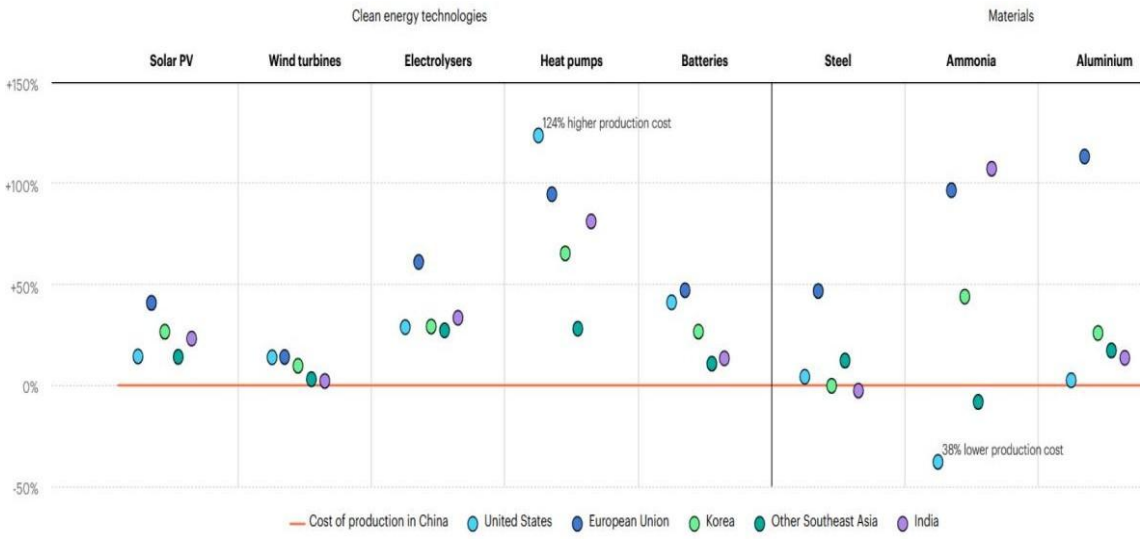


According to the graph from the report, under current economic and environmental policies, its exports of sustainable technologies are expected to reach a value of more than $340 billion by 2035. This is particularly significant when compared to the projected 2024 revenues from oil exports of countries such as Saudi Arabia and the United Arab Emirates, which are at similar figures.

China is currently positioned as the leading global hub for clean energy technology production, boasting significantly lower production costs than other regions of the world. These economic advantages emerge even in the absence of direct financial incentives from the government, suggesting the existence of intrinsic factors that make the country particularly competitive in this sector. Analyzing the economic data, it is observed that the production of photovoltaic modules, wind turbines and battery systems incurs higher expenses of up to 40 percent in the United States, 45 percent in the European Union and 25 percent in India. This cost disparity can be attributed to

several elements, including economy of scale, access to cheap raw materials, and an optimized supply chain, all of which characterize the Chinese industry.

The graph below shows the Levelized Cost of Energy (LCOE), which is the average cost of generating energy from a renewable source over its lifetime, taking into account not only initial investment costs, but also operating and maintenance costs. In a comparative analysis of LCOE for various clean energy technologies in 2023, China is confirmed as having the lowest costs, serving as a benchmark for other regions.



The future of clean energy technology production in the European Union is intrinsically linked to the ability to achieve the goals outlined in the Net Zero Industry Act (NZIA), as highlighted by the International Energy Agency (IEA). This piece of legislation is an important initiative to promote the transition to a low-carbon industry by aiming to stimulate the production of green technologies within European borders.

Chapter 2: Innovation & Sustainability

2.1 The role of start-ups in clean technologies

The introduction of technological and industrial innovations is frequently interpreted as one of the main determinants of overconsumption of natural resources. However, in recent economic history, there is a growing awareness that recognizes a fundamental and indissoluble interconnection between innovation and sustainable development within an integrated approach in which the social, environmental and economic dimensions are closely interdependent.

This outlines a fundamental strategic framework for the promotion of a sustainable future by referring to the 17 Sustainable Development Goals (SDGs) outlined by the United Nations as part of the 2030 Agenda, in particular:

The Goal 6, which aims to "Ensure the availability and sustainable management of water and sanitation for all", highlights the importance of implementing innovative technological solutions to address drinking water and sanitation challenges (such as filters, desalination technology, etc.).

The Goal 7, aims to ensure universal access to affordable, reliable, sustainable and modern forms of energy. There has been a significant decrease in energy intensity-measured as the ratio of energy consumed to gross domestic product (GDP)-in three-quarters of the top twenty energy-consuming countries globally. This reduction was mainly influenced by improvements in energy efficiency, particularly in the industrial and transport sectors. The urgency for stronger and more internationally coordinated strategies, as well as the implementation of innovative technologies that can support a transition to a more sustainable and inclusive energy model is supported by various studies, including the International Energy Agency (IEA) report and analyses provided by the United Nations Development Program (UNDP), which highlight the importance of energy policies that promote not only efficiency, but also equitable access to energy for all populations (IEA, 2018; UNDP, 2019).

The implementation of clean technologies influences various aspects of architecture, transport and the urban environment. This approach, in line with *Goal 11* of the 2030 Agenda, aims to make cities and human settlements inclusive, safe, resilient and sustainable, promotes a more efficient use of environmental resources and reduces the ecological impact of urban areas.

Furthermore, clean technologies play a crucial role in the pursuit of *Goal 13*, which focuses on taking urgent measures to counter climate change and its effects caused by human activities. The aim is to safeguard the stability of the planet and the survival of our species by reducing the concentrations of carbon dioxide (CO2) and other greenhouse gases in the atmosphere that are responsible for climate change that could prove irreversible.

In this context, start-ups are a crucial driver in the innovation process needed to address sustainability challenges, helping to develop innovative and adaptable solutions. In Europe, the start-up landscape is particularly vibrant, with an increasing number of initiatives focused on the clean technology (cleantech) sector. This sector, which includes solutions for energy efficiency, waste management, renewable energy and sustainable mobility, offers significant potential to transform the market and contribute to long-term sustainability goals.

2.2 Description of the existing database on cleantech companies in Europe

For the description of the existing database on European cleantech companies, reference will be made to Bureau van Dijk's Orbis company database, which provides detailed balance sheet information on millions of companies worldwide (Ambrois et al., FEI 2023/91).

The classification of cleantech companies is based on a supervised machine learning (ML) algorithm (Ivi) that consists of two main steps. First, a limited sample of companies is taken from an existing database to be manually identified and classified as Cleantech or non-Cleantech. This appropriately labelled data set serves as a training set for the machine learning models. It is through the analysis of this

data that the model is able to attribute a probability or confidence score to new company descriptions never previously encountered, attributing to them the probability of falling into the Cleantech category.

Based on these assumptions, the model practises generalizing information learnt from training data to apply this knowledge in classifying new descriptions. For example, it can recognize keywords such as “sustainable”, “renewable”, “energy efficiency”, “waste management”, ‘environmental conservation’ and ‘carbon footprint reduction’ that are frequently associated with cleantech companies. Once the training and validation process has been completed, the model is capable of independently classifying a large number of company descriptions, thus facilitating the work of researchers, investors and policy makers in identifying and analyzing Cleantech companies (Ibidem).

The advantage of using a large-scale general administrative balance sheet database allows for a broader scope of analysis in contrast to previous studies, which were based on investment databases that provided a limited perspective of the Cleantech phenomenon as they only considered those companies involved in an investment transaction. As a result, it is possible to make comparisons with respect to sectoral and geographical distribution, as well as innovative capacity, size, VC investment activity, etc.

The analysis conducted reveals that cleantech companies operate mainly in the manufacturing, wholesale and retail trade, water supply and waste management, and construction sectors.

Data on the geographical distribution of European cleantech companies identifies Germany, Italy and France as the countries with the highest density of such companies. Furthermore, it has emerged that the adoption of clean and sustainable technologies is not a recent trend, but is rooted in the European business landscape as an established phenomenon, with many companies established before the start of the new millennium, thus anticipating the two main investment cycles in the sector.

With regard to the patenting activities of cleantech companies, the data from the analysis show the Austrian cleantech ecosystem as an emerging one in terms of innovation, followed by Switzerland and Germany. Specifically, in these regions, the recorded data suggest a considerable commitment to research and development of sustainable technologies related to patents including sustainable energy

production, energy-efficient industrial technologies as well as solutions to reduce water, air and soil pollution. At the same time, the analysis of several key financial performance indicators (KPIs) shows that innovative companies in the Cleantech sector are more able to grow and have greater economic resilience than their competitors.

In the context of venture capital funding, Finland, Sweden, France and Spain appear to be the regions with a significant presence of venture-backed companies.

The difficulty in indentifying Cleantech companies stems from the lack of a clear definition of what universally constitutes Cleantech and which clearly delineates its boundaries. This scenario is exacerbated by the inefficiency of existing classification methods, based on sectoral labels such as NACE codes, which fail to adequately reflect the cross-sectoral and cross-cutting nature of Cleantech firms (Christensen & Hain, 2017; Criscuolo & Menon, 2015). Some attempts at classification, such as the EU Taxonomy, aim to translate EU climate and environmental objectives into specific criteria for economic activities for investment. However, such approaches, due to their inherent rigidity, run the risk of not adequately considering the dynamic and rapidly evolving nature of the Cleantech sector, which is characterized by technological innovations and changes in market practices (European Commission, 2020). The need for a more flexible classification is therefore evident, so as to capture the complexity and interrelationships that characterize this field, fostering a deeper understanding of the dynamics at play.

Based on the sample of companies available in Orbis, the mapping of Cleantech companies takes the following criteria into account:

1. Companies located in Europe;
2. Companies that had recorded accounting data for at least one company year;
3. Companies with an extensive company description available.

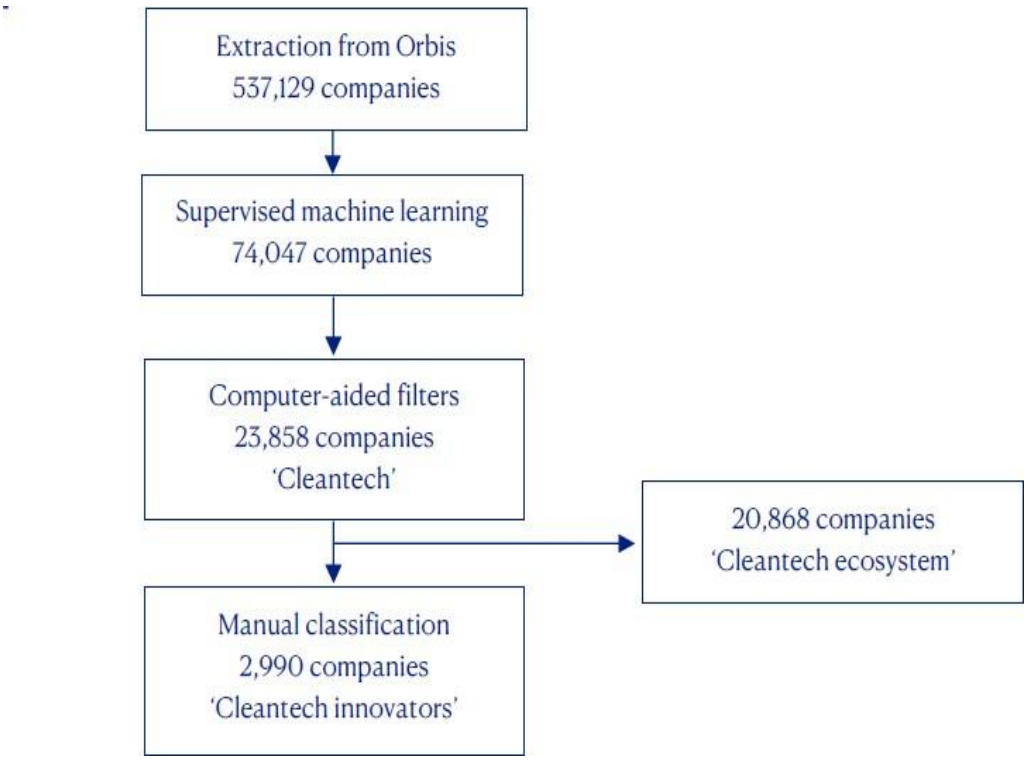


Figure 4: Graphical representation of the methodology used to screen Cleantech companies

The figure graphically illustrates the Cleantech company selection methodology. Considering the initial application criteria of 537,129 companies, through the ML algorithm, the sample was reduced to 74,047 companies, and further computer-assisted filtering brought the number down to 23,858. Of these, 2,990 were manually classified as Cleantech innovators, and 20,868 were labelled as Cleantech ecosystem, comprising companies that use, sell or supply Cleantech technologies.

Text mining from the cross-validated data and predictive performance analyzed in an out-of-sample context revealed that the Gradient Boosting Machine (GBM), a machine learning approach combining several classification trees, proved to be the most effective, achieving a predictive accuracy of over 90%. Based on the optimized GBM model, predictions on the Cleantech state were made in a completely out-of-sample manner, applying it to a larger dataset comprising 537,129 companies.

For the classification of Cleantech companies, seven technology categories (some of which have subcategories) were identified in line with the principles of the European Green Deal and the EU taxonomy:

- Environmental management
    - *Air/water/soil pollution abatement/remediation*
    - *Waste management*
- Resources preservation
    - *Water conservation/availability*
    - *Sustainable agri-food technologies*
    - *Sustainable raw materials*
- Industrial energy management
    - *Sustainable energy production*
    - *Sustainable fuels*
    - *Energy-efficient industrial technologies*
- Capture, storage, sequestration or disposal of GHG
- Sustainable modes of transport
- Sustainable buildings
- Other categories

The spatial distribution of Cleantech companies is shown in the following table:

	Cleantech companies		Cleantech innovators		Cleantech ecosystem	
	# companies	%	# companies	%	# companies	%
Germany	4,444	18.7%	515	17.3%	3,929	18.9%
Italy	4,254	17.9%	559	18.7%	3,695	17.7%
France	3,414	14.3%	371	12.4%	3,043	14.6%
Spain	2,072	8.7%	329	11%	1,743	8.4%
Poland	1,443	6.1%	152	5.1%	1,291	6.2%
Sweden	845	3.6%	141	4.7%	704	3.4%
Czech Republic	743	3.1%	99	3.3%	644	3.1%
Belgium	706	2.9%	101	3.4%	605	2.9%
Norway	677	2.8%	79	2.7%	598	2.9%
Austria	598	2.5%	85	2.9%	513	2.5%
Romania	550	2.3%	47	1.6%	503	2.4%
Finland	500	2.1%	71	2.4%	429	2.1%
Portugal	456	1.9%	47	1.6%	409	2%
Hungary	413	1.7%	30	1%	383	1.8%
Netherlands	387	1.6%	66	2.2%	321	1.5%
Denmark	334	1.4%	51	1.7%	283	1.4%
Bulgaria	312	1.3%	27	0.9%	285	1.4%
Slovakia	267	1.1%	29	1%	238	1.1%
Serbia	239	1%	18	0.6%	221	1.1%
Greece	226	0.9%	41	1.4%	185	0.9%
Croatia	192	0.8%	24	0.8%	168	0.8%
Lithuania	153	0.6%	18	0.6%	135	0.7%
Slovenia	151	0.6%	24	0.8%	127	0.6%
Latvia	112	0.5%	5	0.2%	107	0.5%
Estonia	83	0.4%	13	0.4%	70	0.3%
United Kingdom	70	0.3%	22	0.7%	48	0.2%
Luxembourg	45	0.2%	7	0.2%	38	0.2%
North Macedonia	43	0.2%	2	0.1%	41	0.2%
Switzerland	41	0.2%	3	0.1%	38	0.18%
Iceland	15	0.06%	1	0.03%	14	0.07%
Malta	13	0.05%	3	0.1%	10	0.05%
Turkey	13	0.05%	3	0.1%	10	0.05%
Montenegro	11	0.05%	0	0%	11	0.05%
Ireland	5	0.02%	1	0.03%	4	0.02%
Cyprus	1	0.00%	1	0.03%	0	0%
Total	23,828	100%	2,985	100%	20,843	100%

Source: Orbis, authors' calculations

Over 51% of Cleantech companies are concentrated in three countries: Germany with 18.65%, Italy with 17.85% and France with 14.33%. The remaining companies are scattered in the other European countries.

2.3 Sustainability indicators: a general overview

Environmental indicators play a fundamental role in assessing the ecological impact of companies operating in a given territorial context, as they not only facilitate the measurement of the effect of company activities on the environment, but also allow for the planning and implementation of targeted strategies to mitigate their impact.
In the context of corporate sustainability, they make it possible to measure a company's commitment to adopting environmentally, socially and governance (ESG) responsible practices, while also serving as a vehicle for transparency and accountability, which are increasingly demanded by stakeholders.
Understanding ESG implies a holistic approach that integrates awareness of environmental limits, responsible resource management and a commitment to sustainability.
Specifically:

- Environmental (E): includes management of natural resources, reduction of carbon emissions, waste management and sustainable use of resources.
- Social (S): this dimension concerns the company's relationships with its employees, suppliers, customers and the communities in which it operates.
- Governance (G): this criterion relates to a company's management practices and control structures, including transparency, business ethics, and risk management (OECD, 2015).

Below are the main categories into which environmental sustainability indicators can be classified:

- *Emission indicators*: this category includes measurements of pollutants released into the atmosphere, such as greenhouse gases and other toxic substances. According to the Intergovernmental Panel on Climate Change (IPCC) report, monitoring emissions is essential for developing effective mitigation strategies (IPCC, 2021).
- *Resource consumption indicators*: these indicators assess the use of natural resources, including water, energy and raw materials. The analysis of resource consumption is crucial for understanding the impact of human activities on natural systems and for promoting circular economy practices. According to the World Resources Institute, sustainable resource use is essential to ensure food security and long-term sustainability (World Resources Institute, 2020).
- *Waste management indicators*: this category focuses on the quantity and type of waste generated, as well as disposal and recycling practices.
- *Biodiversity indicators*: these indicators represent the variety of species and habitats present in a given ecosystem. Biodiversity is a key indicator of the health of ecosystems and their resilience to environmental change. According to the United Nations Environment Program (UNEP), biodiversity loss is one of the most serious challenges facing the planet, directly affecting the resilience of ecosystems (UNEP, 2021)
- *Air and water quality indicators*: these indicators assess the healthiness of air and water by analyzing the presence of pollutants and compliance with quality standards. The European Environment Agency (EEA) points out that monitoring these indicators is essential to prevent diseases and promote sustainable development (EEA, 2020).

The implementation of environmental sustainability indicators offers a number of significant benefits that can positively influence organizations and communities. The main benefits include the following:

- *Cost reduction*: through sustainable practices, companies can optimize the use of resources while reducing operating costs. For example, energy efficiency can lead to lower energy expenses, while sustainable waste management can minimize the costs

associated with waste disposal. According to a report by McKinsey & Company (2020), companies that invest in sustainability can reduce operating costs by up to 20 per cent through resource optimization and technological innovation;

- *Improved image and reputation*: consumers and stakeholders are increasingly attentive to sustainable business practices and show a tendency to reward companies that demonstrate a commitment to responsible management. A survey conducted by Nielsen (2015), shows that 66% of consumers are willing to pay more for products and services from sustainable companies;
- *Regulatory compliance*: companies that comply with regulations obtain tax breaks and government incentives. A report by the International Institute for Environment and Development (IIED, 2019) highlights its importance as a key aspect of strategic business planning;
- *Contribution to sustainable development*: in line with the goals of the 2030 Agenda, the importance of sustainability in achieving global goals against climate change and the preservation of ecosystems is emphasized.

One of the key tools for measuring and communicating an organization's environmental performance are the environmental indicators of the Global Reporing Initiative (GRI, 2023). These indicators are included in the sustainability report, a key document that allows companies to account for their environmental, social and economic impact. The official GRI website offers comprehensive and up-to-date resources:

GRI 301 - Materials	301-1: Materials used by weight or volume 301-2: Percentage of materials used that come from recycled material 301-3: Percentage of products sold and their packaging materials that are recycled or
GRI 302 - Energy	302-1: Energy consumption within the organisation 302-2: Energy consumption outside the organisation 302-3: Energy intensity 302-4: Reduction of energy consumption 302-5: Reduction of energy requirements of products and services
GRI 303 - Water and wastewater (2018)	303-1: Interaction with water as a shared resource 303-2: Management of impacts related to water discharge 303-3: Water abstraction 303-4: Water discharge 303-5: Water consumption
GRI 304 - Biodiversity	304-1: Operational sites owned, leased or managed in or near protected areas and areas of high biodiversity value outside protected areas 304-2: Significant impacts of activities, products and services on biodiversity 304-3: Protected or restored habitats 304-4: Protected species found in areas where the organisation operates
GRI 305 - Emissions	305-1: Direct GHG emissions (Scope 1) 305-2: Indirect GHG emissions from energy consumption (Scope 2) 305-3: Other indirect GHG emissions (Scope 3) 305-4: Intensity of GHG emissions 305-5: Reduction of GHG emissions 305-6: Emissions of ozone-depleting substances 305-7: Nitrogen oxides, sulphur oxides and other significant emissions
GRI 306 - Waste (2020)	306-1: Waste generation and significant waste-related impacts 306-2: Management of significant waste-related impacts 306-3: Waste generated 306-4: Waste Not Destined for Disposal 306-5: Waste for Disposal
GRI 308 - Supplier Environmental assessment	308-1: New Suppliers assessed according to environmental criteria 308-2: Negative environmental impacts in the supply chain and actions taken

Environmental sustainability indicators make it possible to:

- Formulate specific and realistic targets: by analyzing certain parameters, companies orient their environmental policies to improve ecological performance in the long term. For example, companies can set a target to reduce CO2 emissions within a certain period of time;
- Identifying areas for action: based on the data provided by the indicators, companies apply improvement measures. For example, high energy consumption becomes an indicator to invest in more efficient technologies, or to review production processes to optimize the use of resources (Hahn et al., 2015);
- Development of targeted strategies: in order to achieve certain sustainability goals, companies can formulate action plans that include the adoption of renewable energy sources, waste minimization and the development of sustainable natural resource management practices;
- Monitoring and evaluation: The achievement of sustainability goals is provided by the cycle of monitoring and reviewing progress through which companies can implement timely adjustments and verify the effectiveness of the actions taken.

Currently, there is no standard set of sustainability indicators that is universally mandatory. However, several states are implementing specific regulations requiring the disclosure of environmental impact information. In Europe, a significant step in this direction is the EU Directive 2014/95, which focuses on non-financial reporting and requires large companies to provide details of their environmental performance (European Commission, 2014). Italy adopted this directive through Legislative Decree No. 254 of 30 December 2016, which gave birth to the so-called non-financial declaration, a measure that marked an important progress in corporate transparency regarding environmental impacts, promoting greater corporate responsibility (Ministero dell'Ambiente e della Tutela del Territorio e del Mare, 2017). Subsequently, the CSRD (Corporate Sustainability Reporting Directive) was introduced, expanding the number of companies subject to reporting obligations regarding the environmental effects of their activities.

This new regulatory framework envisages that, between 2025 and 2029, an increasing number of small and medium-sized companies will be integrated into the reporting process, with the aim of supporting a transition towards a more sustainable and responsible economic model (European Commission, 2021).

Among the international standards that provide guidelines and principles for sustainability reporting and management, in addition to the GRI we refer to:

- Sustainability Accounting Standards Board (SASB), which focuses specifically on sustainability in relation to investments, providing industry standards that help companies develop relevant information for investors (SASB, 2021);
- Greenhouse Gas Protocol, a standardized approach for measuring and managing greenhouse gas emissions. This protocol is used by companies, governments and non-governmental organizations to reduce the environmental impact of their activities (WRI & WBCSD, 2004).

Chapter 3: Venture Capital

3.1 Venture Capital

Venture capital is a crucial type of financing for start-ups and growth companies, characterized by the provision of capital by outside investors, identifiable as venture capitalists (VCs). These investors are constantly on the lookout for promising opportunities, offering financial resources in exchange for an equity stake in the company. This investment model mainly targets innovative entrepreneurial ventures with significant growth potential.

Start-ups that access venture capital funding are generally in the early stages of their business life cycle and therefore need capital for various purposes, including expanding operations, developing new products and implementing effective marketing strategies. Unlike traditional financial institutions, venture capitalists are inclined to take higher risks, motivated by the possibility of substantial returns in the long run. This attitude to risk is often justified by the inherently volatile nature of the start-up ecosystem, where the potential for success can translate into significant profits.

In addition to funding, venture capitalists offer added value to start-ups through strategic support that may manifest itself in various forms, such as advice on operational management, assistance in financial planning and access to a network of contacts that includes potential business partners and investors. Such interactions can be crucial for the sustainable growth of the company and its ability to navigate market challenges (Gompers & Lerner, 2001).

The combination of data on clean-technology (Cleantech) companies from the Orbis database with information on venture capital (VC) investments collected by VICO 4.0-a comprehensive pan-European dataset of VC investment activity developed within the EU Horizon 2020 RISIS2 project-offers a unique opportunity to deepen our understanding of the crucial role of venture capital in the context of Cleantech development in Europe. This project, with over 54,910 VC investment agreements,

is a valuable resource for analysing the financing dynamics of this growing sector (Ambrosis et al, 2023).

Analysing the synergies between the Orbis and VICO 4.0 data not only provides a detailed picture of the investment ecosystem in the sustainable technology sector, but also highlights emerging trends and areas of greatest interest to investors. The table below, in particular, provides an overview of venture capital investors' involvement in Cleantech companies registered in Orbis, highlighting the opportunities and challenges that characterise this innovative sector.

Table 13: Distribution of VC-backed Cleantech innovator companies by technological category

Technological category	VC-backed companies	
	# companies	%
Air/water/soil pollution abatement/remediation (1.1)	5	7.6%
Waste management (1.2)	4	6.1%
Water conservation/availability (2.1)	0	0%
Sustainable agri-food technologies (2.2)	1	1.5%
Sustainable raw materials (2.3)	4	6.1%
Sustainable energy production (3.1)	36	54.6%
Sustainable fuels (3.2)	4	6.1%
Energy-efficient industrial technologies (3.3)	17	25.8%
Capture, storage, sequestration or disposal of GHG (4)	0	0%
Sustainable modes of transport (5)	0	0%
Sustainable buildings (6)	6	9.1%
Others	0	0%
Total	66	2.2%

*Each company can be associated to multiple technological categories; hence, the totals are not the sum of the row values.

Source: Orbis, VICO 4.0, authors' calculations

Below is an analysis of the distribution of venture capital (VC)-supported companies by technology category, looking at two distinct sub-samples: one consisting of Cleantech innovators and the other of the Cleantech ecosystem as a whole. In both categories analysed, it is evident that the class with the highest

percentage of companies supported by VC investments is 'Sustainable Energy Production', with an incidence of 3.1%. This figure highlights the growing importance of sustainable energy technologies in the investment landscape, reflecting a trend that is consolidating globally. In addition, the involvement of venture capital appears particularly significant for Cleantech innovators active in the 'Energy-efficient industrial technologies' sector, which shows a funding rate of 3.3%.

These findings are consistent with the conclusions of a recent European Investment Fund (EIF) study by de Haan Montes et al. (2023), which examined venture capital deals in the Cleantech sector using the Pitchbook database. This report found that energy-focused Cleantech companies constitute a significant portion of investment activity, contributing substantially to the growth of venture capital and private equity across the European Union.

Table 14: Distribution of VC-backed Cleantech ecosystem companies by technological category

Technological category	VC-backed companies	
	# companies	%
Air/water/soil pollution abatement/remediation (1.1)	24	18.3%
Waste management (1.2)	24	19.2%
Water conservation/availability (2.1)	4	3.9%
Sustainable agri-food technologies (2.2)	2	1%
Sustainable raw materials (2.3)	11	6.7%
Sustainable energy production (3.1)	85	47.1%
Sustainable fuels (3.2)	14	9.6%
Energy-efficient industrial technologies (3.3)	36	18.3%
Capture, storage, sequestration or disposal of GHG (4)	0	0%
Sustainable modes of transport (5)	3	2.9%
Sustainable buildings (6)	13	6.7%
Others	4	0.6%
Total	104	0.5%

*Each company can be associated to multiple technological categories; hence, the totals are not the sum of the row values.

Source: Orbis, VICO 4.0, authors' calculations

Reading the reported data, it emerges that, in addition to investing in technologies mainly related to sustainable energy production, venture capitalists are also recognising the importance of innovative solutions to pollution and waste management issues. It can be observed, in fact, that two additional technology categories - 'Air, water and soil pollution mitigation and remediation (1.1)' and 'Waste management (1.2)' - have a level of venture capital (VC) financing that is comparable to that of the subcategory 'Energy-efficient industrial technologies (3.3)'. In particular, it is estimated that around 18-19% of VC-funded companies in the Cleantech context are active in these areas.

In this context, a key role is played by patents, which also increase the attractiveness of companies for potential investors by signalling the innovative potential of the patenting company. This also applies to green technologies (Belucci et al., 2021).

Table 15: Distribution of EPO patenting Cleantech companies by VC-backed status

	At least one EPO patent in any field		At least one EPO patent in a CCMT field	
	# companies	*%*	*# companies*	*%*
VC-backed firms	88	5.8%	56	63.6%
Non-VC-backed firms	2,610	11%	1,107	42.4%
Total	*2,698*	*11.3%*	*1,163*	*43.1%*

*Each company can be associated to multiple technological categories; hence, the totals are not the sum of the row values.

Source: Orbis, VICO 4.0, authors' calculations

The data shown in the Table illustrate the distribution of companies operating in the Cleantech sector that have made patent applications to the European Patent Office (EPO), classifying them according to their VC status. Interestingly, among the companies supported by VC investments, the 51.8% had filed at least one EPO patent in any sector and this percentage highlights an interesting correlation between financial support and patent innovation, suggesting that not all companies receive the necessary impetus to develop new patentable technologies.

More specifically, among the companies that have received VC investment and are engaged in the patenting process, a significant percentage, 63.7 per cent, have obtained at least one EPO patent in the Clean and Sustainable Mobile Technology (CCMT) sector. This figure underlines the importance of venture capital not only as a source of financing, but also as a catalyst for innovation in the field of environmentally friendly technologies.

Below is the distribution of cleantech companies supported by venture capital investments broken down by sample:

Country	Cleantech companies			Cleantech innovators		Cleantech ecosystem	
	# companies	% of total VC-backed	% of national Cleantechs*	# companies	%	# companies	%
France	40	23.5%	1.2%	13	19.7%	27	26%
Finland	32	18.8%	6.4%	21	31.8%	11	10.6%
Germany	20	11.8%	0.45%	1	1.5%	19	18.3%
Sweden	15	8.8%	1.8%	6	9.1%	9	8.7%
Estonia	11	6.5%	13.3%	10	15.6%	1	0.96%
Austria	9	5.3%	1.5%	7	10.6%	2	1.9%
Spain	9	5.3%	0.43%	1	1.5%	8	7.7%
Italy	5	2.9%		1	1.5%	4	3.9%
Netherlands	5	2.9%		1	1.5%	4	3.9%
United Kingdom	5	2.9%		1	1.5%	4	3.9%
Belgium	4	2.4%		1	1.5%	3	2.9%
Denmark	4	2.4%		0	0%	4	3.9%
Lithuania	2	1.2%		2	3%	0	0%
Czech Republic	1	0.6%		1	1.5%	0	0%
Others**	8	4.7%		0	0%	8	7.7%
Total	170	100%		66	100%	104	100%

*The share of VC-backed companies in the number of national Cleantech companies is only reported for those countries with more than 5 VC-backed companies.
**The residual category includes Greece, Hungary, Poland, Portugal, Slovakia and Slovenia.

Source: Orbis, VICO 4.0, authors' calculations

The data show that France hosts the largest number of Cleantech companies, with a share of 23.5%. This is followed, in descending order, by Finland with 18.8%, Germany with 11.8% and Sweden with 8.8%. Focusing exclusively on innovators in the Cleantech sector, it is interesting to note that Finland has the highest share of start-ups backed by venture capital, reaching 31.8%. This figure is relevant as it indicates a significant propensity for innovation in the cleantech sector in this country. Next comes France in second place with 19.7 per cent and Estonia in third place with 15.6 per cent.

The intensity of venture capital investment, expressed as the percentage of cleantech companies that received such funding, shows considerable variation between countries. In particular, there is a disparity ranging from less than 1% in countries such as Spain (0.43%) and Germany (0.45%) to more than 10% in Estonia, which records a rate of 13.3%. These differences can be attributed to various factors, including the local business environment, innovation support policies and the entrepreneurial ecosystem, all of which can influence the ability of start-ups to attract investment.

3.2 Europe and Venture Capital

Analyzing the relationship between environmental indicators and the emergence of start-ups in the cleantech sector is a highly relevant topic, particularly in relation to the presence of venture capital (VC). Several dimensions deserve careful consideration:

- 1. *Environmental indicators*: environmental aspects such as air quality, accessibility of natural resources, effective waste management and the existence of favorable environmental policies are of paramount importance in determining the creation of cleantech businesses. Areas characterized by good environmental practices tend to attract entrepreneurs motivated to develop innovative and sustainable solutions. This phenomenon is supported by the literature, which shows that a healthy, well-managed environment can act as a catalyst for entrepreneurial innovation (Porter & van der Linde, 1995).

- 2. *Concentration of Venture Capital*: regions with a high concentration of venture capital, such as Silicon Valley, show a higher propensity to innovate and support start-ups in the cleantech sector. The availability of funding allows for a significant acceleration in research and development processes, enabling start-ups to grow and scale faster. The correlation between capital availability and innovation is well documented, suggesting that financial support is crucial to the success of cleantech entrepreneurial ventures (Gompers & Lerner, 2001).
- 3. *Synergy between Indicators and Venture Capital*: in contexts where positive environmental indicators are observed together with a robust venture capital presence, a more dynamic and responsive entrepreneurial ecosystem is formed. Cleantech companies in such environments can access resources, expertise and networks that facilitate and accelerate their development. This synergy is crucial, as the combination of favorable environmental resources and financial support creates fertile ground for innovation (Acs & Audretsch, 2010).
- 4. *Government policies*: policies implemented at local and national level play a crucial role in fostering innovation in the cleantech sector. Tax incentives, subsidies and regulations favorable to green innovation can stimulate the creation of new businesses, especially in contexts with a high concentration of venture capital. Government policies, therefore, not only support entrepreneurial initiatives, but can also direct investments towards strategic areas, contributing to the transition to a more sustainable economy (OECD, 2011).

These considerations account for how environmental indicators play a key role in the assessment of the ecological impact of companies operating in a given territorial context, as they not only facilitate the measurement of the effect of business activities on the environment, but also allow for the planning and implementation of targeted strategies to mitigate their impact.

The Startup Heatmap Europe (2023) report analyses the European startup ecosystem, highlighting cities and countries that are emerging as important hubs for innovation and entrepreneurship, and provides an interesting overview of the trends, opportunities and challenges that startups face in different European regions. Generally, the report

includes several variables, such as the number of start-ups, capital raised, attractiveness to investors and other metrics that can influence the success of start-ups.

Most popular startup hubs 2023 (www.StartupHeatmap.eu)

Research conducted by DEEP in 2023, entitled 'Startup Heatmap Europe', analyses European destination preferences among startup founders. The results highlight a significant shift in the startup landscape, with London overtaking Berlin as the top choice for tech entrepreneurs. This trend suggests a renewed appeal of London, which continues to represent a hub of innovation and opportunity, supported by a robust entrepreneurial ecosystem and a network of active investors.

Over the past five years, London, Berlin and Barcelona have consistently occupied the top three positions in the preferences of entrepreneurs. The stability of these cities in attracting start-up founders can be attributed to various factors, including access to qualified talent, modern infrastructure, and a favorable regulatory environment. In addition, the cultural diversity and economic vibrancy of these metropolises contribute to a stimulating environment for innovation and business growth.

DEEP's analysis not only highlights the competitiveness of European cities in the start-up sector, but also offers insights into the dynamics of attracting these destinations. London, in particular, has been able to capitalize on a support network for start-ups, including accelerators, incubators and networking opportunities, making it a favored choice for founders seeking to launch and grow their technology businesses (European Commission, 2022).

In 2023, London regained its leading position in the landscape of entrepreneurial destinations, after Berlin had occupied the top spot in the previous year. Currently, London and Berlin vie for the top spot, with both cities attracting 34% of startup founders, a figure that highlights the importance of these metropolises in the context of European innovation and entrepreneurship. This result represents a significant gap compared to cities such as Barcelona and Amsterdam, each at 17%.

In addition, Paris and Lisbon follow with 12%, while Munich comes in at 10%, ahead of Tallinn, which comes in at 9.4%. This ranking of Europe's ten most influential cities in the start-up sector continues with Stockholm and Zurich, which complete a list of highly relevant entrepreneurial hubs.

These data not only reflect current trends in the start-up world, but also offer insights into the economic and social dynamics that influence entrepreneurs' choice of cities. Cities that emerge as innovation hubs tend to have a favorable ecosystem, characterized by support networks, access to finance and a vibrant entrepreneurial community (European Startup Monitor, 2023; Startup Genome, 2023).

The research conducted involved a large number of innovative entrepreneurs from different European countries, with the aim of drawing up a comprehensive ranking of the most promising cities for entrepreneurship. In the second ten of this ranking are, in order, Madrid, Dublin, Copenhagen, Warsaw, Milan, Helsinki, Brussels, Sofia, Malaga and Vienna, the latter in 20th position. These results offer a significant insight into the preferences of entrepreneurs, who are generally optimistic about the development of entrepreneurial ecosystems in the listed cities. In particular, a high percentage, 66%, of respondents indicated their intention to confirm their choice to set up their business in Europe rather than in other regions of the world

This optimistic trend can be interpreted as a reflection of the vibrancy and resilience of European business ecosystems, which continue to attract talent and innovation despite global economic challenges. The variety of cities in the ranking also suggests a

diversification in the opportunities offered, highlighting how different urban contexts can provide resources, networks and infrastructure favourable to the growth of start-ups. In this scenario, it is crucial to consider the role of public policies and investments in fostering a healthy and competitive entrepreneurial environment in Europe (European Commission, 2021; OECD, 2022).

In conclusion, the data collected not only highlight the optimism of European entrepreneurs, but also their preference for the continent as a privileged location for innovation and business development, an aspect that deserves further investigation and analysis in the context of global economic dynamics.

3.3 Cleantech in Italy

During 2023, funding for sustainable technologies in Italy showed a significant increase, reaching a total of EUR 322.3 million (Cleantech for Italy, 2023). This represents a considerable increase over the previous year, with a growth of 68.6% (Ministry of Ecological Transition, 2023). However, despite this progress, venture capital (VC) investment in the cleantech sector is still lower than in the main European countries. In fact, Italy has a per capita investment of only EUR 3.8 million, a figure that differs substantially from France's EUR 43.2 million and Germany's EUR 38.8 million (European Commission, 2023).

This investment gap highlights a significant challenge for Italy, which could benefit from stronger policies and a more robust innovation ecosystem to attract capital to the green technology sector. The need to increase the allocation of resources towards clean technologies is crucial not only to stimulate economic growth, but also to address global challenges related to climate change and environmental sustainability (OECD, 2023). Therefore, it is crucial that the country implements targeted strategies to enhance the attractiveness of cleantech investments, thereby fostering a favorable environment for start-ups and innovative companies.

However, there is a shortage of funding for advanced stages of business development, which is still insufficient when compared to investment levels in other European

countries. This situation was highlighted in the first ‘Cleantech for Italy’ report, produced in collaboration with MITO Technology, which provides a detailed analysis of the state of the venture capital ecosystem in the Italian cleantech sector. The report emphasizes the importance of strengthening financial support for late-stage start-ups in order to ensure sustainable and competitive growth in the European landscape (MITO Technology, 2023).

In conclusion, the cleantech sector in Italy shows promising signs of development, but it is crucial to address the challenges related to access to finance for the more mature stages of the companies, so that the country can align with other European nations and contribute significantly to the transition to a low-carbon economy.

The report prepared by Leonardo Massa, Investment Director of MITO Technology, and Federico Cuppoloni, director of Cleantech for Italy, presents relevant data regarding funding trends in the cleantech sector in Italy. In 2023, the total amount of funding for cleantech, including venture capital, debt and grants, reached a record high of 322.3 million euros. This result represents a significant increase over the previous year, with growth of 68.6 percent (Massa & Cuppoloni, 2023).

This increase is indicative of a growing interest in and commitment to sustainable technologies, reflecting a collective awareness of environmental challenges and the need for innovative solutions for decarbonization and sustainability. The funding in question not only testifies to the vitality of Italy's cleantech ecosystem, but also suggests a readiness on the part of investors to support initiatives that can contribute to the achievement of nationally and internationally established climate goals.

In addition, the report points out that such investments are key to stimulating the growth of startups operating in the sector, which are faced with the need for adequate financial resources to develop and commercialize their innovations. Clearly, to sustain this positive momentum, it will be crucial to continue investing in policies that foster access to capital and innovation in green technologies (Cuppoloni, 2023).

Another significant aspect that emerged from the report is the substantial increase in post-seed funding rounds, specifically in the €5 million to €20 million range. This dynamic has led to an increase in both the median deal size, which stands at €2.7 million in 2023, compared to the €1.9 million recorded in 2022, and the median deal size, which has increased from €0.4 million in 2022 to €0.8 million in 2023 (Massa & Cuppoloni, 2023).

Such growth in post-seed funding rounds is indicative of increased investor confidence in the development potential of cleantech startups. Increasing the availability of capital for larger deals gives these companies the opportunity to expand their operations, invest in research and development, and improve their competitiveness in the marketplace. This scenario is particularly relevant in the current context, where the transition to a sustainable economy requires large investments in technological innovation and green infrastructure (European Investment Bank, 2023).

Moreover, the increase in average and median deal size suggests an evolution of the venture capital ecosystem in Italy, which is gradually maturing and refining its ability to attract significant investment. Investors, recognizing the growth potential of these startups, are increasingly willing to engage in more substantial funding rounds, thus contributing to a favorable environment for clean technology development (Cuppoloni, 2023).

In 2023, the energy sector emerged as the largest recipient of financing within the cleantech landscape, absorbing 37.9 percent of total deal value. This figure highlights the growing importance of sustainable energy solutions, in a global context increasingly focused on the transition to renewable sources. Next in terms of investment is the agrifood sector, which accounted for 20 percent of the total, reflecting a growing interest in sustainable and innovative agricultural practices (Massa & Cuppoloni, 2023).

However, despite these positive signs, Italy faces a significant gap with other European countries in terms of venture capital investment dedicated to cleantech. In fact, our country recorded a per capita investment of only €3.8 million, which is significantly lower than France's €43.2 million and Germany's €38.8 million (European Investment Bank, 2023). This disparity highlights the need for targeted strategies to boost venture capital in the clean technology sector in Italy.

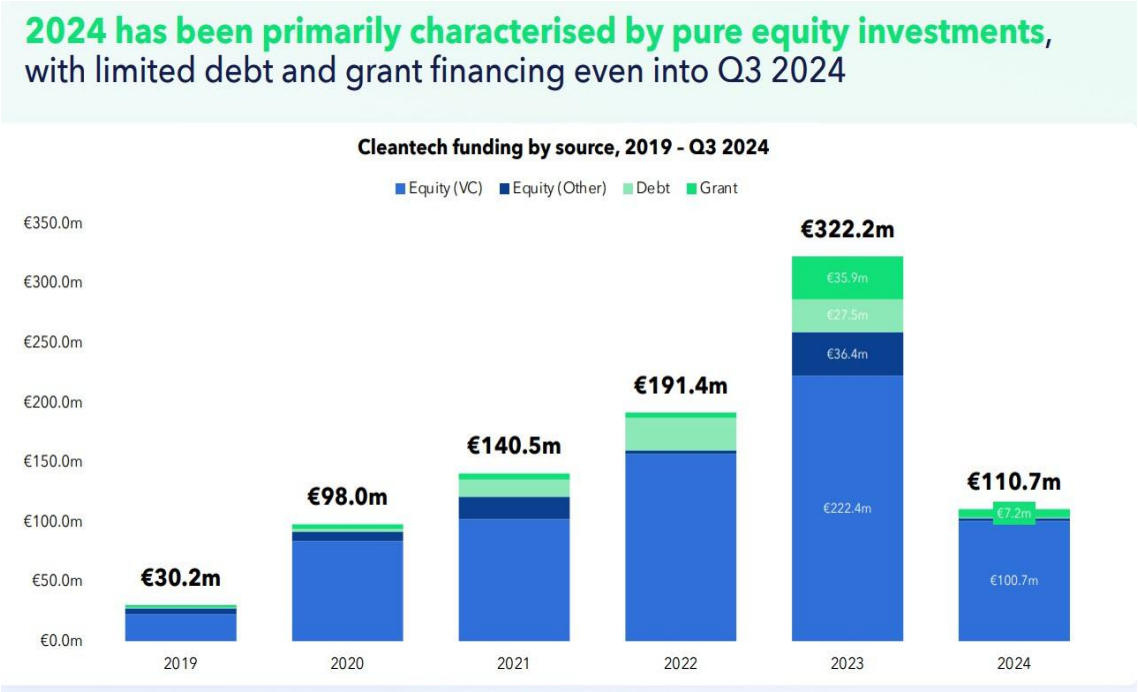
Italy's lag can be attributed to a number of factors, including a less developed innovation ecosystem, a lower appetite for risk on the part of investors, and the need to improve infrastructure to support startups. To close this gap, it will be crucial to establish public policies that stimulate investor interest and facilitate access to capital for emerging cleantech companies (Cuppoloni, 2023).

In summary, while the energy and agrifood sectors are showing signs of growth and innovation, Italy faces significant challenges in aligning with European standards of

clean technology investment, with the goal of promoting an effective and sustainable energy transition.

The benchmark report, shows cleantech investment data related to the following technology taxonomy (Italian Cleantech Quarterly Briefing - Q3 2024):

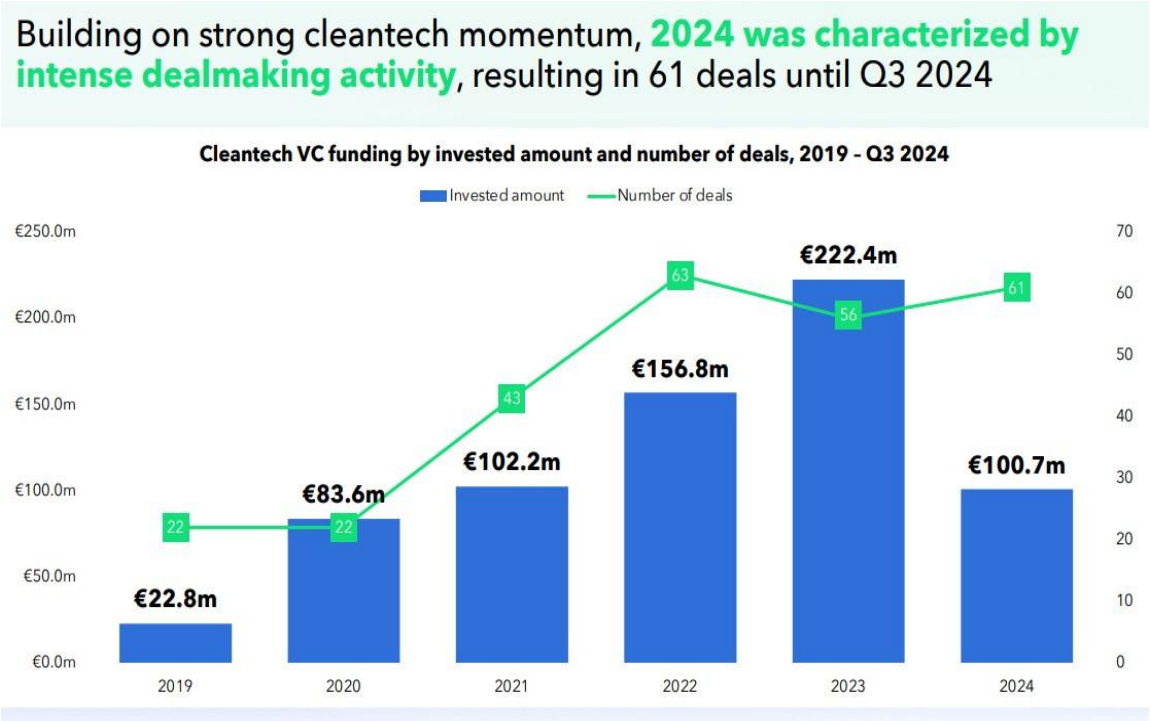
- *Agrifood*: precision agriculture, resource optimization, land use, crop and livestock production, food processing and food security.
- *Energy*: Innovates in renewable energy generation, storage and digital solutions for a cleaner energy landscape.
- *Transportation*: sustainable mobility solutions, electric vehicles, components and infrastructure technologies.
- *Manufacturing & Construction*: industrial electrification, advanced materials, hard-to-abate and building construction and efficiency
- *Climate Neutrality*: emissions offsetting, business sustainability solutions, climate monitoring and data analysis.
- *Water & Waste*: water purity and conservation, monitoring and treatment, waste management and site remediation.



Italian Cleantech Quarterly Briefing – Q3 2024

In the third quarter of 2024, investment in the sustainable technology sector in Italy reached 110.7 million euros. This figure represents a decrease compared to the amounts invested in the same period in 2023, which recorded a 9.6% decline, and compared to 2022, with a 7.8% contraction (Italian Cleantech Quarterly Briefing, Q3 2024).

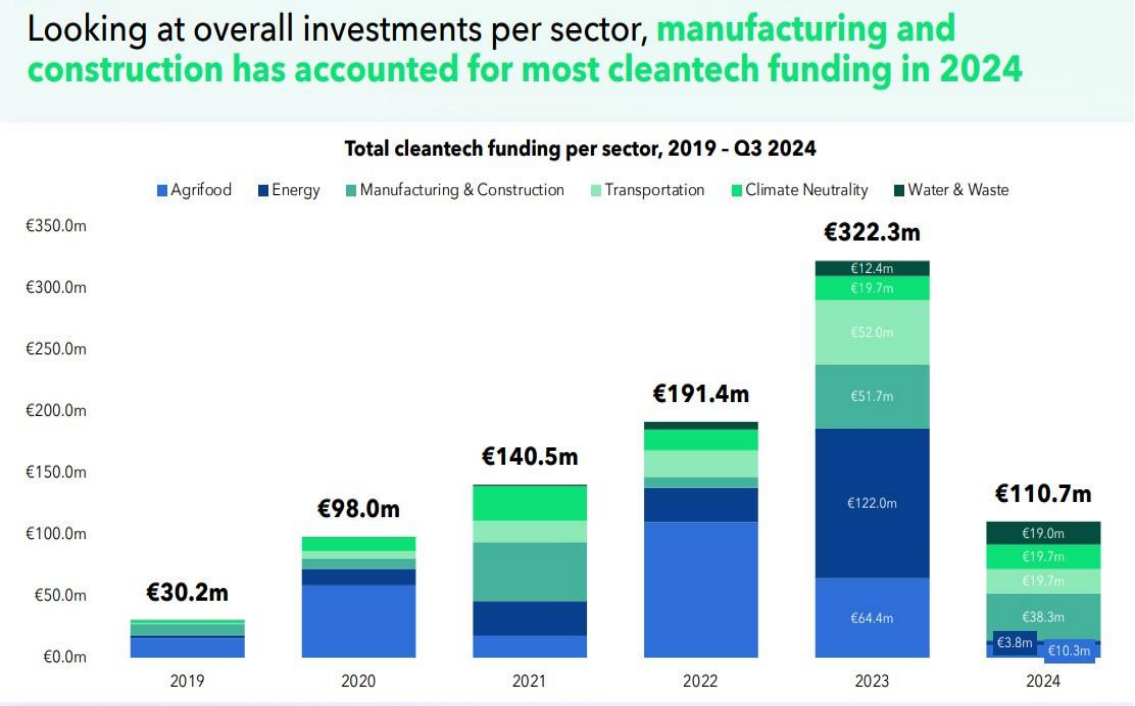
A distinguishing feature of this quarter was the predominance of venture capital rounds, which made up 90.9% of total investments. In comparison, debt-based forms of financing and grants had a marginal impact. This shift toward venture capital suggests growing investor confidence in the growth potential of cleantech startups, despite the overall declining funding environment.



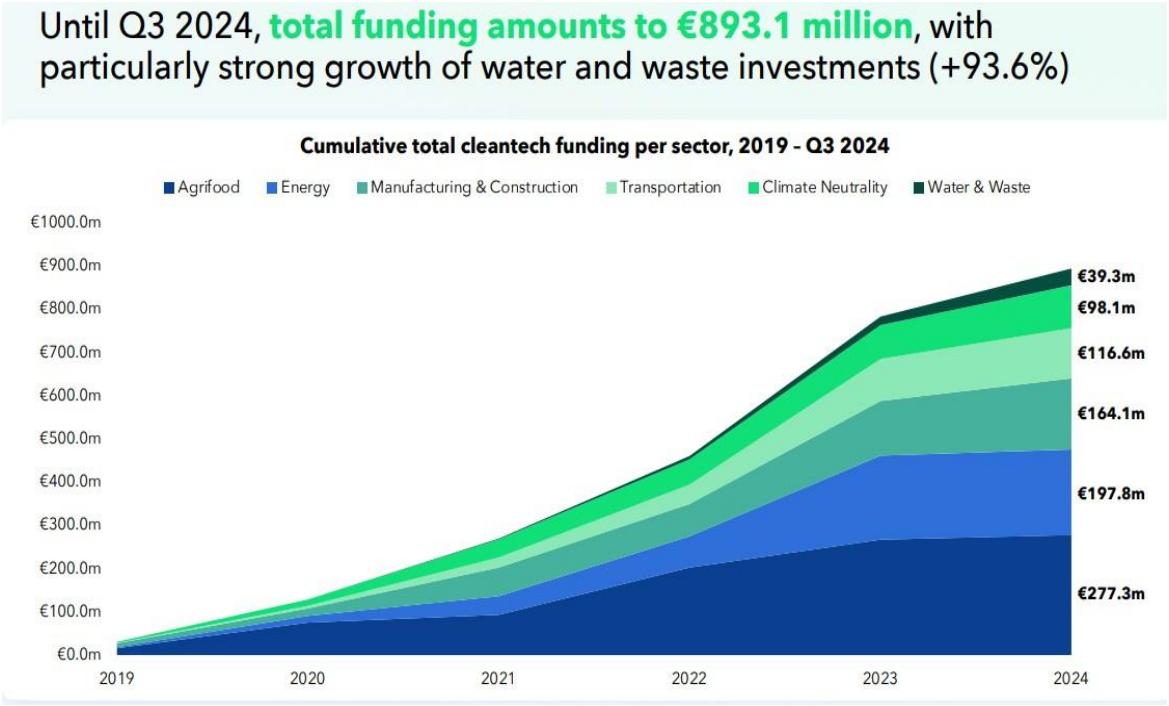
Interestingly, despite the overall decrease in investment, the number of deals closed in the sector remains robust. In fact, 61 venture capital deals were signed by the end of the third quarter, highlighting active investment activity and a continued search for opportunities by investors. This phenomenon may indicate increasing selectivity, where investors are focusing on projects with high return potential, rather than overall investment volume (Italian Cleantech Quarterly Briefing, Q3 2024).

In summary, although 2024 showed a declining trend in clean technology investments compared to previous years, the high number of venture capital deals suggests market resilience and persistent interest in sustainable solutions, which continue to represent a significant opportunity for Italy's economic future.

Looking at total investment by sector, manufacturing and construction accounted for the majority of clean technology funding in 2024, while traditional sectors such as energy and agribusiness declined.



In addition, the chart below shows the total funding recorded, which is around a significant 893.1 million, particularly in the area of investments dedicated to water and waste management, an increase of 93.6%.



Increased investment in water and waste, therefore, highlights a growing awareness regarding the need to protect and enhance these resources while ensuring economic development that respects the principles of sustainability.

Chapter 4: Patents and market dynamics

4.1 Assessment of the level of technological maturity in projects

Entrepreneurial ventures arising from scientific research play a key role in combating climate change and other environmental crises. They aim to translate scientific discoveries into practical and innovative solutions, yet face a significant financing gap compared to other forms of ventures due to their inherent high-risk nature, the long time required for development, and the associated technical uncertainty. The caution with which traditional investors, such as those involved in venture capital and private equity, approach projects that have not yet reached an appropriate level of maturity, and this sometimes leads to a situation where promising ideas do not receive the support they need to progress to commercialization. The phenomenon that emerges from this context is commonly known as "Death Valley," a term that describes the critical stage in which scientific start-ups often find themselves stuck, unable to attract sufficient investment to overcome initial difficulties (Bessant & Tidd, 2015; Gans, 2016).

To address this funding gap, it is essential to develop financial policies and instruments that encourage greater investor involvement in financing high-risk projects by providing incentives and support during the early stages of development (Mazzucato, 2013).

Assessing the technological maturity of a project is commonly done through the Technology Readiness Level (TRL), a methodological approach adopted by several institutions in both the United States and Europe. This measurement system, allows for a systematic assessment of technological progression, facilitating communication among the different stakeholders involved in the project life cycle, is on a scale ranging from 1 to 9, where level 1 represents the initial phase of defining the basic theoretical principles, while level 9 indicates that the system has already found application in a real operational context.

The TRL approach is particularly useful for organizations that wish to manage the risk associated with the adoption of new technologies by ensuring that each stage of the

development process is rigorously controlled and documented (Mankins, 1995; European Commission, 2014).

According to analyses conducted by the European Investment Bank (EIB), the annual funding gap for clean technologies between late-stage projects and those still in the early stages of research, identified with technology readiness levels (TRLs) 1 to 4, is estimated to amount to about 15 billion euros. This significant disparity in investment shows a clear preference by investors for initiatives that are at a stage of development close to commercialization, thus creating a barrier to innovation.

This investment dynamic poses a problem with respect to the ability to address challenges related to ESG criteria as the preference for already advanced projects implies a concentration of capital on more secure and established initiatives, thus neglecting the opportunities for radical innovation that could emerge from projects still in the conception or prototyping stage (OECD, 2020).

4.2 Innovative deep tech startups: an overview

The analysis of the Italian situation in relation to innovation and entrepreneurship in the start-up sector is well highlighted in the latest report of PniCube, a national network that brings together university incubators and regional competitions for start-ups. This entity was established with the aim of enhancing academic research through the creation of innovative start-ups in the field of advanced technologies, commonly referred to as "deep tech."

PniCube is distinguished by the fact that it represents 81 percent of Italy's public universities, which underscores its importance and prevalence in the national academic landscape. Its mission is to promote models of sustainable and entrepreneurial innovation, acting as a bridge between universities, research institutions and various players in the technology ecosystem.

Initiatives such as those promoted by PniCube highlight how academic institutions can actively contribute to the creation of a dynamic entrepreneurial ecosystem. Collaboration between universities, start-ups and other industry players not only

facilitates knowledge transferability, but also generates opportunities for young entrepreneurs and researchers, incentivizing the birth of new businesses and the commercialization of innovative ideas (Bercovitz & Feldman, 2008).

According to the 2024 Report, a total of 264 deep tech startup projects were submitted under the National Innovation Prize (NIP) between 2020 and 2023.

Number of innovative startup projects submitted to PNI in 2020-2023 by innovation sector:

Settore d'innovazione	PNI 2020	PNI 2021	PNI 2022	PNI 2023	Totale progetti PNI 2020-2023	% progetti per settore d'innovazione
Life Sciences-Medtech	28	22	24	19	93	35%
Cleantech & Energy	13	14	16	20	63	24%
ICT	13	12	14	12	51	19%
Industrial	11	15	11	20	57	22%
Totale	***65***	***63***	***65***	***71***	***264***	***100***

Source: Elaboration on PNICube Observatory data.

The overall increase in the number of projects submitted between 2022 and 2023 can be attributed to the favorable results achieved, particularly in the Cleantech & Energy innovation sectors, which saw a 25% increase, and Industrial, which saw an 82% growth over the same period. Analyzing the three-year period 2020-2023, a clear

upward trend emerges regarding the number of startup projects with high potential for deep tech innovation. The Life Sciences-Medtech sector continues to dominate, accounting for 35% of the total number of projects submitted, followed by Cleantech & Energy with 24%, Industrial with 22% , and finally ICT with 19%.

There is evidence of a limited incidence of venture capital as the main means of financing for initiatives designed to enhance research and strengthen technology transfer processes, particularly when transformative interventions are involved.

The analysis of venture capital strategies is particularly illuminating when focused on the United States, in part due to the availability of a large set of data that will be analyzed in detail in the following sections, and a general overview is offered below, within a theoretical framework of reference. In the United States, about 70% of venture capital funds are allocated to startups that are in advanced stages of development, operating in markets that are already well established. In contrast, ventures characterized by a low TRL face significant difficulties in accessing private funding. This phenomenon is further evidenced by the sectoral distribution of investments: in 2022, 40% of global venture capital funds were allocated to the software sector. In comparison, areas related to green technologies and life sciences, despite their potential to generate positive social impacts, received a significantly lower proportion of investment.

This disparity in fund allocation can be attributed to several factors, including investors' preference for sectors that promise faster and more certain returns. Companies in the software sector, for example, tend to show faster growth and high scalability, making them more attractive to venture capitalists (Gompers & Lerner, 2001). On the other hand, startups operating in areas such as environmental technologies and life sciences, while having significant social impact, may require longer development cycles and present high risks, making them less attractive for investment by short-term profit-oriented venture capitalists (Cohen, 2013).

In addition, the concentration of investment in the software sector may also reflect investors' greater familiarity with the dynamics of this market, compared to emerging sectors. The absence of an adequate support ecosystem for startups in more innovative and risky sectors could further limit funding opportunities, creating an investment cycle that favors established companies (Bhide, 1994).

4.3 Impact of environmental indicators on business start-ups in relation to R&D expenditures and patents

The emergence of cleantech startups is influenced by several environmental indicators, particularly in relation to research and development (R&D) and patents. Here are some of the main factors:

- *Environmental Regulation*: stricter regulations can incentivize innovation in the cleantech sector by pushing companies to develop sustainable technologies to comply with standards;
- *Tax Incentives and Subsidies*: government policies that offer tax incentives or subsidies for clean technology research can stimulate R&D investment and encourage patent registration;
- *Access to Funding*: the availability of funds from venture capital and other funding sources is crucial for cleantech startups, as these resources are needed for research and development of new technologies;
- *Collaborations with universities and research centers*: partnerships between companies and academic institutions can lead to new discoveries and innovations, encouraging the registration of patents;
- *Market Trends and Consumer Demand*: increased environmental awareness and demand for sustainable solutions can stimulate innovation and new business creation in the cleantech sector.
- *Innovation Ecosystems*: the presence of an innovation-friendly ecosystem, including incubators, accelerators and support networks, can facilitate new business start-ups and R&D activity.
- *Technological Development and Existing Patents*: The availability and accessibility of patented technologies can influence new entrepreneurial initiatives, allowing start-ups to build on existing innovations.

These indicators, together with economic and social factors, can create a favorable environment for the emergence of new clean technology companies.

The increase in patents in the field of sustainability is a positive sign for the future of the planet, but it requires an integrated approach that considers both the opportunities and challenges along the path towards a sustainable energy transition. Recent years have seen a significant increase in the number of patents covering technological innovations oriented towards environmental sustainability and the transition to cleaner energy sources, prompting many companies and institutions to invest in research and development of eco-friendly technologies. This phenomenon has been documented in a recent report by the European Patent Office, which not only underlines the emerging opportunities in this field, but also highlights the critical issues related to these developments.

According to the report, the increase in patents indicates a growing interest in renewable energy, waste management, and energy efficiency solutions, innovations that not only help reduce environmental impact, but also create new jobs and opportunities for economic growth (Bocken et al., 2014).

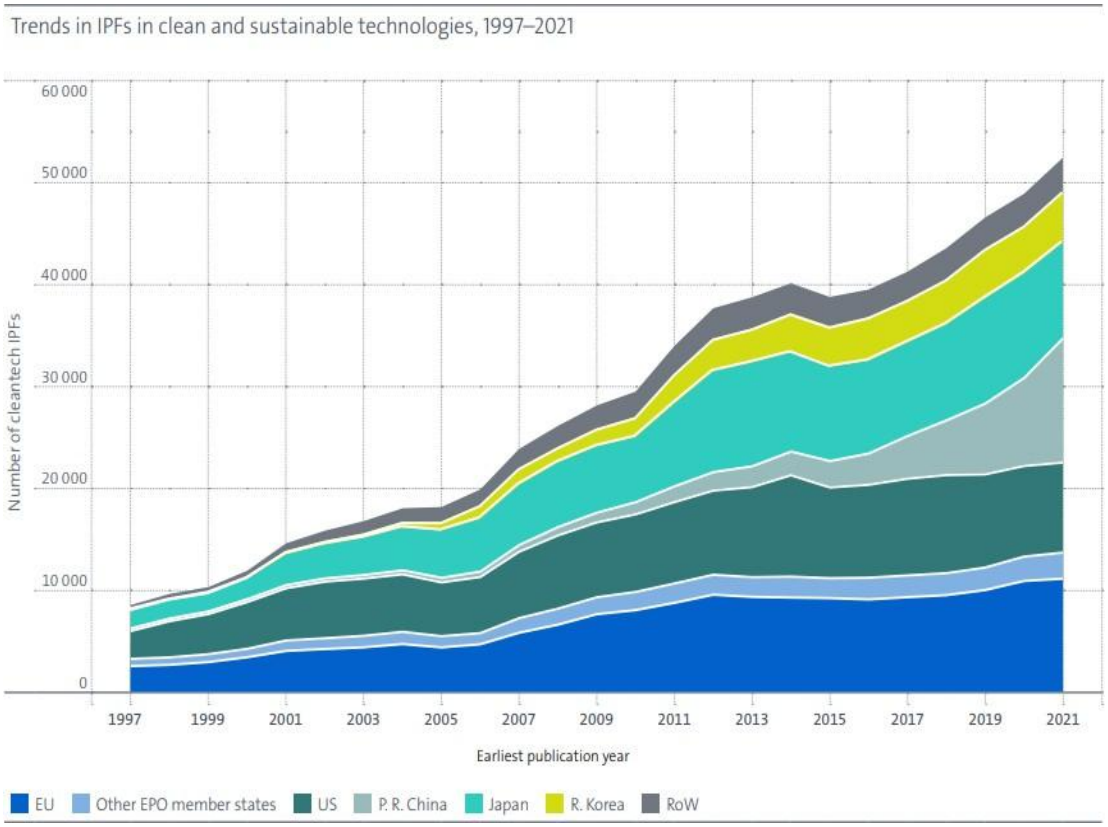
Critical issues, on the other hand, include barriers to entry for small and medium-sized enterprises, which may find it difficult to compete with large market players, and the need for an adequate infrastructure to support the implementation of these technologies.

The increase in patents in the cleantech sector globally in recent years is a trend mainly influenced by two factors, namely, growing energy needs and climate change pressures. While there is an urgent need to move away from the use of fossil fuels towards renewable forms of energy, it is essential to reduce greenhouse gas emissions and curb the environmental impact of air pollution, water contamination and land degradation (IPCC, 2021). However, it is crucial that the innovation, design and development of effective alternatives are accompanied by appropriate policies that incentivize their deployment. A fundamental aspect shared by both research centers and private industry.

A significant figure to support this thesis is the number of international patent families in the field of clean and sustainable technologies, which currently exceeds 750,000, equivalent to nearly 12% of total registered patents, as recently reported in the report *Financing and commercialization of cleantech innovation*, published by the European Investment Bank (EIB) and the European Patent Office (EPO).

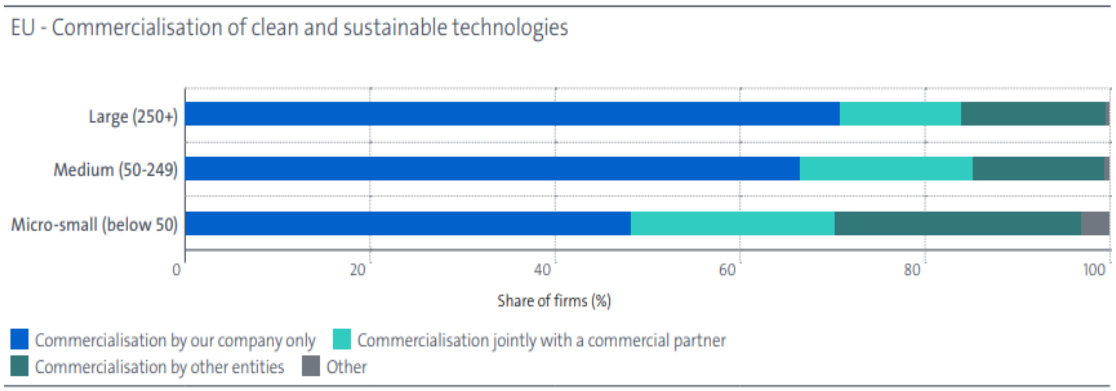
IPFs in the clean and sustainable technology sector grew faster than general patenting activity during the reporting period. Two significant phases of acceleration can be

identified, the first, between 2006 and 2012, mainly fueled by the EU and Japan, which accounted for 27% and 26% of the overall increase in IPFs, respectively. The second phase, on the other hand, occurred from 2017 to 2021, with China leading the way, contributing 70% of the surge in IPF applications during that period, followed by the EU with 16% participation.



EPO

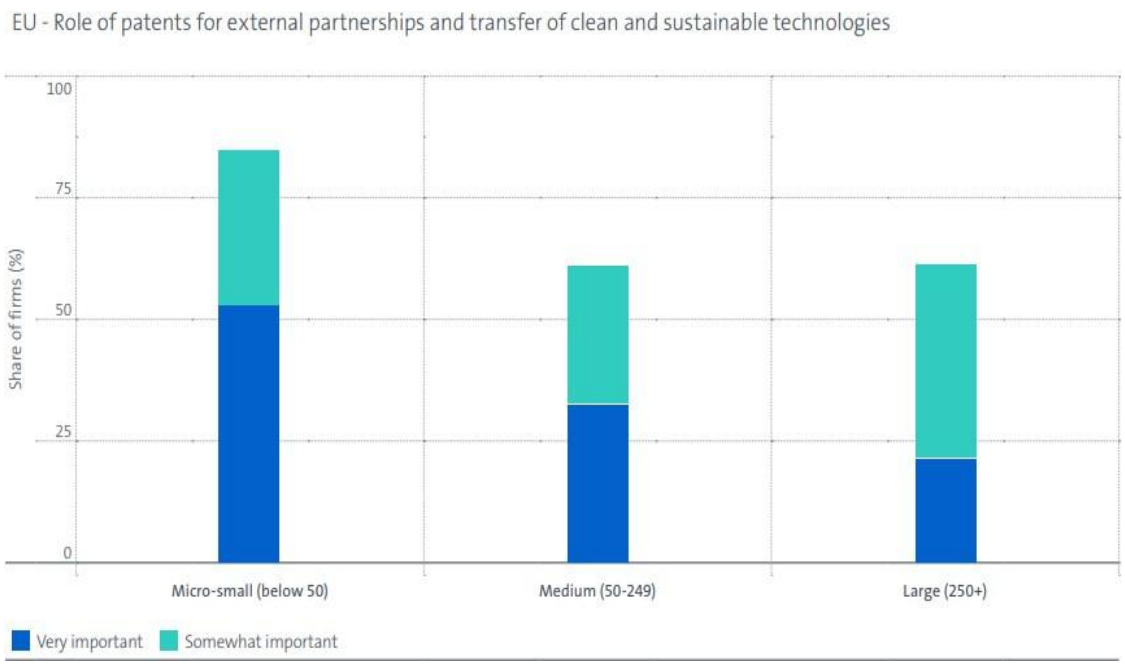
Although large companies account for more than 75 percent of international investment in clean and sustainable technologies in the U.S. and EU, most companies patenting in this area have fewer than 5,000 employees. Therefore, the analysis of these companies is equally important as dynamic ecosystems, as company size is reflected in the commercialization strategies adopted.



Source: Cleantech Survey, 2022

According to recent data, within the EU, small and medium-sized enterprises (SMEs), from 2011 to 2022, launched about 60 percent of the technologies for which they applied for patents, demonstrating an important ability to respond to market needs compared to large companies (European Commission, 2022). However, it should be emphasized that larger companies, in addition to possessing greater financial resources, are able to manage the commercialization process autonomously compared to SMEs, which, on the contrary, are forced to seek strategic alliances such as external collaborations and develop alternative business models to maximize the potential of their innovations. The critical issues they face relate precisely to the stage of getting to market, due to the lack of access to capital, distribution networks and specialized skills needed (McKinsey & Company, 2020).

The importance of patent registration in the context of external collaboration and financing, especially for smaller firms, stems precisely from the fact that patents are strategic tools for creating and consolidating external alliances that are essential for attracting investment, as they also serve as a signal of corporate credibility and value in the eyes of potential business partners and investors (Cohen et al., 2000).



Source: Cleantech Survey, 2022

4.4 Unequal investment in sustainable technologies

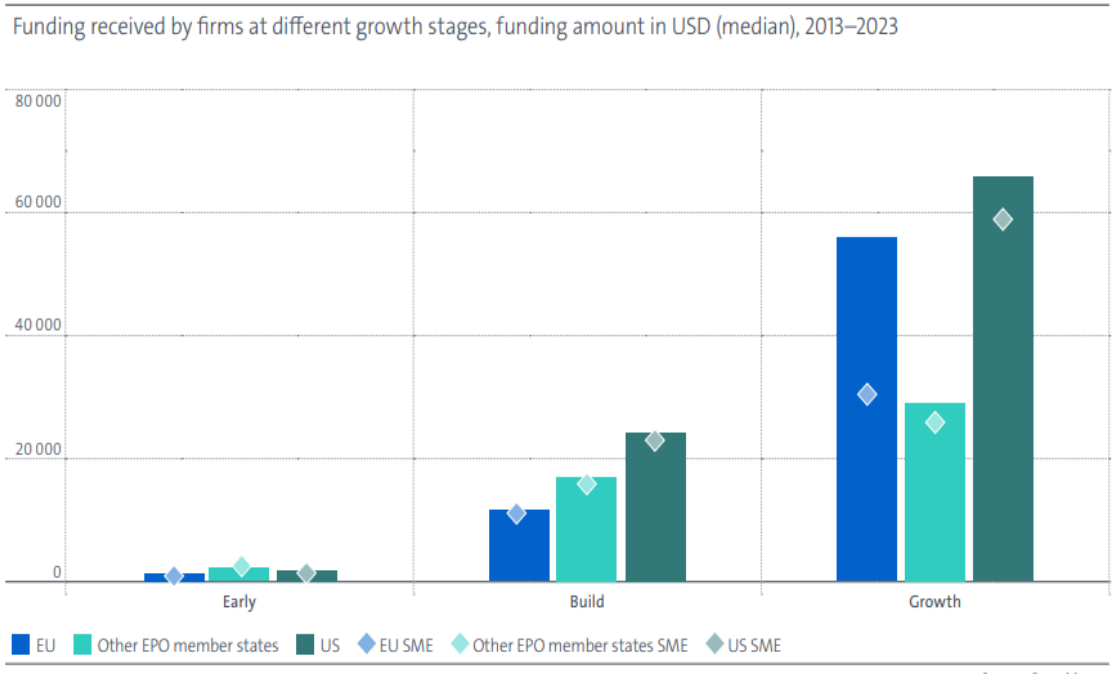
The ability of companies to expand differs greatly between geographical regions. In particular, innovative companies within the European Union (EU) face a significant financing gap compared to their counterparts in the US, and this phenomenon is particularly evident in the clean technology sector where European innovators struggle to raise significant capital during the various stages of development and growth.

According to recent studies, the average capital raised by European cleantech start-ups is substantially lower than that of US companies. This difference not only reflects a disparity in investment opportunities, but also indicates a market environment in which the amounts of capital raised tend to increase much faster in the US than in Europe. Indeed, American companies benefit from a more established entrepreneurial culture and a more developed venture capital ecosystem, which gives them access to broader and more diversified sources of funding.

This situation raises important questions about the strategies needed to close the funding gap and foster innovation within the EU. Investment in research and development, tax

incentive policies and support for emerging start-ups are key elements that could help create a more favourable environment for innovative companies. Furthermore, public-private cooperation could be an effective strategy to address financing challenges and stimulate sustainable growth in the European cleantech sector.

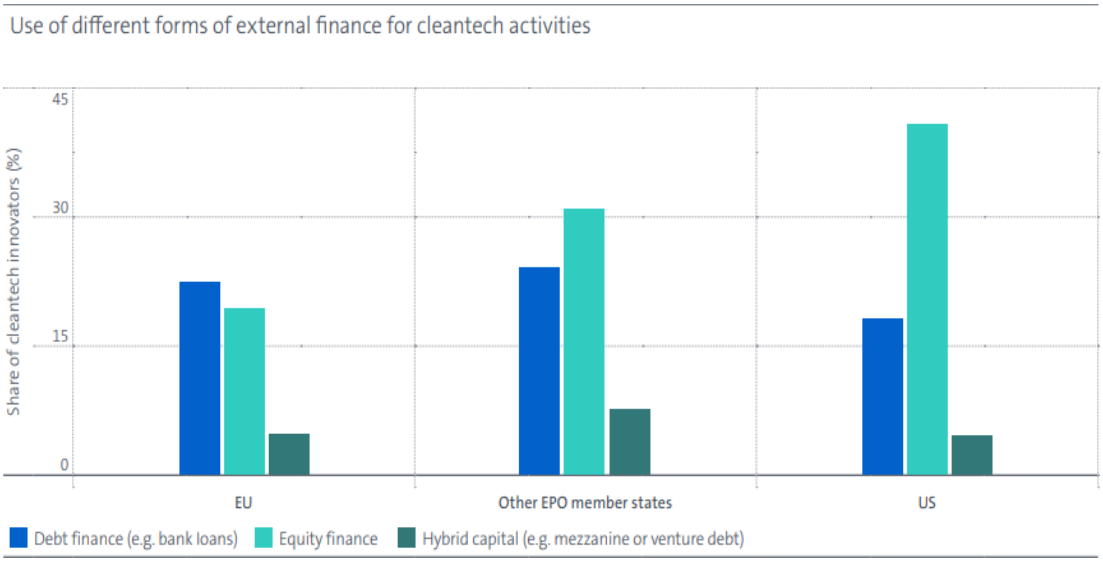
Innovators in the cleantech sector within the European Union tend to rely more on financial debt to sustain their activities. This reliance on debt can be attributed to a number of factors, including the structure of the European capital market and the limited availability of equity investments. In contrast, in the US, venture capital and other forms of equity-based financing play a crucial role as complementary sources of funding. This phenomenon is also found, albeit to a lesser extent, in some member states of the European Patent Organisation (EPO).



Source: Crunchbase

The different preference for funding modalities between Europe and the US can be explained by a different economic and cultural context. In the US, a well-established entrepreneurial ecosystem and a more risk-oriented investment culture have fostered the development of a robust venture capital network, which has proved particularly favourable for technology start-ups. American companies can thus tap into significant

venture capital that enables them to make initial investments and rapidly expand their operations.

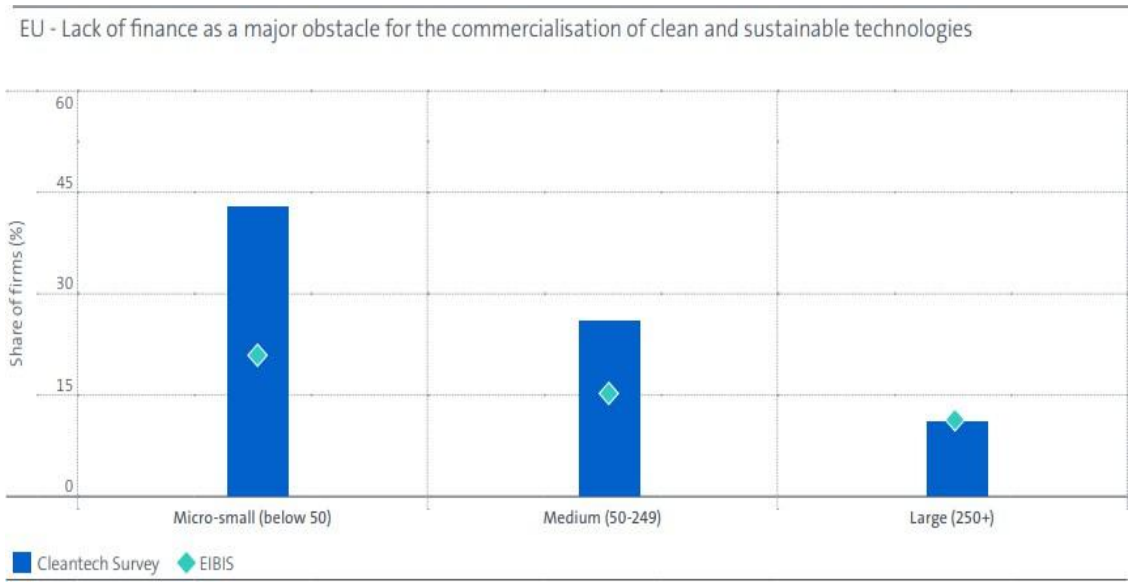


Source: Cleantech Survey, 2023

4.5 Barriers to commercialisation: getting the cash

An in-depth analysis of the financial situation of European companies reveals that more than 30% of them consider the shortage of funds as a significant impediment to the commercialization of environmentally friendly products and sustainable technologies. This figure is particularly worrying in the context of micro and small enterprises, which face greater challenges than large companies. In fact, while only 12% of larger companies report financing as an obstacle, as many as 43% of micro and small enterprises report difficulties in this area.

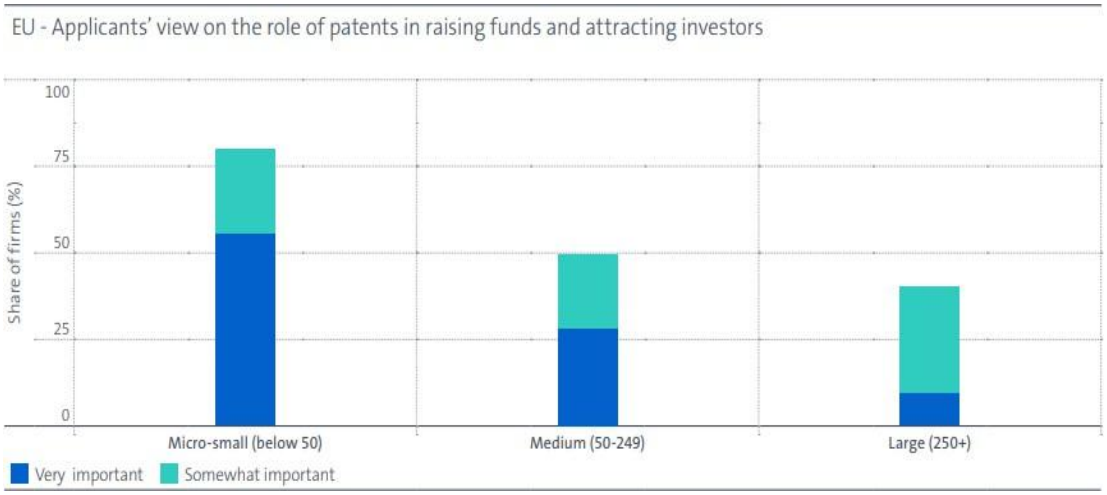
This discrepancy suggests that the problem of lack of access to finance is particularly acute for small and medium-sized enterprises (SMEs) in the context of the European Union. The European Investment Bank documented these issues in its Investment Bank Survey Report, highlighting the urgency of developing financial policies and instruments that can adequately support this vital segment of the economy.



Source: Cleantech Survey and EIB Investment Survey (EIBIS) 2023

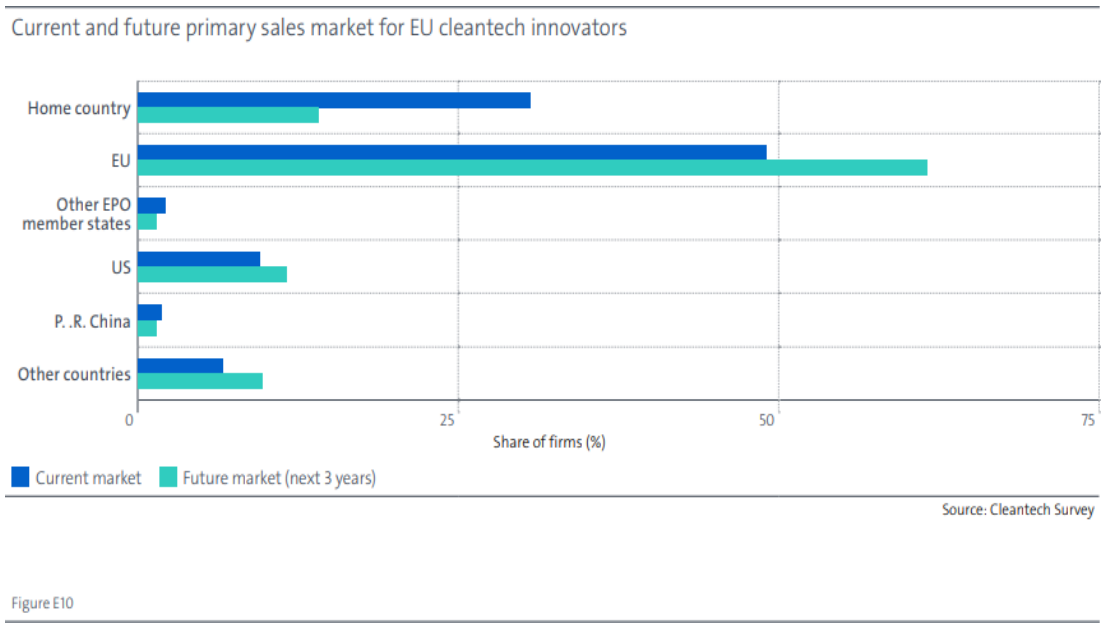
Most innovators recognise the importance of patents not only as tools to protect intellectual property, but also as key levers to secure third-party investment or debt financing. Indeed, the presence of a patent can increase the credibility of the start-up in the eyes of investors by demonstrating the uniqueness and market potential of the proposed technology.

In addition, patents can act as collateral for lenders, reducing the perceived risk and facilitating access to loans. This interplay between intellectual property and financing is crucial for the success of cleantech companies, which operate in an innovation-intensive sector and require large investments for the development and commercialisation of their technologies.



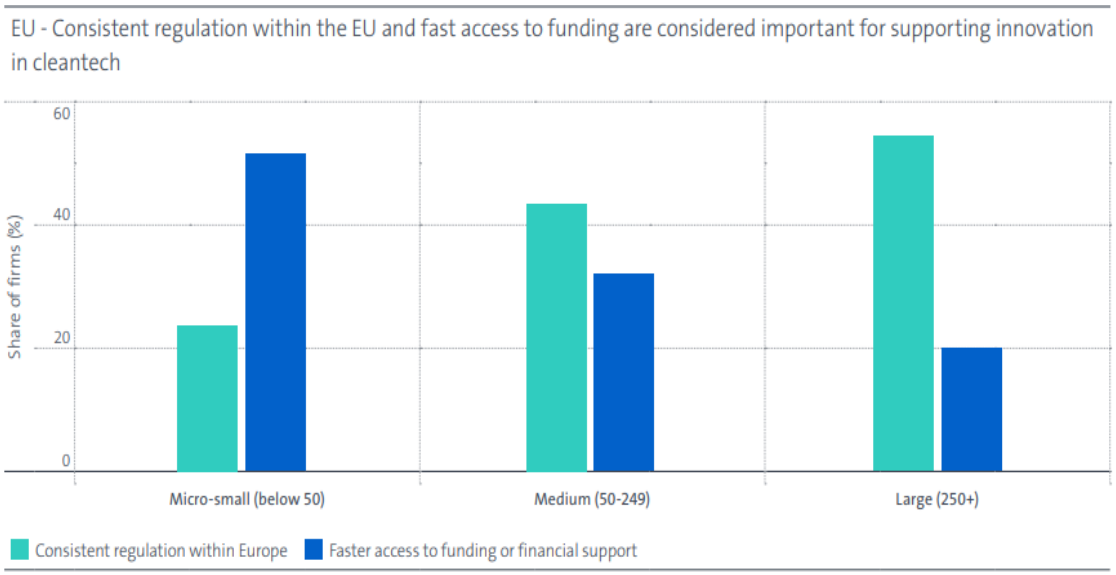
Source: Cleantech Survey, 2023

Entrepreneurs and companies operating in the green technology sector within the EU tend to focus predominantly on European markets for their growth strategies. Although 29% of European companies prioritise operating in their domestic market, a significant percentage, 61%, see the EU as the strategic market for the future, highlighting the importance of a European dimension in the design and implementation of innovations.



Source: Cleantech Survey, 2023

However, expansion in the European context is not without its difficulties. In particular, small enterprises report access to finance as one of their main concerns in the process of bringing new technologies to market. On the other hand, for medium and large enterprises, the need for consistent regulation at EU level is perceived as crucial to facilitate the commercialisation of innovations. In fact, 43% of medium-sized companies and 55% of large companies highlight regulatory consistency as a determining factor for the success of their business initiatives.



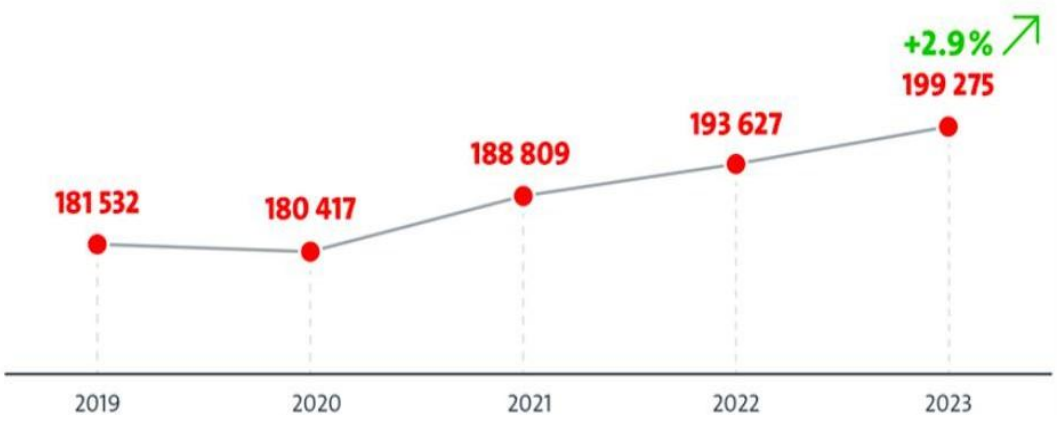
Source: Cleantech Survey, 2023

Patents: a general overview

In the period between 2017 and 2021, as shown in the report prepared by the European Investment Bank (EIB) and the European Patent Office (EPO), approximately 244,000 international patent applications were filed in the field of green technologies. This figure is a significant indicator of innovation in this field. In the year 2021 alone, almost 55,000 new inventions in the field of sustainable technologies were published, which corresponds to about 15 per cent of total technological innovations globally. This volume of publications marks an increase of almost 33% compared to the previous five years, highlighting an increasing trend and growing interest in solutions that promote environmental sustainability (EIB & EPO, 2021).

A new all-time high was recorded in 2023, when the total number of patent applications reached 199,275. Of these, applications related to the clean technology sector, specifically included in the category comprising 'electrical machines, devices and energy sources', showed a remarkable increase of 12.2% (European Patent Office, 2023).

This number represents an increase of 2.9% over the previous year, marking the highest level of applications ever recorded to date. This growth is the result of a positive trend that had already emerged in previous years, with an increase of 2.6% in 2022 and 4.7% in 2021 (EPO, 2023).



In the context of patent applications filed with the European Patent Office (EPO) during the past year, a number of predominant technology areas emerged. The most significant categories include digital communications, which include technologies associated with mobile networks, innovations in the field of medical technologies and IT solutions. Among these areas, the category with the highest growth rate is electrical machines, household appliances and energy sources, with an increase of 12.2% year-on-year. This segment encompasses inventions related to clean energy technologies, particularly batteries, which saw a significant increase of 28% (European Patent Office, 2023). In addition, patenting activity in the biotechnology sector continued to show a positive trend, with an increase of 5.9%.

The five countries that contributed the most to patent applications at the European Patent Office (EPO) were, in order, the United States, Germany, Japan, China and the Republic of Korea. An interesting aspect to note is that approximately 43% of the total patent applications were filed by companies and inventors from the 39 EPO member states. This indicates a broad participation and active involvement of local actors in the innovation process. However, it is also significant that the remaining 57% of applications came from countries outside the European Union. This phenomenon underlines not only the increasing globalisation of innovation, but also the importance of international cooperation in research and development (OECD, 2022).

		2023	+/- 2022
1	Etats-Unis	48 155	+0.4%
2	Allemagne	24 966	+1.4%
3	Japon	21 520	-0.3%
4	R.P. de Chine	20 735	+8.8%
5	R. de Corée	12 575	+21.0%
6	France	10 814	-1.5%
7	Suisse	9 410	+2.7%
8	Pays-Bas	7 033	+3.5%
9	Royaume-Uni	5 918	+4.2%
10	Suède	5 139	+2.0%
11	Italie	5 053	+3.8%
12	Danemark	2 596	-3.3%
13	Belgique	2 547	-2.2%
14	Autriche	2 355	-1.1%
15	Finlande	2 336	+9.2%
16	Espagne	2 111	+6.9%
18	Israël	1 733	-0.9%
19	Taipei chinois	1 555	+5.9%
20	Irlande	1 057	-10.4%
20	Singapour	1 057	+22.3%
22	Australie	1 016	+0.8%
23	Inde	882	+8.4%
24	Norvège	697	+6.1%
25	Pologne	671	+10.5%
26	Türkiye	601	+7.3%
27	Liechtenstein	447	-2.4%
28	Luxembourg	385	+11.9%
29	Portugal	329	+5.4%
30	RAS de Hong Kong (Chine)	298	-16.8%
31	Nouvelle-Zélande	270	+17.4%
32	La Barbade	246	-26.3%
33	République Tchèque	241	+8.6%
35	Arabie Saoudite	174	-15.9%
36	Grèce	157	-15.6%
37	Slovénie	153	+24.4%
38	Iles Caïman	135	-8.2%
38	Russie	135	-23.3%
40	Lituanie	129	+63.3%
41	Hongrie	108	+3.8%
42	Emirats Arabes Unis	86	-3.4%
43	Thaïlande	81	-14.7%
44	Estonie	71	+7.6%
45	Afrique du Sud	64	-26.4%
46	Mexique	61	+5.2%
47	Malte	59	-18.1%
48	Slovaquie	56	+16.7%
49	Chypre	53	+23.3%
50	Croatie	51	+59.4%

The dominance of the United States, in particular, reflects a highly developed entrepreneurial and technology ecosystem, supported by large investments in R&D and a culture that promotes innovation. At the same time, the growth of patent applications from China and the Republic of Korea testifies to the emergence of these nations as technology powerhouses with a strong focus on advanced technologies and sustainable innovation (WIPO, 2023).

The European Patent Office (EPO) has drawn up a classification of patents in the cleantech sector, dividing these innovations into six main categories that include:

- low-carbon energy
- climate change mitigation technologies (CCMT) related to transport and buildings, manufacturing and ICT;
- climate change adaptation solutions;
- smart grids;
- waste and wastewater treatment technologies;
- CO2 capture and storage solutions.

In addition to these, the analysis also includes solutions for plastic recycling and alternatives and hydrogen-related technologies.

Among the most developed cleantech patents are low-carbon energy technologies, with a focus on renewable energy production and energy storage solutions. Between 2017 and 2021, some 78,000 patents were filed in this area, contributing to a total of 244,000 patents overall (WIPO, 2021). In 2023, the analysis of patent applications filed with the EPO confirmed this trend.

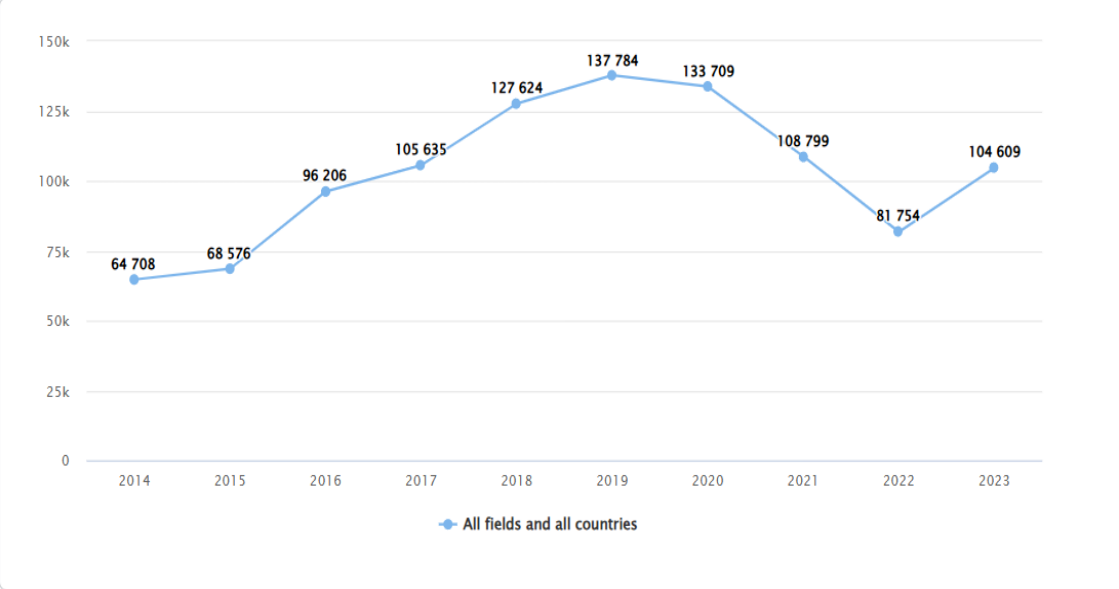
Inventions focused on sustainable and ‘clean’ mobility solutions rank second in the innovation landscape, registering around 47,000 patent families. Right behind, with more than 46,000 patent families, are inventions dedicated to plastic recycling and the development of sustainable alternatives, an area of increasing relevance in an era when plastic waste management is a significant environmental challenge.

Technologies related to clean and sustainable production also showed considerable dynamism, with more than 43,000 patent families registered between 2017 and 2021,

including more than 9,500 in the final year alone. This figure underlines the importance of adopting production practices that minimise environmental impact, thus responding to the growing consumer demand for sustainable products

Other areas worthy of attention include clean technology solutions for buildings, information and communication technologies (ICT) and climate change adaptation strategies, each of which registered around 18,000 patent families in the period analysed. Although the other patent categories counted less than 10,000 families, it is important to note that wastewater treatment and waste management technologies showed the fastest growth, with a compound annual growth rate approaching 18%. These figures suggest a growing focus on innovative solutions that address emerging environmental challenges, making the field of sustainable technologies increasingly crucial for the future.

The collection and analysis of data on granted patents are crucial for understanding trends in research and development and for assessing the economic and social impact of technological innovations. The monitoring and analysis of patents granted by the EPO provide an important window on innovation trends at European level, representing a useful tool for researchers, entrepreneurs and policymakers interested in fostering an innovation-friendly environment.



Source: EPO.

The graph shows the trend observed over the last ten years, illustrating the total number of patents granted by the European Patent Office (EPO) on applications from a wide range of countries and technology sectors. The analysis is based on patents that have been published and subsequently granted by the EPO, thus providing a detailed insight into the dynamics of intellectual property in Europe.

With regard to geographical attribution, it is important to note that the country of residence of the first patent holder, indicated in the published patent document, is used as the main criterion. If a patent mentions more than one owner, only the nationality of the first listed owner is considered. This method of classification allows a clearer understanding of the origins of technological developments and protected inventions by highlighting the geographical areas most active in terms of innovation.

According to the EPO, patent analysis not only provides insights into the level of innovative activity in different regions, but also helps to identify emerging technologies and growth sectors (EPO, 2023).

The topic of granted patents and the adoption of the unitary patent is of particular relevance in the context of technological innovation in Europe. The graph below illustrates the geographical origin of patents granted by the European Patent Office (EPO), using the country of residence of the first patent holder as a criterion, as reported in the published patent document. It also shows the proportion of European patents granted in 2023 for which protection was sought through the unitary effect. Interestingly, the adoption of the unitary patent showed a higher incidence among European patent holders, reaching 25.8.

Source: EPO.

This analysis is based on patents that have been published and subsequently granted by the EPO, and the classification method adopted implies that in the case of patents with multiple owners, only the country of residence of the first listed owner is considered. This approach provides a clearer picture of patent origins and innovation dynamics in Europe. Furthermore, it is important to note that the 39 member states of the European Patent Organisation include the 27 states of the European Union, further expanding the opportunities for inventors and companies to protect their innovations on a continental level.

Chapter 5: Digital transformation and sustainability

5.1 Sustainable innovation

Innovation is a fundamental element in the cleantech sector fueled by digitization, which provides a clear and measurable framework to attract investment. This attractiveness is further underpinned by meaningful environmental indicators that highlight the positive impact of sustainable practices. In this context, digitization introduces a range of tools and technologies that improve the operational efficiency of cleantech companies as the use of advanced data and analytics enables them to optimize their production processes and reduce operating costs.

The cleantech sector is experiencing significant growth in Europe, a phenomenon influenced by a number of interconnected factors. Among these, public policies and funding mechanisms play a crucial role in shaping the development landscape of these sustainable technologies, as policies adopted by governments can act as both facilitators and barriers to innovation and the adoption of environmentally friendly solutions.

On the one hand, public policies can stimulate the growth of the cleantech sector through financial support measures, such as subsidies, tax credits and direct investment in research and development, promoting innovation and fostering the adoption of green technologies, thus contributing to the transition to a low-carbon economy. The European Union has implemented several programs and funds, such as Horizon Europe, to support innovative projects in the field of sustainable technologies (European Commission, 2021). On the other hand, policies can also be a barrier if they are not properly designed. Complex regulations or regulatory uncertainties can hinder investment and market entry of new technologies, limiting the competitiveness of cleantech companies. It is essential that regulations are clear and provide an enabling environment that stimulates innovation while ensuring the protection of the environment and public health (Geels, 2014).

On the basis of these considerations, it is necessary to examine the regulations, both European and national, governing the so-called twin transitions (Orofino, 2023), the ecological and the digital, with the aim of identifying the principles, rules and procedures that guide the digitalization process towards the achievement of sustainable objectives. Moreover, it is important to put in place an integrated approach of these dimensions, as they must be evaluated in a synergetic way both from a practical and a legal point of view, especially in virtue of the objectives that may, in some cases, conflict with each other.

Indeed, on the one hand, if the ecological transition aims to achieve climate neutrality and reduce greenhouse gas emissions, on the other hand, the digital transition, while bringing with it enormous opportunities for innovation and economic growth, is associated with phenomena that may contribute to global warming, in particular due to the increase in carbon dioxide emissions related to the use of technologies and data centers (Krausmann et al., 2018). This integration therefore requires strategic planning and continuous evaluation of current policies, so that contradictions can be minimized and mutual benefits maximized.

Cleantech companies, dedicated to the development of sustainable technologies, are at the forefront of the fight against climate change and play a key role in this context, as they can significantly contribute to both transitions through innovations in the fields of renewable energy, waste management, energy efficiency and sustainable mobility. For example, companies developing solar or wind energy technologies not only contribute to a reduction in dependence on fossil fuels, but also promote a circular economy model, where resources are reused and recycled.

On the other hand, the digital transition represents the integration of digital technologies into business processes and everyday life. Cleantech companies can exploit digital technologies to optimize their operations, improve energy efficiency and monitor the environmental impact of their activities. For example, the use of big data and advanced analytics can help predict energy consumption, optimize distribution networks and reduce waste. Therefore, it is crucial that public policies and funding are designed to incentivize a positive interaction between digital and sustainable technologies, creating a favorable environment for cleantech companies.

Digital transformation thus presents itself as an ambivalent phenomenon in the context of environmental sustainability because while the adoption of tools such as the Internet

of Things (IoT) and artificial intelligence can help to monitor and manage energy use more efficiently, leading to a positive impact on the environment (Zhou et al., 2020), the increased demand for energy to power these digital technologies and the generation of e-waste pose significant challenges to environmental sustainability (Pirina, 2022).

This leads us to reflect on the growth of the cleantech sector in Europe influenced by a delicate balance between favorable public policies and challenges resulting from the digital transformation. It is crucial that policymakers carefully consider these dynamics to promote a sustainable future where cleantech can thrive and contribute to a healthier environment.

The significant environmental impact of digital technologies stems from their inherent structure and operation, as these systems require large amounts of natural resources, generate a high 'energy metabolism' and inevitably produce waste, including materials that are harmful to the environment (Ibid.). According to the report of the United Nations Information and Communication Technology Organization (ITU, 2020), the inadequate management of this waste can lead to serious ecological consequences, as many devices contain toxic substances that can contaminate soil and water resources. Furthermore, the information and communication technology (ICT) sector is responsible for significant daily energy consumption, particularly for the operation of data centers, which are essential for storing and processing data. A report by the International Energy Agency (IEA, 2020) estimates that the ICT sector contributes to a significant proportion of global greenhouse gas emissions, adversely affecting the ecological balance and contributing to increasingly severe climate crises.

Hence the need to outline a regulatory framework to regulate both transitions, to identify the synergies and tensions between technological practices and environmental sustainability needs.

In the European context, this goal is envisaged in the Green Deal (European Commission, 2019) and in the 2030 Agenda for Sustainable Development and requires international cooperation and a shared commitment on the part of governments, companies and citizens. In particular, the Green Deal envisages the allocation of financial resources to support companies in the transition towards low-carbon production models, fostering the adoption of clean technologies and the development of innovative infrastructures such as «artificial intelligence, G5, cloud and edge computing and the Internet of Things that can accelerate and maximize the impact of policies to

tackle climate change and protect the environment» (European Green Deal, p. 10). Oriented towards the same goals, the Digital Compass 2030 (Brussels, 2021), aims at the digital transformation of enterprises (para. 3.3) by encouraging sustainable innovation and the adoption of «digital technologies and products with a smaller environmental footprint and greater energy and material efficiency» (Ibid.).

Europe has achieved a significant milestone in the creation of start-ups, reaching a number of new innovative companies similar to that of the US. However, to consolidate this position and foster fast development and sustained growth, it is crucial for the continent to establish more favorable conditions and a truly functioning single market. Such a market should ensure not only access to resources and opportunities, but also a regulatory environment conducive to innovation and competitiveness.

Despite the fact that the EU has adopted several instruments to support the entrepreneurial ecosystem, the gap in terms of investments for financing the growth of start-ups between Europe and the US, as well as between the EU and China, remains significant. Although Europe has seen the emergence of a growing number of 'unicorns' - companies valued at over $1 billion - the potential for growth remains untapped, suggesting that there are ample opportunities to improve access to capital and market conditions (European Commission, 2020).

A proactive approach to bridging this gap could be the development of standards of excellence for nations that foster a start-up-friendly environment that could stimulate cross-border growth of companies, allowing for greater interoperability and sharing of resources at the European level. Furthermore, widening access to funding for expanding start-ups could facilitate their development and global competitiveness, allowing Europe to not only match, but perhaps even surpass its international competitors in the start-up landscape (Ibid.).

In the transition to a sustainable digital economy, SMEs play a central role, both due to their predominant number within the European business landscape and their function as drivers of innovation. Currently, SMEs account for about 99 per cent of all enterprises in the European Union, contributing significantly to job creation and economic growth (European Commission, 2021). To facilitate this transition, the European Union has initiated the implementation of more than 200 digital innovation poles and industry clusters, which are expected to provide SMEs with access to digital technologies and data on fair and sustainable terms by 2030. Through appropriate regulation, SMEs

should be able to benefit from sufficient support to meet the challenges of digitization, thus ensuring that no company is left behind in this process of change.

The connection between digital solution providers and local ecosystems is another strategic objective, as this will help to create a high level of digital intensity at regional level. This approach not only promotes innovation, but also stimulates the competitiveness of SMEs within the European and global market (OECD, 2021). Furthermore, the European Commission is committed to reviewing and updating its industrial strategy with the aim of accelerating the digital transformation of industrial ecosystems. This update is essential to align European policies with the 2030 targets, aiming for sustainable and inclusive growth that can benefit all companies, regardless of their size and level of digitization.

The European goal of finding a balance between digital technology and the environment led to the Declaration to support the green and digital transformation of the EU, adopted in 2021, another important document that gave birth to the European Green Digital Coalition, whose goals aim to create an ecosystem where digitization, innovation and sustainability complement each other.

At the European level, regulations governing the dimension between technology and the environment include the Artificial Intelligence Act (AI Act), which acts as a guide and support for companies through regulatory sandboxes, in particular Art. 69 on 'Codes of Conduct', paragraph 2 states that EU Member States are required to promote the creation of codes of conduct that provide for the voluntary adoption of specific requirements applicable to all AI systems, formulated on the basis of various policy objectives, among which stands out, as indicated in point b), the need to minimize the environmental impact of AI systems through energy-efficient programming practices.

Government policies and regulations play a crucial role in the development and deployment of sustainable technologies. Alongside these elements, other determinants include the level of investment in research and development (R&D), available funding opportunities and the quality of existing infrastructure. The literature suggests that a robust regulatory framework can act as a catalyst for the adoption of clean technologies, stimulating not only market demand but also boosting investment and innovation in the sector. Furthermore, addressing barriers to entry for new technologies is essential to ensure a smooth transition to a more sustainable economy.

An appropriate regulatory approach not only facilitates business access to clean technologies, but also promotes a favorable environment that encourages innovation and competitiveness. For example, several studies have shown that tax incentive policies and R&D subsidies can lead to a significant increase in the adoption of renewable energy and other environmentally friendly technologies (Mazzucato, 2013; Rennings, 2000).

5.2 Twin transition in the business context

Twin transitions create a fertile ecosystem for the emergence and growth of cleantech companies, offering opportunities for innovation, financing and markets. These interconnected processes create a favorable environment for innovation, investment and growth of companies focusing on sustainable technologies.

The transition to a sustainable ecological model therefore finds key partners in advances in digital technologies, and the marriage of green and digital transactions is not only a matter of regulatory compliance or corporate reputation, but also a strategy for ensuring the resilience and competitiveness of companies in the long term.

Despite increasing corporate interest in sustainable technologies, current efforts are proving insufficient to achieve the internationally defined climate neutrality goals. Projections indicate that annual global investment in transition technologies needs to increase fourfold from current levels in the period between 2023 and 2050 in order to achieve these goals. This increase is crucial to promote economic development patterns that are in line with the aspiration of limiting the rise in global temperatures to a maximum of 1.5°C above pre-industrial levels (Look4ward Observatory Report, 2024).

The circular economy is emerging as a key paradigm to promote a more efficient use of resources, becoming a topic of growing interest at the level of international organizations such as the OECD, the United Nations and the European Union, as the adoption of circular practices reduces waste, optimizes the use of resources and promotes a sustainable development model. Over the past decade, several countries in Europe and the Asia-Pacific region have taken significant steps to facilitate this

transition, implementing tools such as diversified national metrics and strategies to guide the implementation processes of circular economy principles by enabling strategic planning and effective monitoring of progress.

Based on the fundamental idea that environmental sustainability and economic growth can coexist, a radical rethinking of production and consumption processes is called for. Therefore, regulatory strategies include bans on certain materials, the introduction of recycling quotas, targeted taxation and the implementation of Extended Producer Responsibility (EPR) schemes. For example, EPR policies place the burden of waste management on producers themselves, incentivizing them to consider the life cycle of their products from the beginning. Such regulations have been adopted in various sectors, including electronics, plastics and packaging, helping to create an environment where reuse and recycling become standard practice[1].

The "Circular Economy Package", promoted in 2015 by the European Commission, is a key step towards creating an economic model. that not only optimizes costs, but also promotes a balance in current accounts and encourages greater self-sufficiency in resources.

One of the main objectives of these policies is the creation of new jobs through the transition to a low-carbon economy, capable of generating employment in emerging sectors related to sustainable technologies. Furthermore, the package aims to meet the ambitious climate targets set by the European Union, thus contributing to a more sustainable and resilient future for its member states.

Recent studies, such as the one by Kirchgeorg et al. (2020) entitled "The Role of the EU in Promoting Circular Economy: Policies, Challenges and Opportunities", highlight the importance of European policies in facilitating the transition to the circular economy, emphasizing how they can not only reduce environmental impacts but also stimulate technological innovation.

Furthermore, the European Commission's 2020 Circular Economy Action Plan report provides a detailed overview of the initiatives and strategies implemented to promote the circular economy and green technologies.

[1] A more in-depth analysis of circular economy policies can be found in texts such as Circular Economy: A Wealth of Flows by Ken Webster, which explores the economic opportunities offered by this model, and Waste to Wealth by Peter Lacy and Jakob Rutqvist, which outlines how companies can thrive through sustainable practices. In addition, the European Commission's report on the circular economy provides a detailed overview of the initiatives and measures taken in Europe to stimulate this change.

In addition to the 2015 package, the European Union has developed further strategic initiatives, such as the EU Roadmap to a Resource Efficient Economy and the Seventh Framework Program for Research and Development. These initiatives have played a key role in promoting the circular economy, integrating it as a key component of the European economic agenda. The Roadmap, in particular, outlines clear and measurable targets for resource optimization, while the Seventh Framework Program has provided the necessary funding to support research and innovation in this area.

In 2018, the European Union further consolidated its commitment by launching the "EU Strategy for Plastics in a Circular Economy". This strategy represents the first regional policy framework specifically dedicated to plastics management, addressing pollution and sustainability challenges. A distinctive aspect of this strategy is its life-cycle approach, which considers the whole pathway of plastics, from initial design to use, reuse and recycling. This approach aims to integrate circular practices within plastics value chains, promoting a radical rethinking of consumption and production patterns.

Research such as that by Geyer et al. (2017), entitled *Production, use, and fate of all plastics ever made*, provides an in-depth analysis of the environmental impact of plastics and underscores the importance of integrated strategies to address plastic pollution. In addition, the European Commission's report *A European Strategy for Plastics in a Circular Economy* provides a detailed overview of the targets and measures planned to reduce the use of single-use plastics and promote recycling.

Thanks to the expansion of circular economy policies, the transition to a more resource-efficient future is now well underway. In particular, the business case for the chemical industry to embrace the circular model is becoming increasingly persuasive. This shift is attributable to several factors, including the changing regulatory landscape, growing consumer awareness and demand, and the needs of downstream markets.

The changing policy environment has made it clear that companies need to adapt to more stringent regulations and high environmental standards. Chemical companies, in particular, are under increasing pressure to reduce their emissions and optimize resource use. In addition, consumer demand for more sustainable products is influencing production and marketing strategies. Key sectors such as utilities, transportation, textiles and apparel, electronics, cleaning products, food and agriculture, and cosmetics and beauty are increasingly demanding circular solutions that can deliver reduced environmental impacts. McKinsey & Company's 2021 report, *The Circular Economy: A*

Transformative Opportunity for the Chemicals Industry, explores how the chemical industry can benefit from implementing circular strategies, increasing competitiveness and resilience.

The urgency of adopting sustainability-oriented and impact-neutral business models brings up digitization as a key element as it offers tools and technologies that can significantly improve the operational efficiency of companies so from a strategic point of view, it is also necessary to consider the regulatory pressures that Italian and European companies are under. In recent years, the European Union has promulgated a series of regulations that impose stringent requirements for companies' environmental impact reporting. In particular, the Corporate Sustainability Reporting Directive (CSRD), which came into force on January 5, 2023, establishes a requirement for companies to monitor and report their emissions in three distinct categories: direct emissions (Scope 1), which relate to the direct combustion of fossil energy sources; indirect emissions (Scope 2), which are associated with the consumption of energy and raw materials; and induced emissions (Scope 3), which relate to the entire supply chain. This regulatory evolution reflects a growing recognition of the importance of environmental sustainability in the business environment. Companies are no longer evaluated only by their economic performance, but also by their contribution to overall sustainability. Therefore, CSRD represents a significant step toward greater transparency and accountability, pushing companies to integrate sustainable practices into their operational and decision-making strategies. Moreover, emissions reporting is not merely about regulatory compliance, but also represents a strategic opportunity for companies. By measuring and managing their emissions, companies can identify areas of inefficiency, reduce operating costs, and improve their reputation in the marketplace.

5.3 Twin transition, innovation and patents

Twin transitions, have a significant impact on the patent landscape, influencing both the creation and implementation of new technologies. Companies operating in this area must be prepared to navigate this changing environment, and leveraging incentive

policies and seeking partnerships can really make a difference in developing solutions that are both sustainable and digital.

Here are some ways in which these transitions interact with the patent system:

1. *Increased Innovation*: with the growing demand for sustainable and digital technologies, many companies and researchers are incentivized to develop innovative solutions, leading to an increase in the number of patents related to clean technologies, renewable energy, energy efficiency, waste management, and more. Companies operating in this area are motivated to protect their inventions through the patent system to secure a competitive advantage.
2. *New Patent Areas*: twin transitions have led to the emergence of new areas of innovation that require new types of patents. For example, the integration of digital technologies with green solutions has given rise to patents for applications in the Internet of Things (IoT) for energy management, environmental monitoring systems, and smart grid technologies. These developments require a patenting approach that takes into account the specifics of both transitions.
3. *Collaboration and Knowledge Sharing*: twin transitions often encourage collaboration between companies, universities, and research centers. These partnerships can lead to broader knowledge sharing and an increase in the number of joint patents. Companies may decide to share patent rights to maximize the impact of their innovations and accelerate the development of new technologies.
4. *Incentive Policies*: many governments are implementing policies to incentivize innovation in sustainable and digital technologies, such as tax breaks for patent expenses, research grants, and funding the development of technologies that address the challenges posed by twin transitions. This makes the patenting process more accessible for start-ups and small businesses in the cleantech sector.
5. *Protection and Sustainability*: it is important to consider how the patent system can affect the long-term sustainability of innovations. Companies must balance the protection of their patent rights with the need to share critical technologies to

address global challenges, such as climate change. In some cases, this may lead to more open licensing models or collective patenting initiatives.

Over the past two decades, the landscape of power grid technologies has undergone a significant transformation, characterized by a remarkable increase in the number of registered patents. This expansion not only affects traditional infrastructure, but also focuses on smart grids, commonly known as smart grids, and the innovations associated with these advanced technologies. Smart grids represent a fundamental evolution in the way energy is distributed and managed, integrating digital technologies and communication systems to improve the efficiency and sustainability of power grids (Liu, Z., & Zheng, Y., 2019). According to the joint report by the International Energy Agency (IEA) and the European Patent Office, this growth can be attributed to a growing demand for smarter and more flexible energy solutions that respond to modern challenges such as climate change and increasing energy demand.

In a global context where technological innovation is crucial for economic and environmental progress, smart grids are emerging as a strategic answer, not only for efficient energy management, but also for the integration of renewable sources. The growing focus on these technologies has led to a flourishing of investment in research and development, spurring heated competition among companies and countries to gain a leading position in the field.

In 2023, BloombergNEF put forward a significant estimate regarding the investment needed to modernize the global power grid, quantifying it as at least $21.4 trillion by 2050. This investment is considered critical to achieving the goal of net zero greenhouse gas emissions globally. This need to upgrade electricity infrastructure is further supported by projections provided by the International Energy Agency (IEA), which indicate that investment in smart grids, or smart grids, must more than double by 2030. This increase is critical to align with the emission reduction targets in the net zero scenario to be achieved over the next twenty-five years.

The current context of increasing energy demand and the need for a transition to renewable sources requires a radical rethinking of existing infrastructure. Smart grids, which integrate advanced energy management and distribution technologies, are an effective response to these challenges. According to an IEA report (2021), the

implementation of smart grid systems not only improves energy efficiency but also facilitates the integration of renewable energy, thus contributing to a more sustainable energy system.

In a context where the transition to a sustainable energy system is of paramount importance, research and innovation play a crucial role. A particularly significant aspect of this process is patents related to power grid technologies, which can serve as indicators of progress and development in this area. Over the past nineteen years, patenting activity in the field of power grid technologies has shown exponential growth, registering an increase of about seven times over 2005 levels. This figure emerged from the report "Patents for Enhanced Electricity Grids," jointly prepared by the European Patent Office and the International Energy Agency (IEA).

The report highlights not only the quantitative increase in patents, but also their strategic relevance to the future of power grids. Indeed, technological innovation is essential to address the challenges of renewable integration, energy efficiency and infrastructure resilience. Patents as indicators of innovation can provide a clear view of the areas where most investment is being made and the directions in which the industry is headed.

In particular, innovation in electrical infrastructure emerges as one of the fastest growing technology sectors globally. This accelerating trend is particularly evident in the period between 2009 and 2013, during which the pace of innovation in electricity grids showed an astonishing 30 percent annual increase. This growth rate is seven times higher than the average recorded in other technological fields.

In more specific terms, the number of international patent families (IPFs), which represent patent applications filed in different countries to protect the same invention, has reached an average annual growth rate of 30 percent. This compares significantly with average rates of 12 percent for low-carbon energy technologies and 4 percent for technologies overall. These statistics not only highlight the growing importance of power grids in the technological innovation landscape, but also suggest that the sector is attracting increasing interest from investors and researchers.

In recent years, the growth of innovation in the power grid sector has seen a significant acceleration, in part due to the emergence of software solutions as a core strategy for companies operating in this field. This trend has considerably broadened the landscape of inventions associated with smart grids, leading to a 50 percent increase in the number

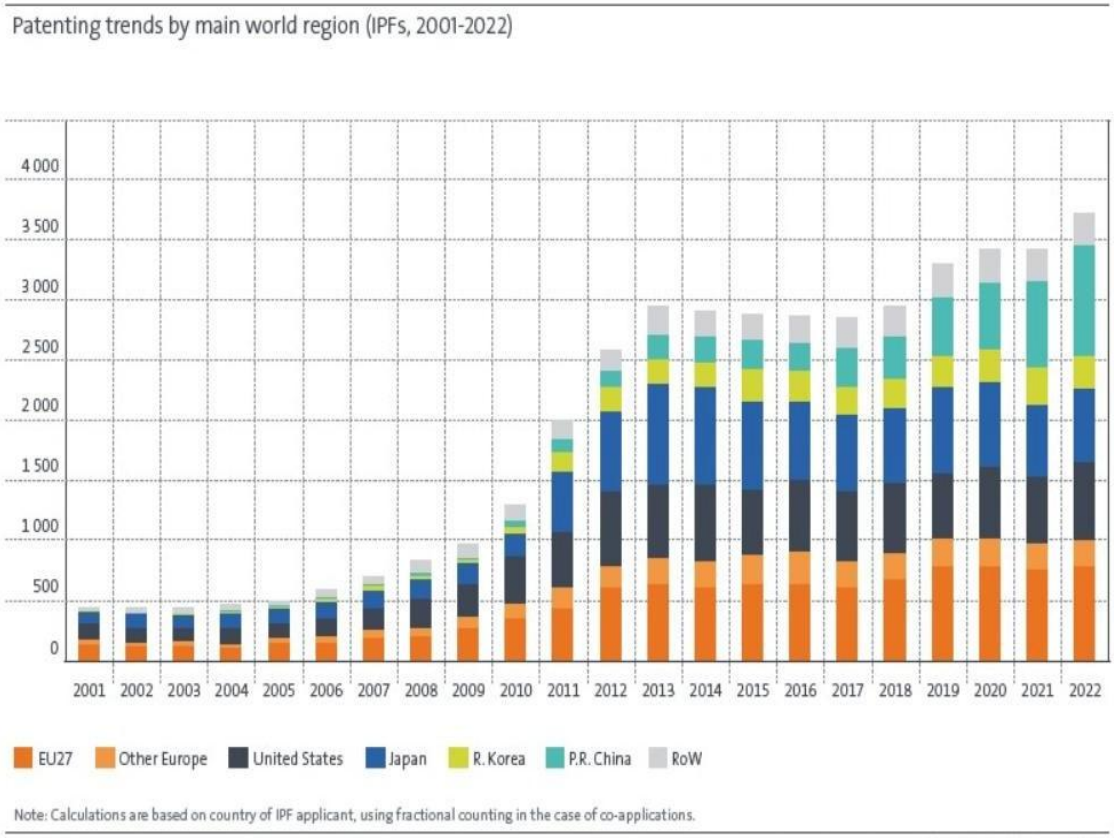
of patents related to physical grids incorporating elements of smart grids in the period between 2010 and 2022, compared to the previous decade.

This remarkable expansion has been observed mainly in regions such as Europe, Japan, and the United States, where investment policies and government initiatives have stimulated research and development in the energy sector. The integration of software into electricity infrastructure has improved operational efficiency, optimized demand management, and facilitated the interaction between different energy sources, including renewable energy systems.

In the context of technological innovation and intellectual property, patents are a crucial indicator for assessing the progress and competitiveness of different regions and companies in the power grid sector. Between 2011 and 2022, the European Union and Japan stood out as the leading global players, each contributing 22 percent of total patents in this area. This figure highlights not only the historical importance of these regions in the technology landscape, but also their ongoing commitment to research and development of innovative solutions.

However, a significant phenomenon has emerged in recent years: China has shown tremendous growth in the number of patents related to power grids. Its market share, which was 7 percent in 2013, has soared to 25 percent by 2022. This change has had a major impact, as for the first time, China surpassed the European Union in 2022, establishing itself as the leading patenting region in this specific field.

This rapid rise can be attributed to several factors, including massive investment in research and development, favorable government policies, and an evolving industrial ecosystem that fosters innovation. Thus, China has not only caught up, but also established new leadership in the field of power grid technologies, a crucial area for the transition to more sustainable energy sources and the modernization of global energy infrastructure (Zhang, Y., & Wang, J., 2021).



Source: author's calculations

5.4 The National and European industrial supply chain: cleantech, investments and regulation

The growing interest from venture capital investors, is influenced by different investment strategies and funding opportunities available for start-ups and innovative companies.

The twin transitions -digital and green- are creating new markets and business opportunities. For example, the adoption of energy efficiency, sustainable mobility, and renewable energy technologies is paving the way for a wide range of start-ups seeking funding, and venture capitalists are capitalizing on these opportunities to invest in companies that can make a significant impact both economically and environmentally.

In addition, venture capital investors are particularly interested in startups developing cutting-edge technologies, such as artificial intelligence, the Internet of Things (IoT),

and data management solutions, as technologies that can be integrated with cleantech solutions, creating synergies that can lead to disruptive innovations and strong growth potential.

In this context, incentive policies encourage investment in sustainable and digital technologies, such as subsidies, tax breaks, and specific investment funds, and make funding cleantech startups more attractive by encouraging venture capitalists to invest. Regulations that encourage the use of clean technologies can push companies to invest in innovative solutions, while a lack of incentives can limit such investments and perpetuate environmentally harmful practices (OECD, 2021).

The Green Deal Industrial Plan, presented by the European Commission, regulates the goals of Europe's zero-emission industrial supply chain to achieve climate neutrality by proposing to create a favorable regulatory environment capable of stimulating the expansion of the Union's manufacturing capacity in technologies and products considered essential to achieving these goals (batteries, turbines, heat pumps, solar panels carbon capture and storage systems).

However, data coming from the International Energy Agency (IEA) regarding the clean technology sector is concentrated in a few nations, with China emerging as the undisputed leader. One aspect that raises questions about the security and sustainability of global supply chains.

The regulatory framework made explicit by the European plan, is based on four key pillars: creating a clear and simplified regulatory environment, accelerating access to finance, enhancing the skills needed for the sector, and promoting open trade that fosters resilient and diversified supply chains. In this perspective, the implementation of new national legislation focused on critical and strategic raw materials underscores not only the intrinsic economic value of these materials, but also their function in promoting a transition to more sustainable and digitized economic models[2].

Regulation (EU) 2024/1252 aims to (Art.1):

- Increasing and diversifying the EU's supply of critical raw materials (Chapter 3) and their monitoring (Chapter 4);

[2] Published in the Official Gazette, (No. 189 of Aug. 13, 2024) Law 115/2024, which converts, with amendments, Decree Law No. 84 of June 25, 2024, aligning our system with the objectives set forth in EU Reg. 2024/1252.

- Strengthen circularity (Chapter 5), including recycling (Art.28);
- support research and innovation in resource efficiency and substitutes development (Art.26).

The regulation aims to strengthen all stages of the European value chain of critical raw materials:

- Diversifying EU imports to reduce strategic dependencies;
- Improving the EU's ability to monitor and mitigate the risks of supply disruptions to critical raw materials;
- Strengthening circularity and sustainability.

In parallel, there is a complex reform of the electricity market structure that aims to ensure that consumers can take advantage of the reduced costs associated with renewable energy sources, therefore, it is essential to focus on activating strategic approaches that enable a level playing field in the single market to accelerate investment and financing for green technology production within Europe, enabling member states to provide the necessary aid to support projects that accelerate the green transition (European Commission, 2022). The active involvement of public institutions and private capital is critical to ensuring the success of these initiatives, as the green transition requires substantial investment and a shared vision. (Karp & P.D., 2020).

To facilitate and speed up the process of granting aid, the European Commission has initiated consultations with member states on the potential revision of the temporary crisis and transition framework regarding state aid (European Commission, 2020) This initiative reflects a significant shift in European policies, as the Union has traditionally maintained a strict stance on state aid, emphasizing the importance of ensuring fair competition in the single market.

The current environment of environmental challenges and the need to promote green technologies has led to an increased focus on Cleantecs. To align with the goals of the Green Deal, a revision of the General Block Exemption Regulation is planned, which aims to adapt existing regulations to this new reality (EuropeanCommission, 2021). This revision includes increasing the notification thresholds for green investments, thus

allowing member states to provide more meaningful support without the bureaucratic complications previously required.

Although there is a concrete diffusion of clean technologies in the Bel Paese, Italian companies face significant challenges related to the integration of cleantech into their business models. In the national business landscape, there is a high percentage, 83 percent, of companies that have not implemented a business plan that integrates sustainability among their strategic objectives. These are the data that emerged from the Clean technology Observatory, conducted by Innovatec Group, in collaboration with Emetra, which involved a sample of 800 companies active in different sectors, including industry, construction, trade and catering, distributed throughout the country.

In the current context, it is possible to outline a complex situation regarding companies' investments in sustainability. In fact, a significant portion, 45%, have already undertaken initiatives in this area. Of these, 38% have directed their resources toward projects focused on energy efficiency, 20% have initiated processes of industrial reconversion, either partial or total, adopting more sustainable solutions, and 18% have invested in the installation of green technologies. Finally, 9% of companies have chosen to implement circular economy practices.

However, despite this progress, several barriers emerge that hinder further deployment of such investments. Among these, lack of appropriate skills is a significant problem, highlighted by 38% of companies, followed by the high cost of raw materials, which is a challenge for 31% of companies. In addition, 30% of companies complain about the lack of adequate government incentives, and 24% point to excessive bureaucracy as a hindrance to investment in sustainability.

This situation highlights the need to develop strategies that foster greater uptake of sustainable practices in the business fabric by addressing the critical issues mentioned above. It is crucial to create training programs to fill skills gaps and incentivize access to affordable sustainable materials, as well as to simplify bureaucratic processes to promote a more conducive environment for sustainable innovation.

5.5 Innovation and public funding: the situation of European start-ups

European start-ups encounter significant difficulties in their growth path, mainly due to an uneven regulatory environment, a limited appetite for risk and the inefficiency of available funding mechanisms. In contrast, the US offers an example of how ambitious strategic goals and strong public support can stimulate the emergence of high-impact innovations.

According to data provided by Eurostat, Europe accounts for around 20% of global investment in research and development (R&D) and European companies are the main players in this field, contributing 66% of total R&D expenditure, which amounts to almost EUR 233 billion out of a total of around EUR 352 billion (Eurostat, 2021). This scenario highlights the importance of a favorable ecosystem that promotes risk and innovation to foster the growth of start-ups on the continent. This approach highlights the need for reforms that can address existing barriers and foster a more favorable environment for startups to grow in Europe.

Europe currently faces a significant challenge in fostering the growth of global technology leaders. Despite the astonishing increase in investment in the tech sector, which from 2015 to 2023 reached the figure of $426 billion - a tenfold increase compared to the previous decade - the continent is struggling to emerge as a major player on the global tech stage. This paradox is further accentuated by the fact that the European technology sector employs around 3.5 million people and has more than 35,000 active start-ups, outnumbering those in the US (European Commission, 2023). One of the main reasons why Europe struggles to develop global start-ups is the fragmentation of the market. Unlike in the US, where a unified technology ecosystem fosters the growth and scalability of companies, in Europe different national regulations and varied languages can hinder expansion and collaboration among start-ups (McKinsey & Company, 2022). Moreover, access to venture capital, although growing, is still less accessible than in the US, where investors are more willing to bet on innovative and long-term ideas (PitchBook, 2023).

In addition, the entrepreneurial culture in Europe tends to be more conservative, with greater risk aversion than in the US. This mentality, combined with an education system that often does not encourage innovation and entrepreneurship, may limit the ability of start-ups to grow and compete globally (OECD, 2023).

Europe stands out as the region on the planet that generates the highest number of PhDs in scientific and technical disciplines, boasting one of the highest levels of training globally. Moreover, the cost of training these PhDs is significantly lower than in the United States, making Europe an attractive location for training highly qualified talent (European Commission, 2023). This abundance of human resources, represented by a critical mass of intelligence and expertise, places Europe in a privileged position compared to other areas of the world. Indeed, European universities and research institutes are able to nurture an innovative ecosystem, capable of generating advanced ideas and technological solutions (OECD, 2023). However, despite this valuable resource, the continent faces the challenge of adequately harnessing and channeling these competences in the industrial and business sector.

The ability to transform human potential into concrete and applicable innovation is crucial for Europe's technological future. To achieve this, stronger synergies between universities, research centers and businesses need to be created, thus fostering an environment conducive to innovation and commercialization of ideas (European Innovation Council, 2022).

The issue of support for start-ups in Europe, through tax incentives, subsidies and other forms of assistance, raises fundamental questions regarding the effectiveness of such measures. It is questionable whether this direction is really the most appropriate one to stimulate innovation and growth in the European entrepreneurial landscape. Despite the global recognition of venture capital (VC) as one of the asset classes with the highest return potential, it is important to analyze why it is necessary to provide fiscal incentives for investments in already promising sectors.

A central aspect to consider is the discrepancy between the availability of capital and its actual deployment in European venture capital. Institutional investors, who manage huge assets, often show reluctance to channel resources into VC, despite the return potential. This situation may stem from a number of factors, including the perceived risk associated with investing in start-ups, the lack of a sufficiently mature and integrated ecosystem and competition with more attractive markets, such as the US (Bock, 2020). Furthermore, the demand for tax incentives to attract VC investments raises questions about the sustainability and fairness of such policies. Instead of incentivizing investments in already high-yielding sectors, it might be more appropriate to explore strategies that promote innovation and competitiveness in a more inclusive

and sustainable way. Creating a favorable entrepreneurial environment that facilitates access to capital and encourages collaboration between start-ups, investors and institutions might prove to be a more effective solution (Mazzucato, 2018).

Ultimately, while the debate on how to stimulate venture capital in Europe is crucial, it is crucial to think carefully about the policies adopted. The mere implementation of favourable tax regimes may not be sufficient to attract significant investment. A more holistic and strategic approach is needed that considers market dynamics, investor needs and growth opportunities for European start-ups.

Entrepreneurial and technology ecosystems at the European level, and particularly in relation to startup investments, show a variety of performances due to multiple factors, ranging from apparent to deeper and more strategic motivations. The first and most obvious reason concerns the fragmentation of national markets, a phenomenon that manifests itself in various areas, including regulations, languages, and capital-raising mechanisms (Morandi, 2022). An example of this fragmentation is the disparity of investments by the main financial institutions: the Cassa Depositi e Prestiti (CDP) tends to invest to a limited extent in Italian start-ups, while Bpifrance, the French public fund, concentrates its investments mainly on local companies. Similarly, German Länder tend to focus on supporting German start-ups, creating a landscape in which local ecosystems are strongly influenced by national and regional policies. This fragmentation is exacerbated by another crucial factor: over-regulation, which manifests itself in a huge number of laws and regulations, often sector-specific. The European Union, with its highly regulated policies, is characterized by a complex and diverse regulatory framework with more than 100 regulations dedicated to the technology sector, together with more than 270 regulators operating within the digital networks of the Member States. This regulatory landscape generates a fragmented environment with heterogeneous and, at times, contradictory requirements, which can hinder the effectiveness of ecosystems across borders (European Commission, 2020).

In addition, Europe has seen a huge proliferation of start-ups in recent years, with more than 13,500 new start-ups born over the past five years, contributing to a massive production of documentation, including millions of pages of regulations, directives and procedures. This phenomenon has accentuated the difficulty for economic actors to navigate in an environment that is as dynamic as it is complex. These factors not only reflect the difficulties inherent to the creation of a single European market for start-ups,

but also suggest a need for reform that can simplify the regulatory framework and foster interoperability between different national jurisdictions. In this sense, an adjustment of regulatory policies and an incentive to transnational cooperation could be the key elements for greater uniformity and competitiveness of European start-up ecosystems.

In response to the criticalities exposed by the European regulatory landscape, the introduction of additional special regimes for start-ups does not always prove to be decisive but sometimes risks exacerbating the distortions of the system as it seems to reinforce the regulatory fragmentation of the system rather than resolving it. In reality, it is unrealistic to think that one can predict ex ante which start-ups will be successful and which will not. This means that the introduction of different regulatory regimes for start-ups implies that some companies, based on criteria that are not always easy to identify in terms of transparency and objectivity, will find themselves operating in more favorable regulatory environments than others. The central issue lies in the fact that often special regimes are likely to favor those start-ups that already have a positive evaluation, for instance companies that already come from certified incubators, are backed by prestigious investors or emerge from certain university circuits or research centers considered elite.

This approach runs the risk of limiting access to regulatory benefits exclusively to those who enjoy a privileged position, excluding a large number of emerging realities that, although innovative, do not fall into these categories.

This system contributes to further widening the gap between star-ups that have access to resources and opportunities linked to special schemes and those that are not part of them, thus limiting the diversity and inclusiveness of the entrepreneurial economy.

Moreover, the scope of public funding for innovation is configured at the European level by a predominance of large companies, some of which have state bodies as majority shareholders, while others are part of multinational alliances, where coordination between different countries becomes more important than the actual ability to introduce innovations. In this context, it is uncommon to observe that European municipalities choose to equip themselves with technology solutions produced by local start-ups or directly support the launch of innovative start-ups, without the support of the largest available customer, the public sector. This scenario highlights a lack of willingness to take risks on the part of public actors in entrusting such contracts to

smaller companies, which could bring innovation but also a higher degree of uncertainty (Mazzucato, 2013).

This situation generates a vicious circle for start-ups, which find it difficult to access private capital, not only due to the lack of a sufficiently mature market, but also due to the absence of public support to act as a 'catalyst' for innovation. Indeed, start-ups have to deal with the difficulty of raising funds, whether through public or private funding, in an environment where large players with significant resources and an established position dominate. The lack of direct public contracts for start-ups and the preference for solutions already tested and implemented by large companies further contribute to the difficulty of scalability for these emerging companies. Without the ability to access meaningful public contracts, startups are unable to grow fast enough to challenge market leaders, thus remaining trapped in a limited development phase (Hemerijk, & Züger, 2017).

This dynamic contributes to the poor scalability of European startups, as access to public contracts is one of the main levers for rapid expansion. The situation would be quite different if there were more openness on the part of public administrations to take risks and invest in young innovative companies, perhaps even through more flexible public procurement mechanisms that allow startups to compete on equal terms with large companies (Edquist, 2019).

To understand how states manage to excel and foster the creation of innovation ecosystems, it is useful to consider two main aspects. First, states achieve significant results when they clearly define their strategic priorities in an area of innovation that they know inside out. Under these circumstances, they are willing to take risks by purchasing innovative solutions from anyone capable of providing them, regardless of their origin. Secondly, states can achieve great things when they set such ambitious goals that, in an attempt to solve the many challenges they encounter along the way, they generate market-transforming innovations. The United States, for example, is a model in this context, having often adopted similar approaches to stimulate innovation and technological progress (Mazzucato, 2013).

Originally, Silicon Valley was simply an agricultural region, without any advanced technological connotations. It was the public sector's appetite for semiconductors, mainly for military purposes, that radically transformed its economic and technological landscape. Similarly, the Apollo program spawned a multitude of innovations not

because there was direct funding for the innovation itself, but because the challenge of realizing a feat considered almost technically impossible drove numerous companies to develop previously non-existent technologies. This dynamic has shown how bold goals can stimulate a fertile environment for innovation, promoting the creation of cutting-edge technologies (O'Neill, 2019).

At the heart of the world's most innovative technology projects is the Defense Advanced Research Projects Agency (DARPA), a US agency dedicated to advanced defense research. Contrary to what one might imagine, it is not a mega-structure, but a relatively lean organization consisting of about 220 people who simultaneously oversee a number of projects of around 250. It is thanks to the willingness to tackle seemingly unrealizable challenges that revolutionary technologies such as the Internet, GPS, quantum computing, stealth technologies, advanced robotics, artificial intelligence, and many others have been developed. This boldness of design has allowed the United States to invest in initiatives that would be considered too risky for public funding in Europe (Fuchs, 2010).

The public sector is often in the privileged position of being able to take greater risks than the private sector, especially in the context of innovation and project development. While private companies usually have to be more cautious in the management of their financial resources, due to the uncertainty of the markets and the need to secure profits for investors, the public sector has a budget that is derived from taxation and administered by government bodies. This budget, due to its relatively stable and predictable nature, allows for riskier ventures. This ability to manage high-risk projects without having to immediately face the consequences of financial failure is a distinctive characteristic of the public sector (Mazzucato, 2013).

Unlike private companies that risk bankruptcy if they do not manage their resources well, the public sector has the opportunity to justify its expenditure with objectives that go beyond the immediate economic return. These objectives include improving public health, ensuring national security and promoting sustainable development. The public sector focuses on these aspects because they are part of its nature and responsibility. However, precisely because public sector tenders require high compliance with technical regulations and high guarantees, this may result in less impetus towards innovation than the private sector.

Conclusion

Europe emerges as a key player in the global landscape geared towards achieving zero net greenhouse gas emissions. In this scenario, the continent emerges as a leader in the field of green technologies, supported by a substantial number of patents reflecting its commitment to innovation and research in this field.

However, it is competing with countries such as China and the United States that are rapidly advancing in the field of green technologies, which implies the need to invest in research and development (R&D) as well as to adopt appropriate policies to support the innovation and commercialization of sustainable technologies.

Clean technologies in Europe face a long-standing and well-documented challenge, namely the funding gap that characterizes the innovation environment on the continent. This gap constitutes a major obstacle for start-ups and emerging companies in the field of sustainable technologies, limiting their ability to grow and expand their activities.

Currently, an increasing number of companies operating in the sustainable technology sector show a marked inclination towards debt financing rather than the use of venture capital or equity investments, and this trend can be attributed to a number of factors, including market dynamics, cultural characteristics that influence entrepreneurship, and the availability of financial resources. However, relying on debt-based financing arrangements presents considerable risks; in particular, firms may find it difficult to manage loan repayments, especially in the early stages of development when cash flows tend to be uncertain (Rennings, 2000).

The European Union (EU) market is emerging as a nerve center for innovators in the field of sustainable technologies, representing a major strategic choice for the development of European companies. This inclination is supported by several factors, including the size of the market itself, the possibility of access to a large customer base and the opportunity to benefit from economies of scale. A key aspect that enhances the value of the EU single market is the presence of a well-defined and consistent regulatory framework. This regulatory system not only facilitates entry and competitiveness of firms, but also promotes innovation through uniform standards that incentivize research and development in the area of clean technologies (European Commission, 2020).

Businesses, particularly larger ones, recognize the importance of maintaining regulatory stability, which is essential for facilitating international operations and ensuring a competitive and fair environment. According to a report by the European Commission, a robust regulatory system fosters innovation and helps ensure that companies meet high environmental standards, thereby promoting sustainable business practices (European Commission, 2020).

Furthermore, a robust single market offers opportunities for collaboration and partnership between companies, institutions and research centers, facilitating the exchange of knowledge and expertise (European Investment Bank, 2021).

In this context, a key role is played by patents as a fundamental element for European companies in the field of environmentally friendly technologies, as they enable them to safeguard their competitive advantages in an ever-changing field. The protection provided by patents does not only safeguard technological innovations, but also proves to be a strategic element in the commercialization of new solutions and the promotion of fruitful collaborations with other market players. Furthermore, patents can facilitate access to finance, which is particularly significant for small and medium-sized enterprises (SMEs) in the field of sustainable technologies, which often face capital constraints (European Patent Office, 2020).

The ability to demonstrate a robust patent portfolio can increase the chances of attracting investment, thus contributing to the growth and expansion of cleantech companies. A report by the European Investment Bank shows that companies with strong intellectual property are more likely to receive funding and establish strategic alliances (European Investment Bank, 2021).

In this context, the introduction of the Unitary Patent represents a significant step that offers new opportunities for European companies as it aims to simplify and make the registration of patents throughout the European Union more accessible, eliminating the need for separate national proceedings and reducing the associated costs. The possibility of obtaining a patent valid in several member states with a single application could significantly increase the protection of innovations and, consequently, further stimulate investment in research and development in the area of clean technologies (European Commission, 2022).

Clean and sustainable technologies are a dynamic area of research, ranging from inventions for low-emission energy production and conservation, to solutions for

creating eco-friendly buildings and transport systems. Smart networks, known as smart grids, represent another area of significant development, facilitating more efficient management of energy resources.

With reference to investment in the cleantech sector, the current state and future prospects of VC both at the European and Italian levels, appear comforting, as confirmed by the data recently collected and published in State of the Italian Cleantech Ecosystem, by Cleantech for Italy & MITO Technology and State of European Tech 24, by Atomico. In line with the observed trends, there was a decrease from the year previous year, in particular, in Italy, where investments decreased significantly, from more than 220 million euros in 2023 to about 100 million euros in the first nine months of 2024.

In general, over the past decade, the Climate-Tech sector in Europe has shown steady growth, roughly doubling in size. Currently, one-fifth of venture capital allocated to Venture Capital on the continent is directed toward creating a more sustainable future through innovative approaches involving the development of new technologies, many of which are still at a pre-industrialization stage.

The acceleration in the allocation of venture capital to this asset class highlights not only the significant efforts that entrepreneurs and innovators are making, but also the substantial opportunities that investors perceive in these initiatives. In the period between 2015 and 2021, the proportion of funding allocated to sustainability-focused ventures remained between 9% and 12%, which is a remarkable figure. However, there was a significant increase in 2022, with this proportion reaching 18%. This positive trend continued in 2023, peaking at 27 percent, supported by large financing deals such as the $473 million Series B round of 1KOMMA5°[3] and the $935 million Series C round of Verkor[4].

Interestingly, transactions of this magnitude were not repeated in 2024, suggesting a possible slowdown in this specific market segment.

In 2024, a significant 21% share of the capital invested in Tech-Venture in Europe was directed to companies engaged in the fields of “climate” and “sustainability.” By comparison, in the United States, this percentage stands at a modest 11 percent. Furthermore, it is interesting to note that 95 percent of European sustainability funding

[3] German startup specializing in renewable energy, particularly in sustainable home energy solutions.

[4] French startup born in 2020, specializing in infrastructure and energy transition. Specifically, it refers to a gigafactory for the production of batteries for low-carbon electric vehicles.

supported initiatives focused on climate change mitigation, rather than those related to adaptation and resilience. This finding suggests that European innovators tend to set ambitious goals and tackle complex challenges, seeking to make a meaningful change in an increasingly critical global context.

These trends point to a proactive approach by European investors and companies in responding to environmental challenges, placing a strong emphasis on reducing emissions and combating climate change (Pwc, 2021; European Investment Bank, 2022). This scenario could reflect growing social awareness and responsibility, as well as a long-term investment strategy that seeks to align with global sustainability goals. It is critical to understand that the sector has development timelines that are, to a large extent, inevitable. While in the short term there is a tendency to overestimate the impact of a technology, along with the efforts required to validate it and launch it into the market, in contrast, in the long term, the tendency is to underestimate its relevance and the effects it can generate. This phenomenon can be attributed to a narrow view of innovation dynamics, where immediate effects capture more attention, while deeper and more lasting transformations take time to manifest.

Understanding these dynamics is relevant to investors and innovators, as a more realistic assessment of the timing and impact of emerging technologies can lead to more informed and strategic decisions (Rogers, 2003; Christensen, 1997). Recognizing the value of the long run can, therefore, foster greater sustainability and resilience in business models.

Synergistic collaboration between different players, research centers, companies and academic institutions, emerges as a key step in the Climate-Tech context precisely because technological challenges necessarily require a collaborative effort and a sharing of purpose that involves both investors and entrepreneurs. In addition, substantial industrial infrastructure is required to operate at scale, and this process requires significant capital investment, which makes the transition to full operation a complex and never immediate journey. The slow adoption of innovative solutions in Climate-Tech related sectors such as plants, power generation, materials, chemicals and infrastructure is a well-documented phenomenon. This resistance to change is often attributable to the conservative nature of customers, who tend to be risk-averse. In addition, many of them use existing rules and regulations as an excuse to procrastinate the implementation of significant innovations in their production processes. This

dynamic creates an environment in which innovation is frequently hindered, thereby limiting progress toward more sustainable and efficient solutions (Rogers, 2003).

In recent years, corporate involvement in fostering innovation has increased significantly, not only in terms of financial resources allocated, but also in terms of the quality and effectiveness of the strategies adopted. Many industrial groups, having had unsuccessful experiences with direct investments in startups, have revised their approach, returning to focus on more sustainable and strategic methods. According to recent studies, an estimated 89 percent of corporate investors plan to increase or maintain their level of investment in innovative startups in 2024. Moreover, Corporate Venture Capital (CVC) is currently involved in a quarter of startups operating in Europe, signaling a significant shift in the corporate investment landscape (Gonzalez et al., 2023; European Investment Bank, 2023).

This evolution of the corporate approach not only reflects an increased awareness regarding the opportunities offered by external innovation, but also a willingness to create more effective synergies with startups. Indeed, corporations are realizing that collaborating with startups can lead to mutual benefits, contributing to a more robust and dynamic innovation ecosystem (Chesbrough, 2020).

The Climate-Tech sector has gained prominence on the European Union's policy agenda as it is understood that its evolution is not only about mitigating the negative impacts of climate change, but also about safeguarding the competitiveness of the entire European industrial landscape. In a global context where Southeast Asian nations have invested significantly in sustainable technologies, Europe faces a crucial challenge. In addition, the recent resurgence of investment in the United States, fueled by an extensive public support program aimed at promoting green transition and decarbonization, has further intensified competition (European Commission, 2023; Smith & Jones, 2023).

The European Union is therefore called upon to develop effective strategies to catch up, but also to position itself as a leader in climate innovation. This requires an integrated approach that combines public and private investment, research and development, and incentive policies that stimulate the adoption of green technologies (Baker et al., 2022). Europe's ability to address these challenges will have a crucial impact on its competitive position in the global Climate-Tech market.

The “Draghi Report” clearly and directly highlighted some key critical issues regarding the competitiveness of the European Union compared to the United States. It points out

that the productivity gap between the two regions is strongly influenced by the performance of the technology sector, where Europe appears to be falling short in emerging technologies that promise to support future growth (Draghi, 2023).

European companies also face significant challenges related to energy costs, which are two to three times higher than those in the United States, a factor that undermines their competitiveness in the global market. In the international context, China continues to invest enormous resources to assert its leadership in several key areas, including new materials and energy research. This competitive dynamic highlights the urgency for Europe to develop strategies that can boost innovation and improve energy efficiency in order not to fall behind emerging global players (European Commission, 2023; Wang & Chen, 2023).

It became clear that the creation of a more sustainable industrial environment is of paramount geopolitical importance. This implies that before pursuing immediate economic returns, it is important to ensure control over technological and industrial aspects in order to protect the independence of our production system and improve its efficiency in the medium term. Climate-tech investors, who understand the inherent dynamics of their field, are well aware that no technological innovation capable of significantly reducing emissions will have a tangible impact unless it is accompanied by a proportional reduction in consumption, production time, cost, and ease of integration with existing production systems (Smith et al., 2022; Jones & White, 2023).

Therefore, it is essential to develop solutions that not only address the issue of emissions, but are also feasible and sustainable in the current operating environment. Only through a holistic and integrated approach can a balance be achieved between environmental sustainability and industrial competitiveness, thus ensuring a more resilient future for the manufacturing system.

The Climate-Tech issue highlights the need for a radical transformation of the European manufacturing landscape, which, over the past decades, has undergone only incremental improvements. This situation has made it difficult for European companies to compete effectively with emerging industrial powers outside the continent (Baker & Thompson, 2023; European Commission, 2023).

Deep innovation is therefore imperative to restore competitiveness and ensure the resilience of the European industrial sector. The transition to more sustainable practices not only responds to pressing environmental challenges, but also represents an opportunity to renew and modernize the productive fabric, making it more competitive in a changing global context. To meet this challenge, it is essential to invest in research and development and adopt advanced technologies that can promote a true sustainable industrial revolution (Smith et al., 2022).

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Sitography

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