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A Data-Driven Analysis of Green Energy Companies in Europe:

Market Dynamics, Financing Sources, and Key Profitability Drivers

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Executory Summary

In an increasingly sustainability-oriented world, green energy companies are driving the transition towards clean technologies. This thesis aims to understand the evolution of this sector and the main challenges it faces.

This thesis is based on a European project, funded by the EIBURS program of the EIB, and conducted by Elisa Ughetto (Politecnico di Torino), Annalisa Croce (Politecnico di Milano), and Laura Toschi (Università degli Studi di Bologna). The project objective was to map Cleantech companies in Europe, creating a comprehensive database using machine learning techniques. I used this dataset to analyze the market dynamics, funding sources, and profitability drivers of the Green Energy companies in Europe.

The study describes sustainability, the European regulatory landscape, Cleantech and Green Energy companies, and their role in the energy transition. Subsequently, a descriptive statistical analysis (Chapter 3) segments the companies by ecosystem role, technological specialization, geographical distribution, and year of foundation. The analysis explores patent activity and financial KPIs, revealing that green energy companies are concentrated in Germany, Italy, France, and Spain, and that those supported by VCs tend to have higher levels of innovation. Furthermore, the analysis of financial KPIs showed that some sectors are more consolidated than others, for instance manufacturing companies that on average show a Net Profit of €5.540 million, compared to €0.242 million for distributors.

Chapter 4 focuses on funding sources, analyzing whether VC support is positive or not. Companies were distinguished between those supported by VC or business angels (BA) and those relying on alternative financial mechanisms. The analysis found that most investors are Independent Venture Capital firms based in France and Germany.

Finally, in Chapter 5 I deepen the analysis of the key factors influencing profitability, implementing an econometric model. The analysis considers variables such as geographical location, funding method, and company size. The results indicate that the profitability of the previous year, company size and certain sectors contribute to higher mean profitability. Contrary to expectations, VC funding shows a negative impact on profitability. However, it is important to note that this coefficient is attributable to the fact that VC-backed companies often adopt aggressive growth strategies that prioritize market expansion at the expense of short-term profitability. This is particularly true for established companies, while for startups the effect of VC funding on profitability was found not significant.

The results of the analysis reveal several key findings. Most of the green energy companies in the dataset are concentrated in Germany, Italy, France, and Spain, reflecting the presence of national policies and incentives towards the green economy. The analysis also highlights that VC-backed companies tend to have higher levels of innovation, as measured by patent activity, compared to non-VC-backed companies. Furthermore, company size, geographical location, and access to funding are identified as the key factors that influence profitability, with larger companies demonstrating greater financial stability and performance.

By offering a data-driven perspective on the financial and operational characteristics of green energy companies, this research aims to provide valuable information for industry stakeholders, contributing to the development of a more sustainable and economically reliable energy sector in Europe.

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Introduction

The climate crisis and the urgent need to reduce greenhouse gas emissions have made the transition to sustainable energy sources a global priority. Global average temperatures have increased of about 1°C compared to the pre-industrial era, and extreme weather events have become increasingly frequent and intense, with economic impacts estimated in trillions of dollars. In this context, European green energy companies are called upon to play a crucial role in the transition to a sustainable future. However, despite the growing attention to sustainability, the sector faces significant challenges, including high initial capital requirements, market fragmentation and the need for targeted public policies. In this complex scenario, a fundamental question arises: what are the factors that determine the success and profitability of green energy companies in Europe, and how can we support their growth to address the environmental challenges of our time?

To answer this question, this thesis relies on a data-driven analysis, starting from a valuable database created by the CLEU project (The Cleantech Industry in the European Green Deal), funded by the European Investment Bank (EIB). The CLEU project has developed a comprehensive database of cleantech companies in Europe using advanced machine learning techniques, classifying over 23 000 companies. This thesis focuses on a specific subset of the CLEU database: 11 221 Green Energy companies specialized in the production of sustainable energy, clean fuels and energy-efficient industrial technologies. The objective is to provide an in-depth quantitative analysis of the sector, identifying the key factors that drive their performance and their contribution to the European energy transition.

In particular, this thesis aims to analyze the market structure of green energy companies, assessing sectorial differences, geographical distribution, and temporal evolution. Furthermore, it will examine their capacity for innovation and growth, analyzing patent activity and financial KPIs. Finally, it will deepen the role of Venture Capital (VC) in financing these companies, examining investments, geographical and sectorial preferences, and the correlation between VC funding and profitability.

This thesis contributes to a better understanding of the dynamics of the green energy sector in Europe, providing a data-driven perspective from a large dataset.

To achieve these objectives, the thesis is structured in five chapters. Chapter 1 introduces the context of sustainability in Europe, the European Green Deal and Cleantech and Green Energy companies. Chapter 2 describes the methodology for creating the CLEU database and the selection criteria for green energy companies. Chapter 3 presents a descriptive statistical analysis of the companies, segmenting them by role in the ecosystem, technological specialization and geographical distribution. Chapter 4 examines the sources of funding, with particular attention to the role of Venture Capital and Business Angels. Finally, Chapter 5 analyzes the factors influencing the profitability of green energy companies, using linear regression models.

Chapter 1 SUSTAINABILITY IN EUROPE

1.1 The role of sustainability

“Sustainable development is development that meets the needs of the present without compromising the ability of future generations to meet their own needs.” (Gro Harlem Brundtland)

Sustainability is a principle that has guided the economic, social, and environmental development for long. Today, more than ever, it has become a global priority, influencing political strategies, technological innovations, and economic models.

Since the 1960s and 1970s, the interest in environmental issues has started to grow significantly. During those years, early environmental movements began questioning the prevailing development model, which was based on money, uncontrolled growth and the indiscriminate use of natural resources to get to the objectives. The concept of sustainability was first expressed at the United Nations Conference on the Human Environment in 1972. This led to a crucial turning point with the publication of the Brundtland Report in 1987, which defined for the first time the sustainable development as: "Development that meets the needs of the present without compromising the ability of future generations to meet their own needs." (World Commission on Environment and Development, 1987, p. 43).

This definition signed a shift in the mentality of the population, laying the foundation for an integrated vision of development in which economic, social, and environmental aspects must be considered together and balanced.

In recent decades, sustainability has become a key global topic. Technological advancements have demonstrated that reducing the environmental impact of production activities is possible through the adoption of more efficient solutions. In particular, the increasing use of renewable energy sources, such as solar and wind power, has provided concrete alternatives to fossil fuels, reducing emissions and promoting a more sustainable energy model. These technological developments not only contribute to the ecological transition but also serve as replicable models on a global scale.

Nowadays, Europe has taken a leading role in promoting sustainability by adopting strategies and regulations aimed at reducing environmental impact and supporting the ecological transition. This commitment has led to a significant evolution of environmental policies, which have progressively incorporated ambitious goals in emission reduction, circular economy, and renewable energy. Policies such as the European Green Deal have translated environmental goals into concrete actions through investments in green infrastructure, sustainable mobility, and digitalization. Europe is becoming a true laboratory for experimentation, where technological innovation and energy efficiency are integrated with responsible resource management. More and more industries and firms are emerging in Europe and in these late years they are gaining a significant share of the market also thanks to the environmental awareness in the Europeans.

The role of sustainability in modern business practices is increasingly being recognized as essential for long-term success. Companies are not only focusing on financial performance but also on their environmental and social impact, as highlighted in recent ESG and CSR research. According to recent research, the integration of ESG criteria has become a crucial aspect for companies aiming to achieve long-term sustainability and positive social impact (Smith & Jones, 2023).

Addressing the challenge of sustainability requires a multidisciplinary approach that involves public policies, scientific research, and engineering applications. Only through this synergy will it be possible to build a truly sustainable development model, capable of meeting the needs of contemporary society without depleting the planet's resources for future generations.

Primary objectives for achieving real sustainability include:

- Safeguarding biodiversity by managing its causes and implementing corrective actions;
- Increasing the use of renewable energy sources for power production;
- Encouraging and promoting the circular economy;
- Engaging society as a whole to support environmental sustainability;
- Significantly reducing greenhouse gas emissions from industry, agriculture, and transportation;
- Developing agriculture with a low environmental impact.

1.2 European Policies for Sustainability

In recent years, the European Union (EU) has intensified its commitment to combating climate change and environmental degradation, outlining ambitious strategies for a transition to a sustainable economy. The European Green Deal, introduced by the European Commission, represents one of the key policies aimed at achieving carbon neutrality by 2050, promoting a wide range of environmental objectives

Presented by the European Commission in December 2019, the European Green Deal aims to make Europe the first climate-neutral continent by 2050. One of the key aspects of the Green Deal is the revision of energy policies to accelerate the transition to a system based on renewable sources. Notable measures include the update of the Renewable Energy Directive, which aims to increase the share of clean energy in Europe's energy mix, and the enhancement of smart electricity grids, essential for efficiently managing the distribution of energy from intermittent sources like solar and wind power.

Another fundamental pillar is the implementation of 55 packages, approved in 2021, which aims at reducing net emissions by at least 55% by 2030 compared to 1990 levels. To achieve this, the Green Deal has reinforced the Emissions Trading System (ETS), asking to the most polluting industries to purchase permits for their emissions, thereby incentivizing them to adopt greener practices. Additionally, the Carbon Border Adjustment Mechanism (CBAM) has been introduced, imposing tariffs on imports of carbon-intensive products to prevent unfair competition from less sustainable industries outside Europe.

The Green Deal also seeks to revolutionize the transport sector, one of the main contributors to CO_2 emissions in Europe. Measures include the development of high-speed rail networks, incentives for electric mobility through investments in charging infrastructure, and the expansion of public transportation in urban areas to reduce reliance on private vehicles.

Sustainability is one of the political priorities set by European Commission President Ursula von der Leyen. In this context, the 2030 Agenda for Sustainable Development and its 17 Sustainable Development Goals (SDGs), adopted by the United Nations General Assembly in September 2015, have also played a crucial role, giving new momentum to global efforts to achieve sustainable development.

The SDGs aim to ensure a continuous improvement in the quality of life and well-being of citizens without compromising the well-being of future generations. They also address key issues such as climate change mitigation, environmental protection, and social justice, emphasizing the need for a balanced and inclusive approach to sustainability.

In 2023 Eurostat, the statistical division of the European Union, published the report "Sustainable Development in the European Union – Monitoring Report on Progress Towards the SDGs in an EU Context – 2023 Edition.", a document that provided a statistical overview of the progress made towards achieving the Sustainable Development Goals (SDGs) in the EU.

The report offers a comprehensive analysis of all SDGs, focusing on trends observed over the past five years, with data primarily covering the periods up to 2021 and 2022. While it is clear that the EU has made significant progress on several SDGs, the report also highlights that environmental trends are not as positive.

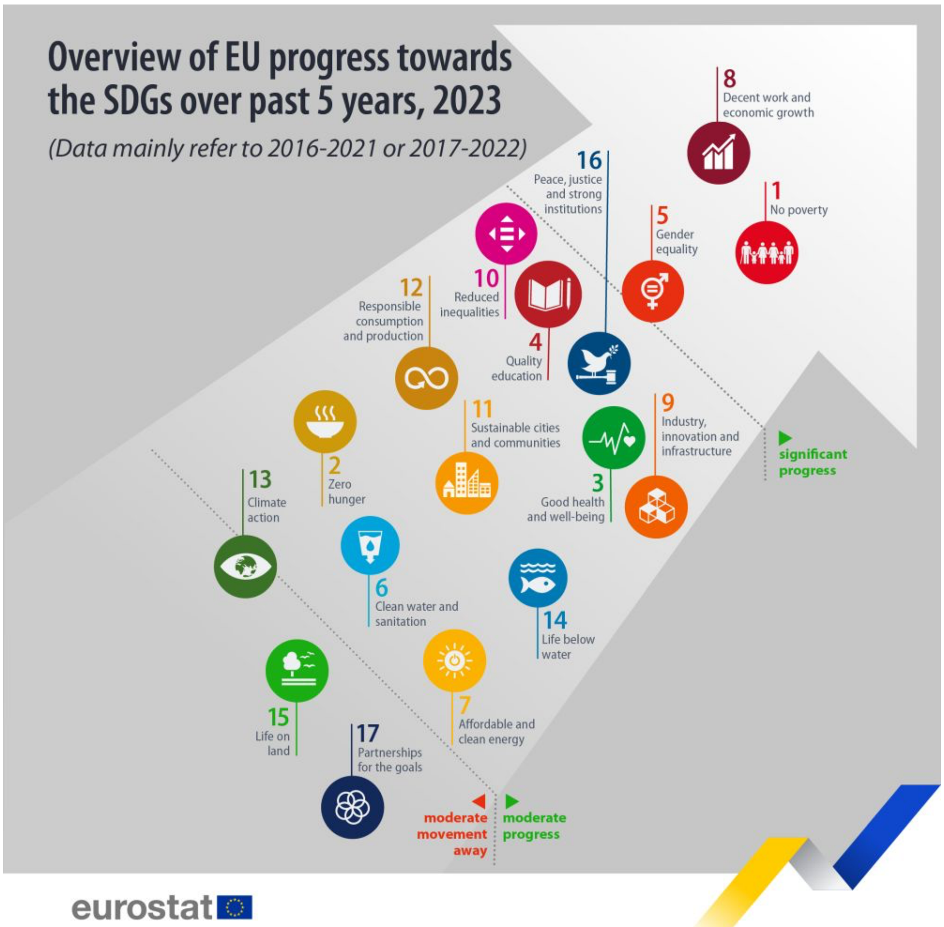

Figure 1.1: Overview of EU progress toward SDGs, Eurostat

Where possible, the report evaluates indicators on two different time frames: the short term, considering developments over the past five years, and the long term, analyzing trends over the last 15 years.

For the first time, the report has also examined the short-term impact of recent crises on the SDGs, taking into account the energy challenges caused by Russia's aggression against Ukraine and the post-COVID economic adjustments.

The main SDGs studied in this thesis are the following:

- SDG 6, Clean Water and Sanitation. The data show a steady decrease in the percentage of people lacking access to adequate sanitation facilities. However, water quality assessments indicate ongoing concerns, such as a rise in phosphate concentrations in rivers, which poses a risk to the aquatic ecosystems.

Figure 1.2: SDG 6, Clear water and sanitation

- Sustainable Development Goal (SDG) 7, Affordable and Clean Energy. It is influenced by two main factors. Recent agreements between the Council and the European Parliament have set even more ambitious energy targets for 2030, requiring much faster progress in energy efficiency and renewable energy compared to the trends observed in the reporting period. In 2021, both primary and final energy consumption increased compared to the 2020 low, although they remained below pre-pandemic levels. A similar trend was observed in the residential sector, where household final energy consumption saw a significant rise.

Figure 1.3: SDG 7, Affordable and clean energy

- SDG 9, Industry, Innovation, and Infrastructure. The trend shows moderate progress, but challenges remain. The EU has improved its research and innovation capacity, with investments in R&D reaching 2.2% of GDP in 2022, yet still below the 3% target. The assessment is also influenced by the slow adoption of circular economy practices in manufacturing. To meet 2030 targets, greater private-public collaboration and funding for clean technologies will be essential.

Figure 1.4: SDG 9, Industry, Innovation and Infrastructure

- SDG 13, Climate Action. Its trend shows a slight negative slope. The EU has already reduced its net greenhouse gas emissions by approximately 30% compared to 1990 levels. However, much greater efforts will be required to meet the ambitious goal of a 55% reduction by 2030. A key challenge is the need for a significant increase in the share of renewable energy in the EU's energy mix. Additionally, the assessment is negatively affected by the intensifying impacts of climate change, such as the rising of temperatures.

Figure 1.5: SDG 13, Climate Action

- SDG 15, Life on land. While the EU's forest area has expanded, human activities continue to put ecosystems and biodiversity under pressure. To reverse environmental degradation, the EU has introduced major commitments within the 2030 Biodiversity Strategy, the 2030 Forest Strategy, and the EU Soil Strategy, which aims to restore degraded land and combat desertification by 2030.

Figure 1.6: SDG 15,Life On Land

1.3 Cleantech and Green Energy companies

One definition of Cleantech is “any technology, process, product, or service that reduces or, where possible, eliminates negative environmental impacts through significant improvements in operational performance, productivity, and energy efficiency, while reducing costs, inputs, and resource consumption upstream, and waste emissions and pollution generation downstream”. Cleantech companies, or clean technologies, represent an emerging sector of the global economy that focuses on innovation and the development of sustainable and environmentally friendly technologies. These companies are dedicated to creating solutions that reduce environmental impact, improve energy efficiency, and promote the sustainable use of natural resources. Cleantech technologies cover a wide range of sectors, including renewable energy, waste management, water efficiency, and sustainable mobility.

Cleantech companies operate with the goal of facing some of the environmental challenges of our time, such as climate change, air and water pollution, and waste management. These companies develop and implement technologies that reduce greenhouse gas emissions, improve air and water quality, and promote the efficient use of natural resources. For example, cleantech technologies can include solar panels, wind turbines, waste management systems, and energy efficiency solutions in buildings.

In recent years, cleantech companies have experienced exponential growth, driven by increasing environmental awareness and government policies aimed at combating climate change. The adoption of international agreements, such as the Paris Agreement of 2015, has prompted many countries to invest heavily in clean technologies to reduce greenhouse gas emissions. This has led to an increase in investments in the cleantech sector, with many startups receiving significant funding to develop new sustainable solutions.

According to BloombergNEF data, global investments in cleantech technologies reached $500 billion in 2023, a 20% increase compared to the previous year. This growth was primarily driven by investments in renewable energies, which accounted for over 70% of total cleantech investments. In particular, the solar sector saw significant growth, with a 30% increase in investments compared to 2022.

Technological progress has made cleantech solutions more accessible and affordable. For example, the cost of renewable energies, such as solar and wind, has decreased dramatically in recent years, making them competitive with traditional energy sources. According to the International Energy Agency (IEA), the cost of solar energy has decreased by 90% since 2010, while the cost of wind energy has decreased by 70%. This has encouraged many companies and governments to adopt clean technologies, promoting a transition to a more sustainable economy.

The growth of the cleantech sector has also been supported by a shift in consumer preferences, with consumers becoming increasingly aware of the environmental impact of their choices and seeking sustainable products and services. This has created new market opportunities for cleantech companies, which can offer innovative and sustainable solutions to meet consumer demand.

Within the vast landscape of cleantech companies, the subgroup of green energy companies plays a prominent role. Green energy companies specialize in the production and distribution of energy from renewable sources, such as the sun, wind, water, and biomass. These companies play a crucial role in the energy transition, helping to reduce dependence on fossil fuels and mitigate the effects of climate change. Renewable sources are natural resources that regenerate quickly compared to human time scales and include the sun, wind, water, and biomass. Green energy companies aim to replace traditional energy sources, such as coal, oil, and natural gas, which are limited and significantly contribute to pollution and climate change.

Green energy companies focus on various technologies and solutions for the production of renewable energy. For example, solar companies develop and install photovoltaic panels to convert sunlight into electricity, while wind companies build and operate wind farms to harness wind energy. Hydroelectric companies use the power of moving water to generate energy, while biomass companies produce energy using organic materials such as agricultural residues and forest waste.

According to the IEA, renewable energies accounted for 29% of global electricity production in 2024, a 3% increase compared to 2023. This growth was primarily driven by the increase in installed capacities of solar and wind energy, which accounted for 60% and 30% of new renewable capacities installed in 2024, respectively.

Main Characteristics of Green Energy Companies:

1. Environmental Sustainability: green energy companies are committed to reducing the environmental impact of their operations. They use renewable energy sources that do not emit greenhouse gases and do not impact natural resources. This approach helps reducing pollution and preserving the environment for future generations. According to an IEA report, the adoption of renewable energies avoided the emission of over 1.5 billion tons of CO_2 in 2024.

2. Technological Innovation: these companies invest in research and development to improve the efficiency of renewable technologies. Technological innovation is essential to make renewable energies more competitive and accessible to everyone. For example, solar panels companies are developing more efficient and less expensive products, while wind companies are designing larger and more powerful turbines. According to BloombergNEF data, investments in research and development in the renewable energy sector reached $50 billion in 2023.

3. Circular Economy: many green energy companies adopt circular economy principles, seeking to minimize waste and reuse of materials and resources. This approach helps creating a more sustainable and resilient system. For example, biomass companies can use agricultural residues and forest waste as raw materials for energy production, reducing the amount of waste that ends up in landfills. According to a World Resources Institute report, the adoption of circular economy practices in the energy sector could reduce global CO_2 emissions by 20% by 2030.

4. Social Responsibility: green energy companies often engage in social responsibility initiatives, working closely with local communities to promote sustainable development and creating jobs. For example, companies can collaborate with local communities to develop renewable energy projects that benefit both the environment and the local economy. According to the International Labour Organization (ILO), the renewable energy sector created over 11 million jobs globally in 2023.

5. Policies and Regulations: green energy companies operate in a regulated environment that promotes the use of renewable energies. Government policies, such as tax incentives and feed-in tariffs, play a crucial role in supporting the growth of these companies. For example, many governments offer tax incentives for the installation of solar panels or the construction of wind farms, making it more convenient for companies to invest in these technologies. According to an IEA report, supportive policies for renewable energies contributed to a 40% increase in installed renewable energy capacities in 2023.

Chapter 2 THE CREATION OF THE DATABASE

This chapter will explain the sources and the methodology used to construct the database dedicated to the European Green Energy sector. The database used in this study is based on the one used in the paper "*Using machine learning to map the European Cleantech sector"* (Ambrois et al., 2023). This paper was the result of the CLEU project financed by IBURS (European Investment Bank University Research Sponsorship Programme). In the CLEU project the authors, created a database of 23 858 Cleantech companies through advanced machine learning techniques and meticulous manual classification, and then they did several analyses to better understand the mapping of the Cleantech sector in Europe to overcome the limitations of traditional industrial classifications through advanced machine learning techniques and meticulous manual classification. The process of creation of the dataset was extracted from the "*Using machine learning to map the European Cleantech sector"* (Ambrois et al., 2023) document.

The primary data source used is the Orbis database, one of the most complete global industrial databases that gives information about millions of companies, commercialized by Bureau van Dijk, a company specialized in business data that provide access, through platforms such as Orbis, to information and analytics.

The companies included in the Cleantech dataset were selected based on three key criteria:

1. Geographic location: the companies have their main headquarters in Europe, focus of the study.
2. Availability of financial data: companies were required to have at least one year of recorded financial data.
3. Detailed business descriptions: a complete description was necessary to apply the next steps of the creation of the repository, to fully understand in which sector were involved the firms taken in consideration and if they could have been categorized as "Cleantech firms".

After applying these criteria, the initial sample included 537 129 companies, that was the starting point.

From that point there was the need to progressively refine the starting dataset and accurately identify cleantech companies. To do so, three main steps were applied:

1. Application of Supervised Machine Learning Algorithms: the first stage involved using the companies' detailed description extracted from Orbis to filter the dataset through a machine learning algorithm. This process included the following steps:
    - A training dataset manually created by labeling the firms as "Cleantech" or "non-Cleantech".
    - Text mining techniques, such as "keyword extraction", "text preprocessing", and "feature extraction" were applied to extract relevant information from the companies' descriptions, such as words and phrases that indicated being involved into clean energy activities (e.g., "renewable energy," "energy efficiency," and "sustainable technologies").
    - When choosing the right machine learning algorithm some criteria indicated that the Gradient Boosting Machine (GBM) algorithm was the most suitable for the study thanks to its great ability to handle the differentiation between "Cleantech" and "non-Cleantech" of the training dataset, to extract patterns from the business descriptions and its high accuracy (over 90%), demonstrated through cross-validation.

    This model classified the 537 129 companies of the initial sample and reduced them to 74 047 potentially Cleantech companies.
2. Computer-Assisted Filters to Reduce False Positives: In the second stage the sample was further refined using keyword-based filters. These filters were developed with a literature review and a manual validation of the firms' descriptions. This process further reduced the sample to 23 858 companies.
3. Manual Classification: The final stage involved a manual analysis of the descriptions to combine each company with one or more technological categories and to classify the specific roles of the firms in the sector.

To develop a deepen study on Green Energy companies, expanding the study on the Cleantech sector done in the document "*Using machine learning to map the European Cleantech sector*" (Ambrois et al., 2023), and carried out in this thesis, the final database was furtherly refined selecting only companies belonging to the Green Energy sector and deleting duplicates, obtaining a final sample of 11 221 companies and 108 384 observations.

Despite its advanced approach, the methodology has some limitations such as:

- Human Bias: the influence of the researchers' decisions made during the whole process that could have wrongly labeled a firm during the creation of the training dataset or that could have misinterpreted some descriptions putting the company in the wrong category. Also, the choice of the words associated with the term "Cleantech and Green Energy" that trained the algorithm could have been biased by a human error.

- Quality of Business Descriptions: some companies' descriptions may have been too poor to classify the firms without doubts into the right category or may use some words that are easily misunderstood by human and consequently by the machine learning algorithm.

- Focus on Isolated Companies: The analysis focuses on the companies as single entities and does not take into consideration the interconnection that can exist between them (such as a supplier-client relationship, supply chain interactions, distributors, alliances and collaborations) that could have helped fully understanding the behavior of these firms.

Some opportunities for improvement of the methodology used to create the dataset where the study was based may be:

- Integration of complementary sources: in this study the database relies exclusively on Orbis. However, some information could have been incorporated with additional databases such as public sources (Eurostat), patent registers or venture capital registers. This could amplify the dataset, making it closer to the real situation or it could add data related to companies already present in the dataset or it could clarify some business descriptions that could have been misunderstood.

- Consideration of the interconnections between companies: As highlighted before, including a mapping of relationships between companies (e.g., suppliers, distributors, collaborations, partnerships) could have enriched the analysis.

- Reducing human bias: even though this is a systematic bias that will always be present. A cross-validation method could reduce it, introducing experts that at each phase of the process control and validate what has been done by the researchers.

The identified Cleantech companies were divided into seven main technological categories inspired by the pillars of the European Green Deal and the EU Taxonomy. Each category reflects a different aspect of environmental sustainability:

1. Environmental Management: it includes technologies for pollution reduction and waste management.
2. Resource Conservation: it covers technologies for water conservation, sustainable agriculture, and eco-friendly raw materials.
3. Industrial Energy Management: it encompasses sustainable energy production, alternative fuels, and efficient industrial technologies.
4. Greenhouse Gas Capture and Storage: it includes technologies for the capture and treatment of CO2 emissions.
5. Sustainable Modes of Transport: it focuses on technologies for electric and hydrogen-powered vehicles.
6. Sustainable Buildings: it includes materials and technologies for energy-efficient construction.
7. Other Technologies: it covers innovations not classified in the previous categories but relevant to sustainability.

Chapter 3 DESCRIPTIVE STATISTICS ON GREEN ENERGY COMPANIES

The final sample consist of 11 221 companies identified as belonging in the Green Energy sector. The total number of observations is 108 384, implying that the data have been collected in different years in a time range from 2000 to 2022.

Some descriptive statistics were made to better understand the European situation of this sector.

Stata 14 was used as a tool to drive this analysis.

3.1 By ecosystem segment, technological category and sector

The companies associated with the Green Energy sector can be firstly segmented into two main categories:

- **Green Energy Innovators:** companies focused on the develop and innovation of renewable energies. They create solutions that allow a more efficient generation, storage and distribution of clear energy. Their main activity is indeed the R&D of renewable technologies.
  Some examples of activities a "Green Energy Innovator" could focus are the develop of new innovative solar panels, or the research of some new advanced systems for producing green hydrogen that can be adopt as energy, or even the storage of energy in solutions such as lithium batteries.
- **Green Energy Ecosystems:** this type of companies does not use energy as primary source of earning like Innovators, but they provide services, inputs, or infrastructure essential for implementing, improving and bring Green Energy solutions to the local costumer. They use clear energy indirectly in their business.
  Of course, they represent the biggest part of the companies working in the Green Energy sector. For this reason, they can be easily divided into subgroups:
  - **Operators:** energy companies that manage and operate a renewable energy plant. They maintain the infrastructure, optimizing production and distributing the energy produced to the consumer in the grid. They represent the most common type of Green Energy company.
  - **Integrators:** This type of companies designs, engineers and installs renewable energy tailored to specific requirements. They are the bridge from the producers and the final consumers, they assemble at the end the final renewable solution found strictly for that kind of user. For example, they install solar farms, or they integrate battery storage with power sources.
  - **Manufacturers:** companies that produce WIP or equipment and components for renewable energy systems. They have a crucial role in the Green Energy sector, since they supply the physical tools required to spread clean energy and technology. They produce for instance solar panels, turbine bladers or energy storage devices.
  - **Distributors:** companies that handle the logistic part of the clean energy sector. They program and monitor transportation and supply chain of the

product, ensuring that the components and the systems required reach unaffected the final user.

- **Experimenters:** companies and organizations (such as labs and universities) that have the role of testing the innovations developed by the Green Energy Innovators in real world settings, before the products are commercialized.
- **Researchers:** Entities like universities that work in the R&D sector of Green Energy companies, they study the theoretic part. They can be differentiated with Green Energy innovators, since Innovators not only develop the theoretic part, but they physically develop and test the innovated technology to patent and license them in the future.

Green Energy segment	Number of companies	Percentage of companies
Green Energy Innovators	1911	17%
Green Energy Ecosystems	9310	83%
Operators	2875	25.62%
Integrators	2747	24.48%
Manufacturers	2253	20.08%
Distributors	1403	12.50%
Researcher	29	0.26%
Experimenters	3	0.03%

Table 3.1: Classification of Green Energy companies into different ecosystem segments

In the database sample, composed by 11221 final Green Energy companies, as shown in table 3.1, 1911 companies resulted being Green Energy Innovators, corresponding to 17% of the whole sample. Taken into consideration the highly complicated and specialized role where they operate, this is a quite high percentage, indicating that Europe is moving toward ecological innovation, especially thanks to incentives and regulations ad hoc.

Green Energy Ecosystems represent 83% of the total amount, with 9310 companies that operate in this specific sector. Among the subgroups, companies are mainly distributed between operators (25.6%), integrators (24.5%) and manufacturers (20.1%).

Green Energy companies can be divided in technological categories (Haščič & Migotto, 2015) based on their ambiental contribution, as a tool for building indicators for innovations for the

OECD (Organization for Economic Co-operation and Development). These technological categories are aligned with the key aspects of the European Green Deal and UE's taxometry.

Specifically, firms were classified into seven main categories:

- **Environmental management:** firms that aim at reducing or eliminating the ambiental contamination with bonification and abatement and better administration of waste. This category can be furtherly divided into:
  - Air/water/soil pollution abatement/remediation;
  - Waste management;
- **Resource preservation**: firms that protect and promote the sustainable usage of natural resources. This category can be furtherly divided into:
  - Water conservation/availability;
  - Sustainable agri-food technologies;
  - Sustainable raw materials;
- **Industrial energy management**: firms making more efficient energy, developing clean energy. This category can be furtherly divided into:
  - Sustainable energy production;
  - Sustainable fuels;
  - Energy-efficient industrial technologies;
- **Greenhouse gas (GHG) capture, storage, sequestration or disposal:** firms that aim at eliminating CO_2 from the atmosphere and reducing the global warming;
- **Sustainable modes of transport:** firms that want to minimize emissions from the transport sector;
- **Sustainable buildings:** firms that aim at developing innovating green buildings from the energetic point of view;
- **Other categories.**

The analysis of the distribution of the green energy companies in the sample into the technological categories is shown in the graph below.

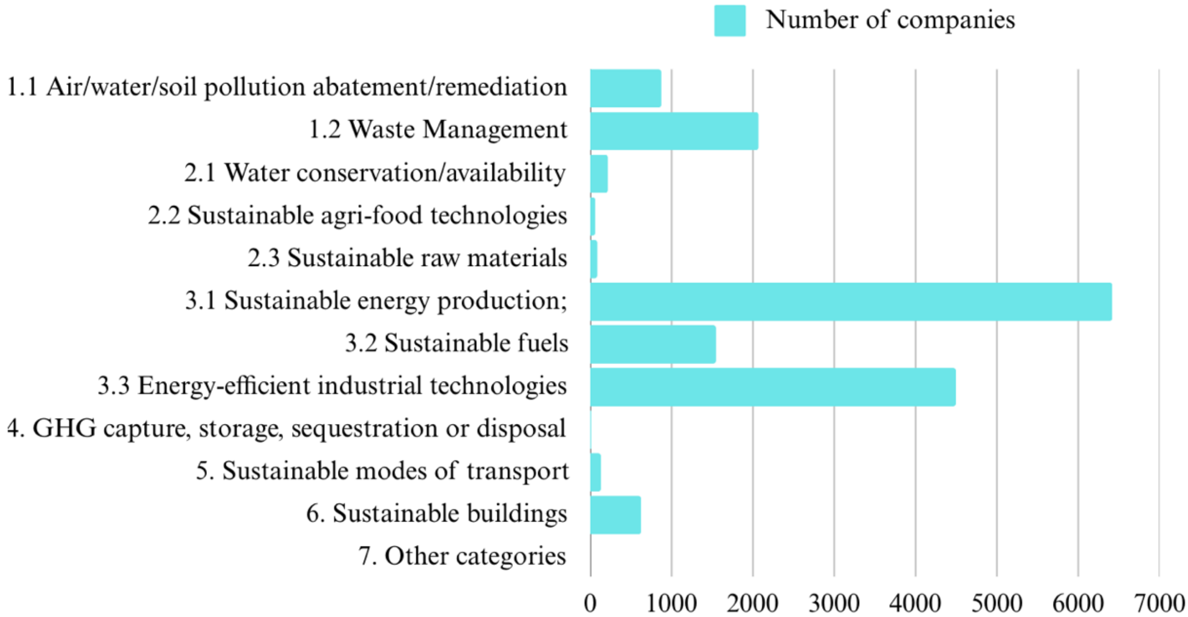

Figure 3.1: Classification of Green Energy companies by technological categories

As it clearly emerged from the analysis, Green Energy companies are mostly involved in the third category of the classification, industrial energy management, indeed Sustainable energy production category (3.1) represents more than the half of the firms in the sample companies with 57.22%, reaching 6421 firms out of 11 221 of the sample, highlighting the importance of facing the challenge of decarbonization of production and energy-efficient industrial technologies category (3.3) is the second sub-sector for percentage reaching 40.07%, counting 4497 companies in total. These two sub-categories cover the majority of the firms involved in the study. Following Waste Management (1,2) and Sustainable fuels (3.2) also maintain some relevance. On the other hand, the Green Energy sector is almost not present in the second category, in the fourth and in the seventh.

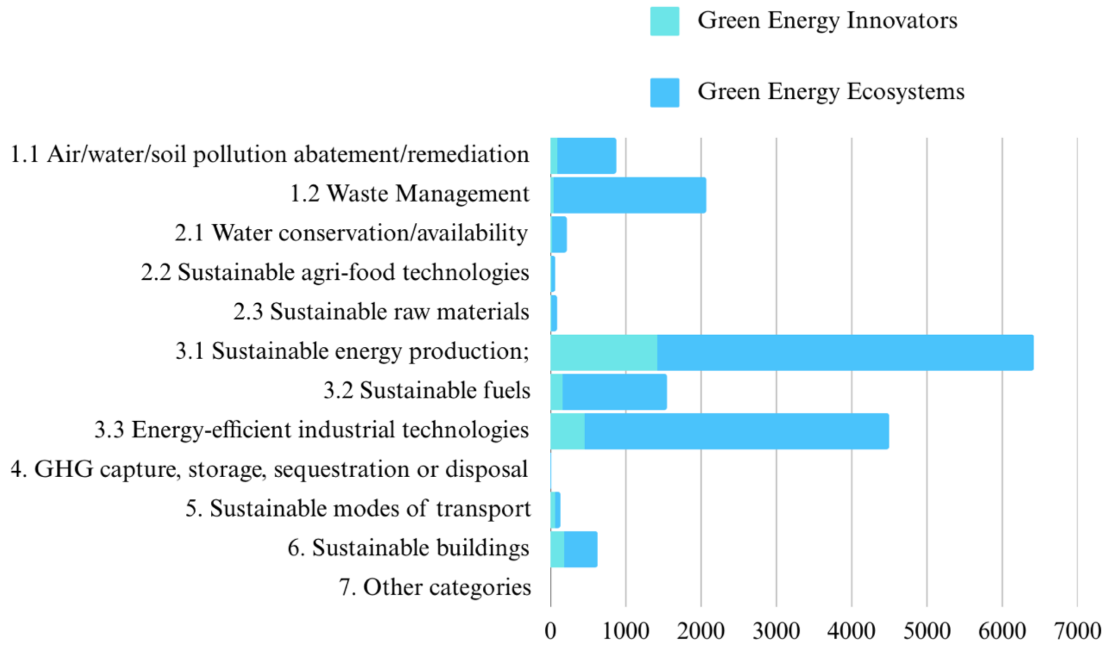

Figure 3.2: Comparison between Green Energy Innovators and Green Energy Ecosystems companies classified by technological categories

By further classifying the companies in the sample, adding a diversification between Green Energy innovators companies and Ecosystem ones, it can be stated that both kind of firms follow the same trend in the sectors explained beforehand, always maintaining the proportion ca. 20% against 80% between the two, confirming the data found previously.

Taking the most diffuse technological category, Sustainable energy production categories (3.1), the market is shared almost equally between integrators, operators, innovators and manufacturers.

Technology companies in the sustainable energy production sector focus on developing and implementing innovative solutions to generate electricity in an eco-friendly and efficient way. These companies work with solar, wind, hydro, geothermal, and green hydrogen energy, aiming to reduce reliance on fossil fuels and lower CO_2 emissions.

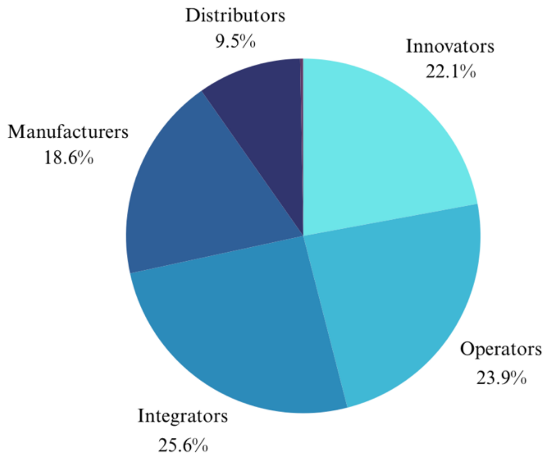

Figure 3.3: Segmentation of the market in the "sustainable energy production" technological category

This category is indeed very flexible, since the aim of producing sustainable energy, reducing carbon fossils need many entities specialized in different background that can co-operate to reach the objective.

The same distribution is maintained not only in Europe, but also in the United States, where the 97% of jobs in this sector are dealing with production of components and installation and maintenance services (Winston, 2012).

To understand what the main role in the market of the companies in the sample is exactly, it was adopted a European approved clusterization of the economic activities, called NACE.

NACE, Nomenclature statistique des Activités économiques dans la Communauté Européenne, translated in "Statistical Classification of Economic Activities in the European Community", is a standard classification method used to define the economic and industrial activities within EU. It is used mostly to allow analyzing and comparing statistical data between firms, that without a proper differentiation wouldn't be exact.

It was born in 1970 to harmonize statistics across European countries. The first major revision happened in 1990 with NACE Rev.1, that brought changes to improve compatibility with the ISIC (*International Standard Industrial Classification*) of the United Nations. Then, in 2002, a further update was implemented, becoming NACE Rev.1.1 to reflect economic changes and the emergence of new sectors, such as information technology. Finally, the final version was open in 2008, NACE Rev.2, introduced with Regulation (EC) No. 1893/2006. NACE Rev.2 introduced new categories for emerging sectors like renewable energy, the green economy, and digital services, better aligning with the need of the times.From 2008 the categorization was widely spread in Europe and became a basis for statistical analysis.

NACE Rev. 2 counts 21 sectors, identified with the letters from A to U. Each sector can be furtherly divided into sub-categories.

The 21 sectors are the followings:

- A: Agriculture, Forestry, and Fishing;
- B: Mining and Quarrying;
- C: Manufacturing;
- D: Electricity, Gas, Steam, and Air Conditioning Supply;
- E: Water Supply; Sewerage, Waste Management, and Remediation Activities;
- F: Construction;
- G: Wholesale and Retail Trade; Repair of Motor Vehicles and Motorcycles;
- H: Transportation and Storage;
- I: Accommodation and Food Service Activities;
- J: Information and Communication;
- K: Financial and Insurance Activities;
- L: Real Estate Activities;
- M: Professional, Scientific, and Technical Activities;
- N: Administrative and Support Service Activities;
- O: Public Administration and Defense; Compulsory Social Security;
- P: Education;
- Q: Human Health and Social Work Activities;
- R: Arts, Entertainment, and Recreation;
- S: Other Service Activities;
- T: Activities of Households as Employers;
- U : Activities of Extraterritorial Organizations and Bodies.

NACE rev.2 section	Green Energy companies		Green Energy Innovators		Green Energy Ecosystems	
	Number of Companies	Percentage	Number of Companies	Percentage	Number of Companies	Percentage
A – Agriculture, forestry and fishing	65	0.6%	9	0.5%	56	0.6%
B - Mining and quarrying	73	0.7%	7	0.4%	66	0.7%
C - Manufacturing	2555	22.8%	735	38.6%	1820	19.6%
D - Electricity, gas, Steam and air conditioning supply	1643	14.7%	324	17.0%	1319	14.2%
E - Water supply; sewerage, waste management and remediation activities	1576	14.1%	26	1.4%	1550	16.7%
F - Construction	1449	12.9%	178	9.3%	1271	13.7%
G - Wholesale and retail trade; repair of motor vehicles and motorcycles	1941	17.3%	191	10.0%	1750	18.8%
H - Transportation and storage	143	1.3%	10	0.5%	133	1.4%
I - Accommodation and food service activities	30	0.3%	5	0.3%	25	0.3%
J - Information and communication	101	0.9%	21	1.1%	80	0.9%
K - Financial and insurance activities	289	2.6%	77	4.0%	212	2.3%
L - Real estate activities	135	1.2%	18	0.9%	117	1.3%
M - Professional, scientific and technical activities	850	7.6%	261	13.7%	589	6.3%

N - Administrative and support service activities	256	2.3%	32	1.7%	224	2.4%
O - Public administration and defense; compulsory social security	7	0.1%	1	0.1%	6	0.1%
P - Education	8	0.1%	0	0.00%	8	0.1%
Q - Human health and social work activities	25	0.2%	3	0.2%	22	0.2%
R - Arts, entertainment and recreation	11	0.1%	0	0.00%	11	0.1%
S - Other service activities	46	0.4%	8	0.4%	38	0.4%
Total	**11203**	**100.00%**	**1906**	**100.00%**	**9297**	**100.00%**

Table 3.2: NACE Rev.2 segmentation

By looking at the data of the sample, the majority of the firms operate mainly in just 5 sectors: Manufacturing (C), Wholesale and retail trade; repair of motor vehicles and motorcycles (G), Electricity, gas, steam and air conditioning supply (D), Water supply; sewerage, waste management and remediation activities (E) and Construction (F). By taking only these 5 categories the 81.9% of the total is reached.

This of course is due to the fact that they are the sectors most involved in the type of process the analysis was focused on.

To have a confirmation of the data, the same sectorization was repeated by only taking the firms categorized before as belonging to the Sustainable energy production category (3.1), Sustainable fuels (3.2) and Energy-efficient industrial technologies (3.3).

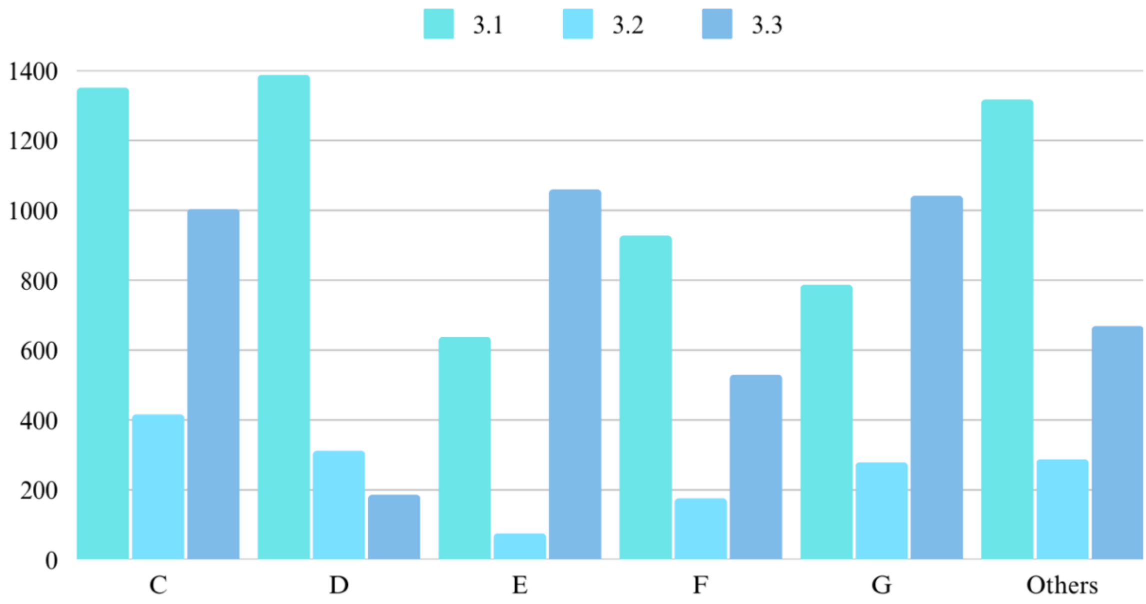

Figure 3.4: companies of the third technological category divided into NACE Rev.2 segmentation

It is clear that the data previously explained are confirmed. By taking all firms categorized as "Sustainable energy production (3.1)", for a total of 6409 companies, 79% operate in the sectors C, D, E, F and G, the most suitable sectors for producing sustainable energy. The same happens for the other two categories which totalize respectively 81% and 85% of the firms belonging to these sectors.

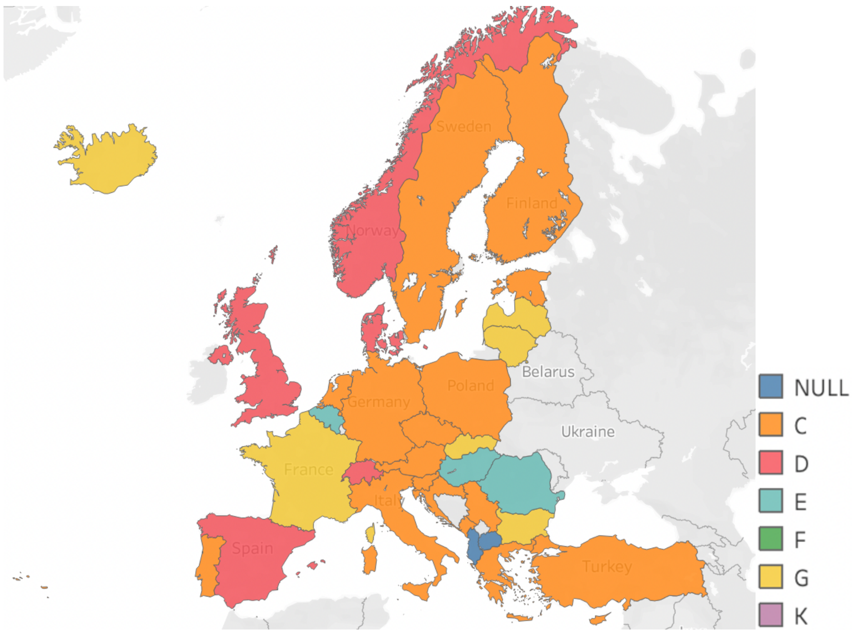

Figure 3.5: Map of the most spread NACE Rev.2 sector in each country

The map shows the most spread NACE Rev.2 sector in each European country, and it is furtherly confirmed that C and G are the most important category in which Green Energy operate. In particular the central part of Europe, comprehensive of Germany, Italy, Poland and Greece have a prominent presence of the C group, while in France G and in Spain the D.

3.2 By geography

A great importance in the development of Green Energy firms is to attribute to local regulations and policies, since they can incentivize or obstruct their spread. For this reason, to have a complete vision of the topic, it was essential to have a clear view of the spatial distribution of the firms in the sample.

Country name	Green Energy companies		Green Energy Innovators		Green Energy Ecosystems	
	Number of companies	Percentage	Number of companies	Percentage	Number of companies	Percentage
Albania	1	0.01%	1	0.05%	0	0.00%
Austria	299	2.66%	54	2.83%	245	2.63%
Belgium	298	2.66%	54	2.83%	244	2.62%
Bosnia	2	0.02%	0	0.00%	2	0.02%
Bulgaria	151	1.35%	21	1.10%	130	1.40%
Croatia	58	0.52%	14	0.73%	44	0.47%
Cyprus	2	0.02%	1	0.05%	1	0.01%
Czech Republic	292	2.60%	50	2.62%	242	2.60%
Denmark	165	1.47%	38	1.99%	127	1.36%
Estonia	33	0.29%	9	0.47%	24	0.26%
Finland	248	2.21%	45	2.35%	203	2.18%
France	1522	13.56%	209	10.94%	1313	14.10%
Germany	2212	19.71%	355	18.58%	1857	19.95%
Greece	126	1.12%	29	1.52%	97	1.04%
Hungary	185	1.65%	20	1.05%	165	1.77%

Iceland	14	0.12%	1	0.05%	13	0.14%
Ireland	12	0.11%	0	0.00%	12	0.13%
Italy	1902	16.95%	316	16.54%	1586	17.04%
Latvia	40	0.36%	3	0.16%	37	0.4%
Lithuania	53	0.47%	9	0.47%	44	0.47%
Luxembourg	41	0.37%	6	0.31%	35	0.38%
Malta	8	0.07%	2	0.10%	6	0.06%
Montenegro	3	0.03%	0	0.00%	3	0.03%
Netherlands	189	1.68%	39	2.04%	150	1.61%
Macedonia	16	0.14%	1	0.05%	15	0.16%
Norway	337	3.00%	47	2.46%	290	3.11%
Poland	562	5.01%	92	4.81%	470	5.05%
Portugal	222	1.98%	29	1.52%	193	2.07%
Romania	190	1.69%	25	1.31%	165	1.77%
Serbia	77	0.69%	7	0.37%	70	0.75%
Slovakia	103	0.92%	15	0.78%	88	0.95%
Slovenia	60	0.53%	17	0.89%	43	0.46%
Spain	1135	10.11%	252	13.19%	883	9.48%
Sweden	405	3.61%	88	4.60%	317	3.40%
Switzerland	29	0.26%	3	0.16%	26	0.28%
Turkey	9	0.08%	3	0.16%	6	0.06%
United Kingdom	220	1.96%	56	2.93%	164	1.76%

Table 3.3: Spatial distribution of Green Energy companies in Europe

The companies in the sample are spread in 37 European countries. As it could be expected some nations have a green side of the market that is more developed, indeed innovations associated with energetic transition will contribute to the definition of some geographical clusters, that will be more and more defined, leaving some regions behind. This process will reconfigure the spatial patterns of economic and social activity, (Bridge et al., 2013).

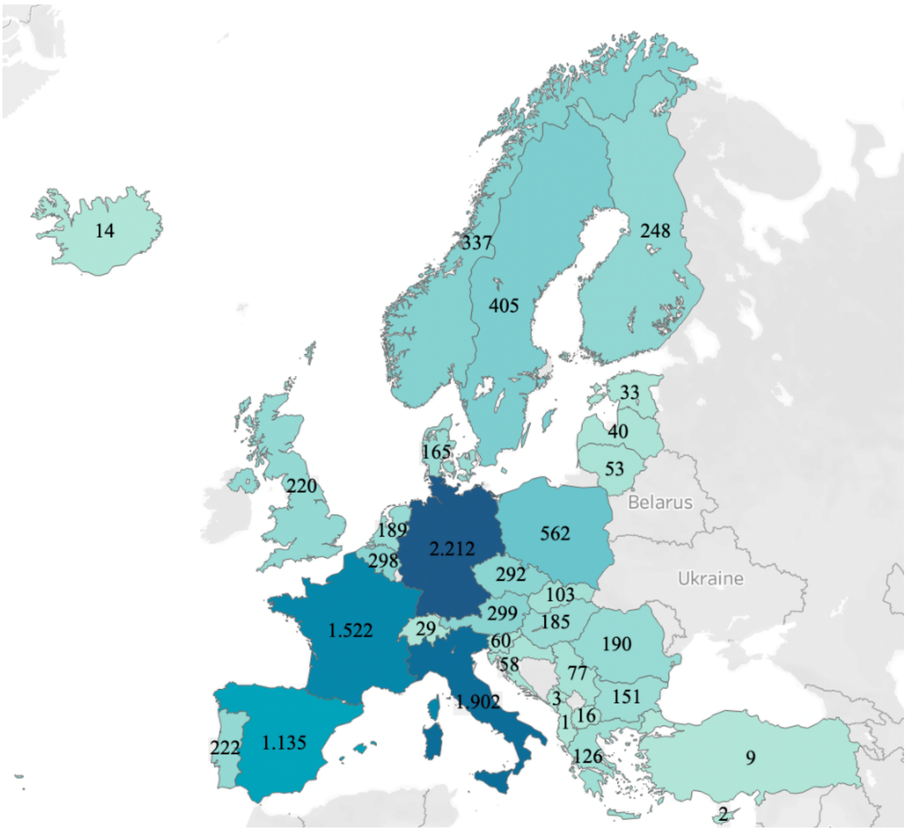

Figure 3.6: Distribution of Green Energy companies in Europe

By looking at the data, over the half (60.33%) of the Green Energy companies sampled are concentrated in just four countries: Germany, with 2212 companies, reaching 19.71% of the whole dataset, Italy, with 1902 firms, that is the 16.95%, France, counting 1522, 13.56% and Spain, 1135 Green companies and the 10.11%.

These four countries are recognized as some of the most advanced countries in the energy transition, also thanks to the governments that implemented several actions to help Green Energy firms to emerge, besides the European laws and incentives, already mentioned in the previous chapters.

Germany is one of the global leaders in adopting renewable energy and has implemented many policies to promote the energy transition, known as "Energiewende." Germany has promised to become carbon neutral (klimaneutral) by 2045, and to double the size of renewable energies usage by 2030. The energy transition is big deal for the Germans: in the first half of 2012 renewable energy provided over 25% of electricity (Winston, 2012), reaching in the first half of 2024, 57% of the electricity consumed covered by renewable energies.

Figure 3.7: Bundesministerium für Wirtschaft und Klimaschutz

Some of the main German regulations and incentives are:

- Klimatschutzprogramme 2030 (Climate action programme 2030): adopted on the 9th October 2019 and approved by the cabinet, it's not a specific law, but the Germany's strategic plan for moving to a sustainable energy system, which includes reducing greenhouse gas emissions, increasing energy efficiency, and expanding renewable energy.
- Erneuerbare-Energien-Gesetz (EEG): translate in English as "Renewable Energy Sources Act", it was firstly introduced in 2000 and then updated several times in the following years. This act guarantees feed-in tariffs for electricity from renewable sources producers. The current EEG has been criticized for setting the targets too low to meet Germany's long-term climate protection goals.
- Carbon Pricing: included in the National Emissions Trading System (nETS), that covers all sectors, transports and heating, not included in the EU ETS. Its aim is to reduce CO_2 emissions, with a minimum price for carbon emissions.
- Kohleausstiegsgesetz: translate in English as „Coal Phase-out". Germany has decided to eliminate coal use by 2038, with strong incentives to facilitate the transition.

These policies have brought Germany on top levels in renewable energy, leadership reflected also by the analysis of this thesis.

France has a great focus on nuclear energy, used to reach the European targets, but, meanwhile, it is also sustaining the development of renewable energy sources. France is committed in reducing its greenhouse gas emissions by 40% from 1990 and 2030 and in achieving carbon neutrality by 2050 minimizing emissions by a factor of more than six compared with the one in 1990.

Some of the main policies adopted by the French government are:

- Loi relative à la transition énergétique pour la croissance verte, LTECV (Energy Transition for Green Growth Act): it was implemented in 2015, and it aims to reduce greenhouse gas emissions by 40% by 2030 (compared to the 1990 index). This law also intends to strengthen its energy independence while providing its businesses and citizens with access to energy at a competitive cost.
- Programmation Pluriannuelle de l'Énergie, PPE (Multi-Annual Energy Plan): it sets France's energy goals for the next decade, for the period 2024-2035, and it will be then upgraded in the 2030. It is included in the "Stratégie française pour l'énergie et le climat (SFEC)" and it consists of 4 main objectives:
    - Energy sobriety;
    - Energetic efficiency;
    - Relaunch of nuclear energy;
    - Acceleration of renewable energies;

Figure 3.8: Stratégie française pour l'énergie et le climat

- Carbon Tax: part of the Contribution Climat-Énergie (CCE), a tax that gradually increases over the years to encourage the transition.
- Incentives for Renewables**:** the French government has activated several incentives for locals and firms that use clean energy.

Italy has a long history dealing with renewable energies, with a mix of national and regional resources.

Some of the main policies adopted by Italy for contributing to the goal are:

- Strategia Energetica Nazionale (SEN): Adopted in 2017, the SEN defines Italy's energy goals up to 2030. It aims at drawing a growth path for renewables, ensuring security and stability for investors. The SEN’s objective is to achieve a share of renewables of at least 28% of final gros *Figure 3.3: PPE logo* 1 as follows:
    - About 55% for renewable in electricity.
    - About 30% for renewables in heating and cooling applications.
    - About 21% for renewables in transport applications.

Figure 3.9: Strategia Energetica Nazionale

- Incentives for Renewables: Italy has implemented in the years several incentive schemes such as the followings:
    - Conto Energia: incentive for the usage of photovoltaic solar panels, adopted from 2005 to 2013.
    - Decreto Fer 1 e Fer 2: incentive for the usage of renewable resources other than photovoltaic.
    - Superbonus 110%: introduced with “Decreto Rilancio” in 2020 and then become effectively a law. It allows for a 110% deduction of expenses for energy efficiency measures and the installation of photovoltaic systems.

- Decreto Crescita: It gives investors that invest in innovative start-ups a deduction of taxes IRPEF of 30%, up to 1 million euros, with the clauses that the participation is maintained for at least 3 years.
- Decreto Rilancio: Implemented in the Covid-19 period, the tax deduction was brought up to 50%, up to 300 000 euros for SMEs investors.

- Piano Nazionale Integrato per l'Energia e il Clima (PNIEC): submitted by the European commission in 2019, it outlines Italy's goals for 2030, including a 30% share of renewable energy in final energy consumption.

Figure 3.10: Italian PNIEC logo

Spain is a country with great potential for solar and wind energy, due to its climate. Its current framework for energy and climate is based on the 2050 objectives of national climate neutrality. It wants to reach 100% renewable energy in the electricity mix and 97% renewable energy in the total energy mix.

Following some of the key regulations it has adopted:

- Ley de Cambio Climático y Transición Energética: Approved in 2021, this law sets the goal of achievement of the climate neutrality by 2050, with a 23% reduction in emissions by 2030 compared to 1990 levels.
- Estrategia de Transición Justa: To ensure fair and supportive treatment of workers and territories affected by the transition to a low-carbon economy. The objective is that there should be no negative impact on employment or depopulation.
- Plan Nacional de Energía y Clima 2023-2030 (PNIEC): The Spanish plan aims to achieve a 42% share of renewable energy in final energy consumption by 2030, to reduce the greenhouse effect and global warming.

Figure 3.11: Spanish PNIEC logo

- Support for Self-Consumption: incentives for people that use renewable energy as personal energy, with a particular focus on solar energy.
- Competitive Auctions for Renewables: Spain has used competitive auctions to allocate renewable energy generation capacity. These auctions are regulated by the "Real Decreto 960/2020".

Spain also won the ranking "EU Taxonomy Barometer 2023" done by EY as the country with the highest number of green companies as for revenues.

While Germany, France, Italy, and Spain are among the European leaders, other countries are making significant progress.

Sweden, reaching 3.61% in the sample analyzed, is the leader in the use of hydroelectric, wind, and biomass energy.

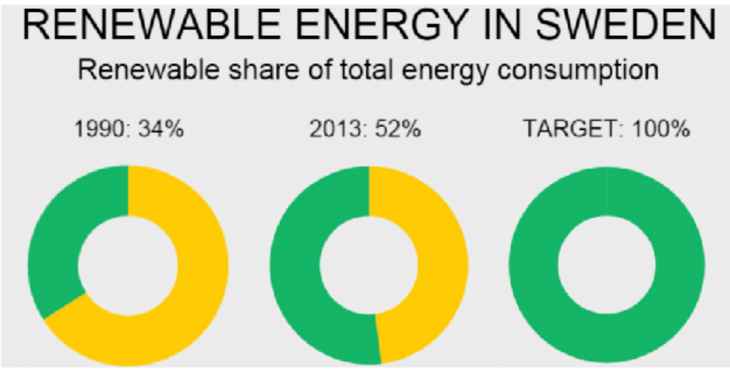

Figure 3.12: Renewable energy in Sweden, Researchgate

Norway, 3% of companies of the sample, can claim to use almost 100% of electricity coming from renewable sources (hydroelectric), and is the leader in electric mobility.

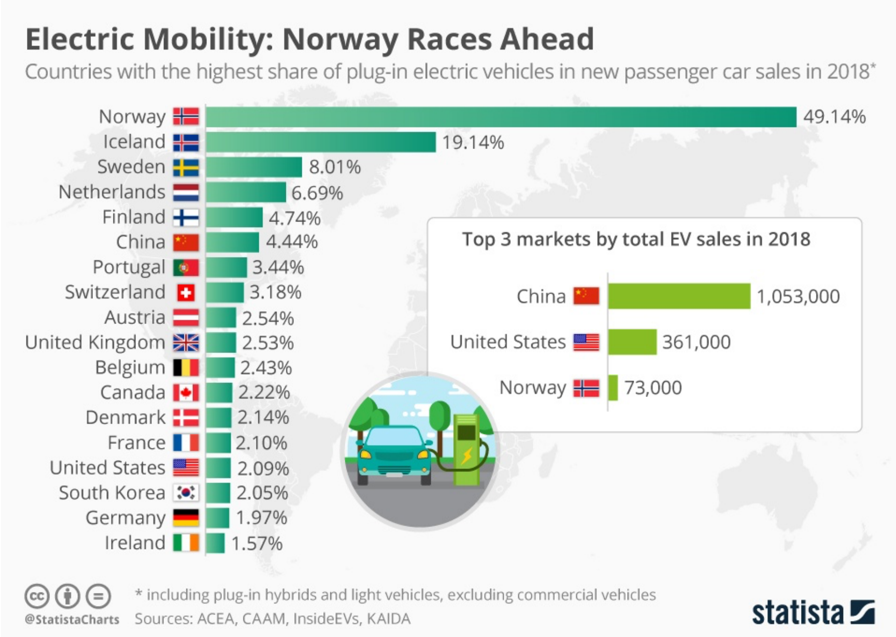

Figure 3.13: Norway leadership in electric mobility, statista

The Netherlands have implemented aggressive policies for emission reduction. Denmark also has a very strong commitment toward Green Energy topics.

Some European countries are still in transition and are facing more slowness and problems moving toward renewable resources. In particular, as highlighted by the analysis the Baltic is the more dependent form fossil fuels (especially coal and gas). Thanks to European incentives and laws they are not totally left behind and they will be helped to reach the independence they need for the change management and behavior the locals need.

The distribution of Green Energy Innovators and Ecosystems companies follow the distribution of the previous map.

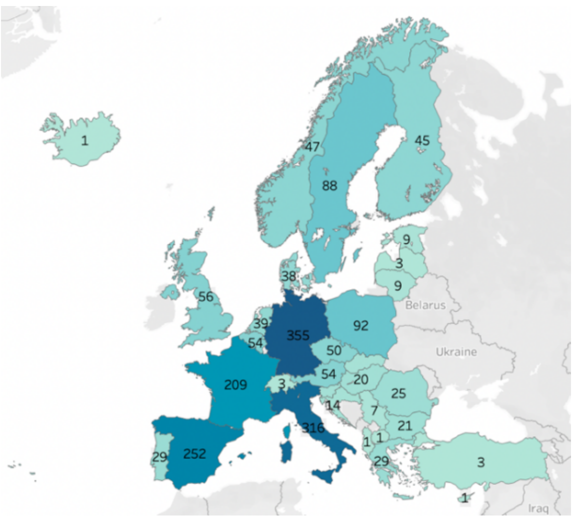

Figure 3.14: Map with density of Green Energy Innovators companies in Europe

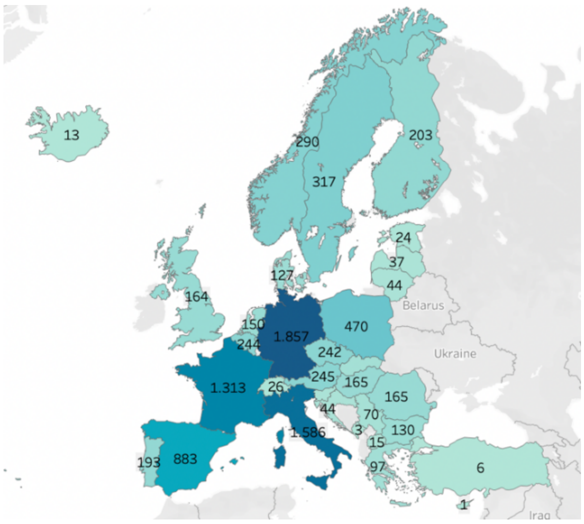

Figure 3.15: Map with density of Green Energy Ecosystems companies in Europe

3.3 By year of incorporation

Analyzing the founding year of companies in the green energy sector is crucial for understanding how the industry has evolved over time. This information helps identifying growth trends, periods of significant expansion, or phases of stagnation, often linked to external factors such as government policies, tax incentives, technological advancements, or increasing environmental awareness. Additionally, examining the timeline of company foundations can provide valuable insights into market entry dynamics and the overall maturity of the sector. This type of analysis helps contextualize the development of the green market in relation to regulatory, economic, and social changes, offering a more comprehensive perspective on the database. Below is a summary table showing the distribution of companies based on their founding year.

Year of Incorporation	**Green Energy Companies**		**Green Energy Innovators**		**Green Energy Ecosystems**	
	Number of companies	**Percentage**	**Number of companies**	**Percentage**	**Number of companies**	**Percentage**
Before 1980	1686	15.0%	255	13.4%	1431	15.4%
1981-1985	545	4.9%	72	3.8%	473	5.1%
1986-1990	903	8.1%	119	6.2%	784	8.4%
1991-1995	1459	13.0%	173	9.1%	1286	13.8%
1996-2000	1477	13.2%	228	12.0%	1249	13.4%
2001-2005	1578	14.1%	275	14.4%	1303	14.0%
2006-2010	1876	16.7%	449	23.6%	1427	15.3%
2011-2015	867	7.7%	182	9.5%	685	7.4%
2016-2020	752	6.7%	138	7.2%	614	6.6%
2020-2022	60	0.5%	15	0.7%	45	0.5%
Total	**11 203**	**100.00%**	**1906**	**100.00%**	**9297**	**100.00%**

Table 3.4: Distribution of Green Energy companies based on the year of incorporation

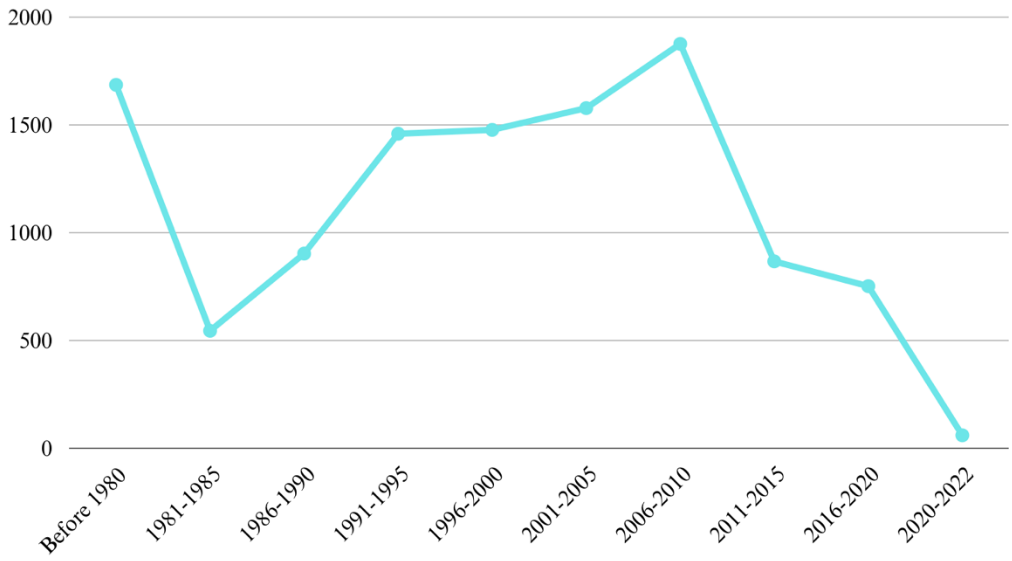

Figure 3.16: Graph of Green Energy companies based on the year of incorporation

Although it can be unexpected to see that 15% of the companies of the whole sample where established before 1980, when the focus on sustainability and clean technology was not as important as today and many scientific information were ignored at the time, a very possible reason for this high value can simply be that many firms were first created with other aims, targets and methodologies and during the years they evolved becoming Green Energy firms. For this motivation, the data that it is extracted by the incorporation year before 1980, is not significant.

A significant data is the clear peak that can be highlight in the years between 2006 and 2010. This peak can be due to many economic, political and technological factors:

- The creation of a favorable environment for businesses focused on sustainable energy solutions, through financial incentives like feed-in tariffs, tax credits, and subsidies to encourage investment in the green energy sector, thanks to several local and European policies approved in those years.
- Public concern about climate change and global warming has risen enormously during those five years, putting the focus on the topic and making this kind of companies more appreciated and viral.
- Significant progress in renewable energy technologies improved efficiency and reduced production costs. This made it more feasible and profitable to start new ventures in green energy.
- The 2008 Financial Crisis made investors seeking for emerging sectors with growth potential to invest to and green energy firms benefit from it.

After 2010 there is a progressive decline that can be related to the maturity and slow saturation of the market, that will need to differentiate itself to arise again. Moreover, international competition, post crisis period, covid-19 and uncertainty in regulations and governance play a huge role in the decline of the incorporation. Between 2011 and 2015 the so called “Cleantech crash” occurred: a global economic downturn that led to reduced investments and funding opportunities for innovative companies (Ambrois et al., 2023).

3.4 Patent data

To make the analysis of companies in the green energy sector more comprehensive and in-depth, it is important to also consider aspects related to patents and intellectual property. Patents are not only an indicator of a company's innovative capacity, but they also reflect the level of investment in research and development the companies are into. Analyzing patent portfolios allowed to identify if companies are heading to innovation and how competition in the sector is evolving. In addition, this analysis gives a better understanding of the dynamics between companies, highlighting potential collaborations. In the context of green energy companies, patents play a particularly strategic role as they protect key technologies related to energy efficiency, renewable energy, and environmental sustainability, helping to strengthen the competitive position of businesses in the market.

A patent is a legal title that grants the holder the exclusive right to produce, use, sell, or commercialize an invention for a limited period, typically 20 years from the date of the application. This right is granted in exchange for the public disclosure of the invention, promoting the dissemination of scientific and technological knowledge, but also lowering the competitive advantage the company could have had with the disclosure of information. The invention covered by the patent must meet specific fundamental requirements to be registered: it must be new, involve an inventive step, and have industrial applicability. Patents can cover products, processes, or innovative methods that provide a technical improvement over existing solutions.

In Europe, the patent system is primarily regulated by the European Patent Office (EPO), which grants protection to technological innovations across its member states through the European patent. This system allows companies to secure uniform protection in multiple countries without needing to file separate national patents, simplifying the process and reducing costs. However, regulatory fragmentation among different countries has made the enforcement and recognition of patents more complex at the continental level. To address this challenge, the European Union introduced the unitary patent, a new tool designed to provide more harmonized protection and reduce bureaucratic barriers. Despite these advancements, the European patent system still faces issues related to the length and cost of procedures, as well as legal disputes over patent validity and infringement.

Starting from the identified sample, firm-level data were matched with patent data in the Orbis Intellectual Property (Orbis IP) database by using the Bureau van Dijk company identifiers. It was decided to select only patent identified by European Patent Officer (EPO) to ensure the comparability between different countries.

Considering a total of 10571 of companies, since there is no available information for the remaining firms in the dataset, 9366 companies are registered as not owning any patent, leaving only the 11.52% of the companies as IP owning.

As it could have been expected Green Energy Innovators are more likely to have at least 1 patent, reaching 22.78% against the 9.23% of the Green Energy Ecosystems companies.

	Green energy companies		**Green energy Innovators**		**Green energy Ecosystems**	
	Number of companies	**Percentage**	**Number of companies**	**Percentage**	**Number of companies**	**Percentage**
At least one in any field	1219	11.52%	407	22.78%	812	9.23%

Table 3.5: EPO patenting activity of Green Energy companies

Technological category	**At least one in any field**	
	Number of companies	**Percentage**
Air/water/soil pollution abatement /remediation (1.1)	126	7,38%
Waste management (1.2)	96	5,63%
Water conservation / Availability (2.1)	35	2,05%
Sustainable agri-food technologies (2.2)	7	0,4%
Sustainable raw materials (2.3)	15	0,8%
Sustainable energy production (3.1)	699	40,97%
Sustainable fuels (3.2)	176	10,31%
Energy-efficient industrial technologies (3.3)	451	26,43%

Capture, storage, sequestration or disposal of GHG (4)	2	0,11%
Sustainable modes of transport (5)	26	1,52%
Sustainable buildings (6)	73	4,27%
Total	**1706***	**100%**

*Each company can be associated to multiple technological categories

Table 3.6: EPO patenting activity of Green Energy companies distributed by technological categories

As it could be expected the technological category where the highest number of firms own at least one patent is the most innovative one and the one more related to the analysis of Green Energy: Sustainable energy production (3.1). Some key examples of patents in this field include high-efficiency solar cells, like Tesla's patented solar panels designed to improve heat dissipation, advanced energy storage systems, such as the long-lasting lithium-ion batteries developed by Tesla and Panasonic, and next-generation wind turbines, like those created by Vestas, which are designed to maximize energy production even at low wind speeds.

Patenting companies depend on technology used, market status and regulatory policies decided by the country. In Table 3.7 Green Energy patented companies are analyzed based on the country they're established in.

At least one in any field

Country	**Green Energy companies**		**Green Energy Innovators**		**Green Energy Ecosystems**	
	Number of companies	**Percentage**	**Number of companies**	**Percentage**	**Number of companies**	**Percentage**
Germany	371	30.43%	116	28.50%	255	31.40%
Italy	225	18.46%	66	16.22%	159	19.58%
France	116	9.52%	31	7.62%	85	10.47%
Spain	92	7.55%	34	8.35%	58	7.14%
Poland	20	1.64%	7	1.72%	13	1.60%
Sweden	88	7.22%	34	8.35%	54	6.65%

Czech Republic	13	1.07%	4	0.98%	9	1.11%
Belgium	32	2.63%	12	2.95%	20	2.46%
Norway	29	2.38%	10	2.46%	19	2.34%
Austria	58	4.76%	19	4.67%	39	4.80%
Others**	175	14.36%	74	18.18%	101	12.44%
Total	**1219**	**100.00%**	**407**	**100.00%**	**812**	**100.00%**

**The residual category includes Romania, Finland, Portugal, Hungary, Netherlands, Denmark, Bulgaria, Slovakia, Serbia, Greece, Croatia, Lithuania, Slovenia, Latvia, Estonia, United Kingdom, Luxembourg, North Macedonia, Switzerland, Iceland, Malta, Turkey, Montenegro, Ireland, and Cyprus;

Table 3.7: EPO patenting activity of Green Energy companies distributed by country

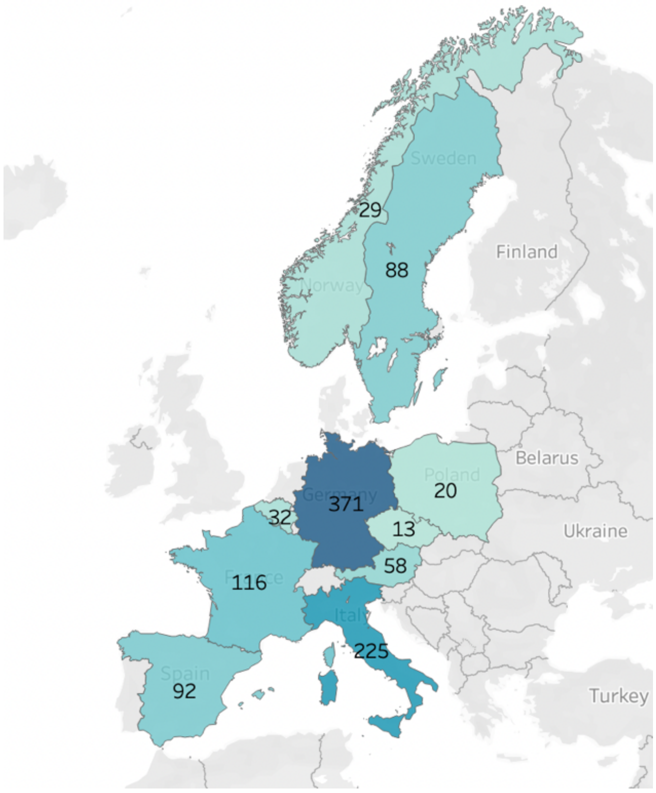

Figure 3.17: Distribution of patented Green Energy companies in Europe

Following the wave of Green Energy companies' location, the highest density of patented firms is in Germany by far. This data can be biased by the choice of the sample but it gives a hint that in general, the countries where more patent are taken is in West-Europe, where clean tech companies are already well developed and have already gained a great share of the market, moreover they are locations with many VC-hubs or where many European and American Venture Capitalists rely on and by consequence these firms have money to finance R&D and studying new forms of sustainable energy to patent and license. East Europe still has to develop a market for Green Energy firms, once they will have a credibility in the market investors will be proactive in financing also those firms.

The same density is confirmed by only taking Green Energy Innovators and Ecosystems.

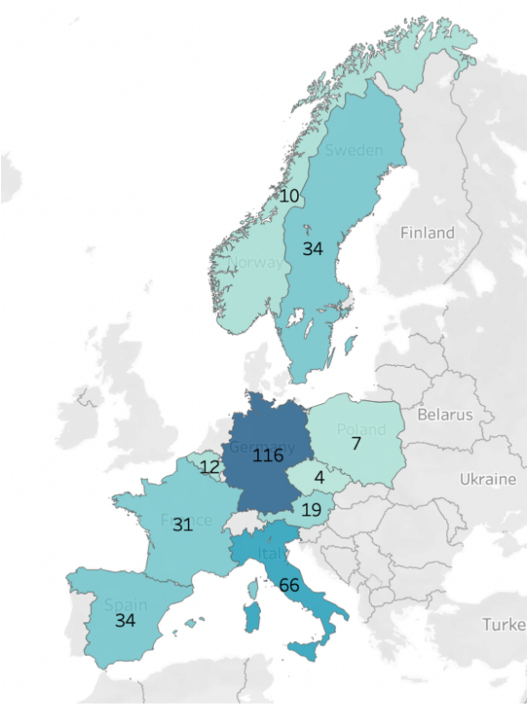

Figure 3.18: Distribution of patented Green Energy Innovators companies in Europe

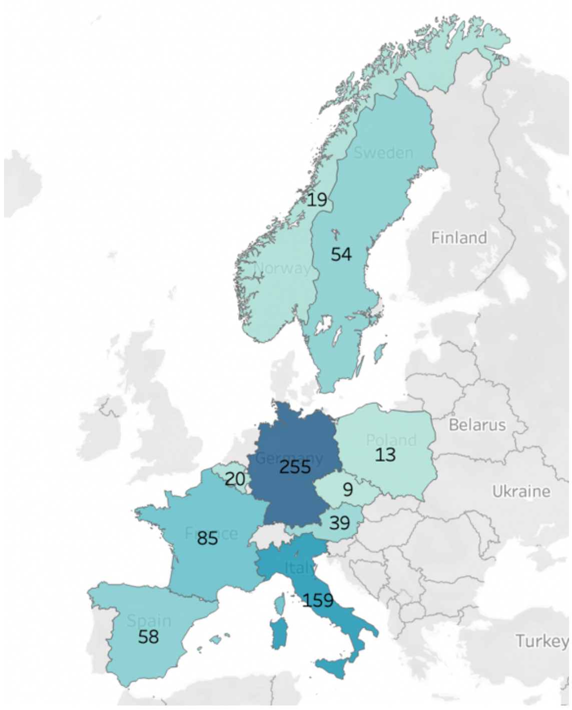

Figure 3.19: Map with density of patented Green Energy Ecosystems companies in Europe

By going deeper on the ecosystem segment, Manufacturer is the most engaged sector in patenting activity reaching 484 companies and composing the 59,6% of the Ecosystems firms with patents, followed by Integrators (16,25%%) and Operators (14,9%).

	At least one in any field	
	# companies	%
Innovators	407	33,38%
Ecosystems	812	66,61%
Experimenters	11	1,35%
Manufacturer	484	59,6%
Distributors	64	7,88%
Integrators	132	16,25%
Operators	121	14,9%

Table 3.8: EPO patenting activity of Green Energy companies distributed by segment

It is also interesting the evolution over time of the patenting firms. In the graph it can be seen the number of firms that in that year gained their first patent. This allows to understand in which years patents gained more and more importance and also the future trend.

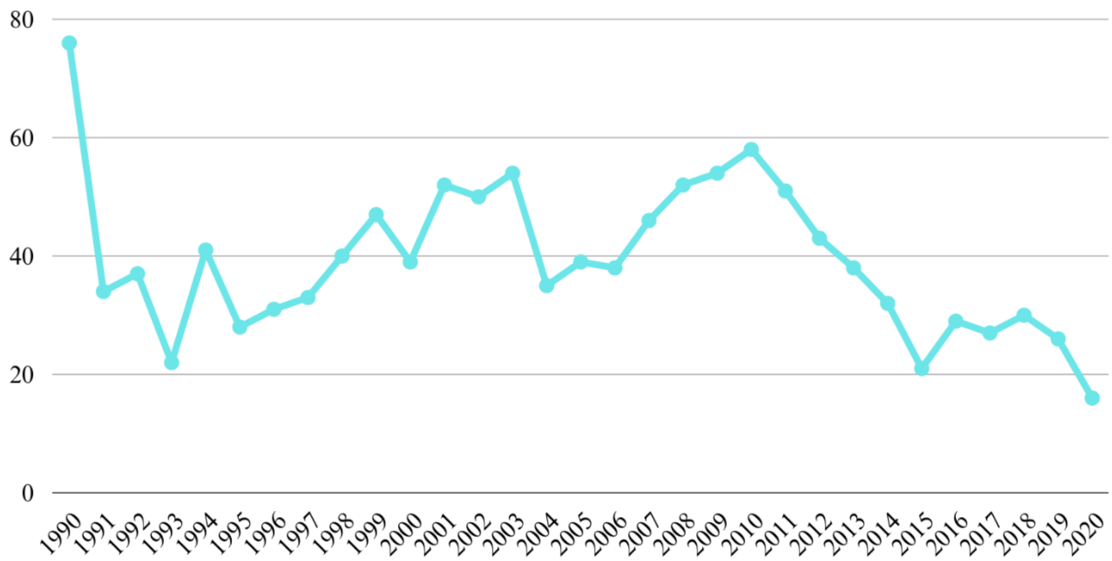

Figure 3.20: Trend of first EPO patent gained through the years 1990-2020

It can be highlighted that in 1990 there was a clear peak, this can be attributed to a combination of historical, political, and economic factors that encouraged innovation in sustainable energy technologies. The publication of the Brundtland Report (1987) played a key role in shaping the concept of sustainable development and growing environmental awareness. The oil crisis of 1970 also was crucial, since companies dealing with energy production started investing in research, getting in the 90s with patented solutions that started to change the way people thought about energy.

Many geopolitical events, such as the end of the cold war made the focus of the moment change, slowing the development of new technologies to be patented. The graph shows then a progressive increase, with a peak around the 2001-2003 and in 2011, where the focus became again finding new technologies to improve the environmental situation, and all firms invested more and more the find better solutions and gaining a biggest share of the market. A market that it is promised to become in the close future the most important one, destroying the oil market.

The increase in patents in the green energy sector, observed in this analysis, is in line with the growing tendency of companies to adopt low-carbon technologies.

3.5 Financial KPIs

To truly understand which companies can establish themselves in the market and remain competitive in the long run, it is essential to integrate a study of Financial Key Performance Indicators (KPIs). Indicators such as Return on Investment (ROI), profit margin, EBITDA allow us to evaluate not only the numerical growth of companies but also their financial stability and ability to attract investments.

The analysis of financial KPIs within Green Energy companies reveals that those in line with ESG practices tend to outperform their competitors. This correlation underscores the financial benefits of integrating sustainability into the business strategies (Smith & Jones, 2023).

The renewable energy sector is characterized by high initial investments, long payback periods, and a strong reliance on government incentives and environmental policies. For this reason, a big help is given by investors, as we will analyze in chapter 4. In this context, analyzing financial KPIs helps identify the most effective business models, the main differences between sectors, size and maturity of the companies.

The analysis of financial KPIs confirms the influence of carbon risk on company performance, consistent with the observations of Cumming et al. (2024) regarding the relationship between carbon risk, cost of debt, and speed of leverage adjustment. Specifically, the analysis reveals that companies with higher carbon risk tend to exhibit lower profitability metrics, such as return on assets (ROA) and return on equity (ROE). Additionally, these companies often face higher borrowing costs, which can be attributed to the increased risk perceived by lenders, potential financial and regulatory risks associated with carbon emissions. (Cumming et al., 2024).

Starting by understanding the size of the companies a first distinction into SMEs (Small and Medium Enterprises) and big companies was made. SMEs are recognized by UE as those firms with:

- Less than 250 employees;
- Less than 50 Mln € annual revenues OR
- Less than 43 Mln € total assets.

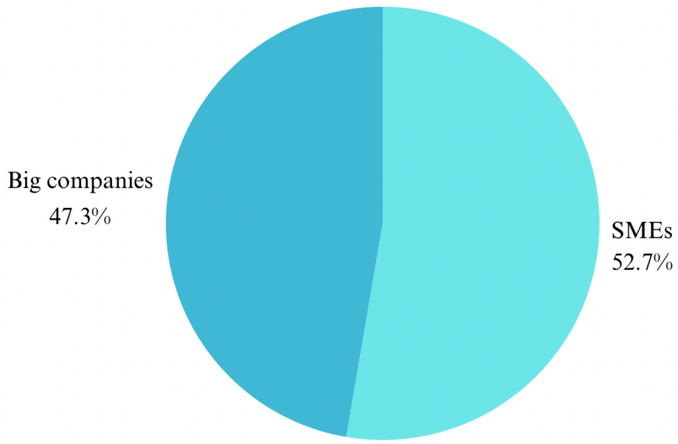

Figure 3.21: Distribution of the sample by size

The database resulted to be very equally distributed, with the two categories sharing almost half of the firms each.

To deepen the analysis a more detailed categorization was made, always following UE directives. Firms were categorized as:

- Micro-enterprises: < 2 mln € annual revenues;
- Small enterprises: between 2 mln € and 10 mln € annual revenues;
- Medium-enterprises: between 10 mln € and 50 mln € annual revenues;
- Big enterprises: more than 50 mln € annual revenues;

	Frequency	**Percentage**
Micro	2544	22,67%
Small	3966	35,34%
Medium	2810	25,04%
Big	1901	16,94%

Table 3.9: Distribution companies in the sample for size

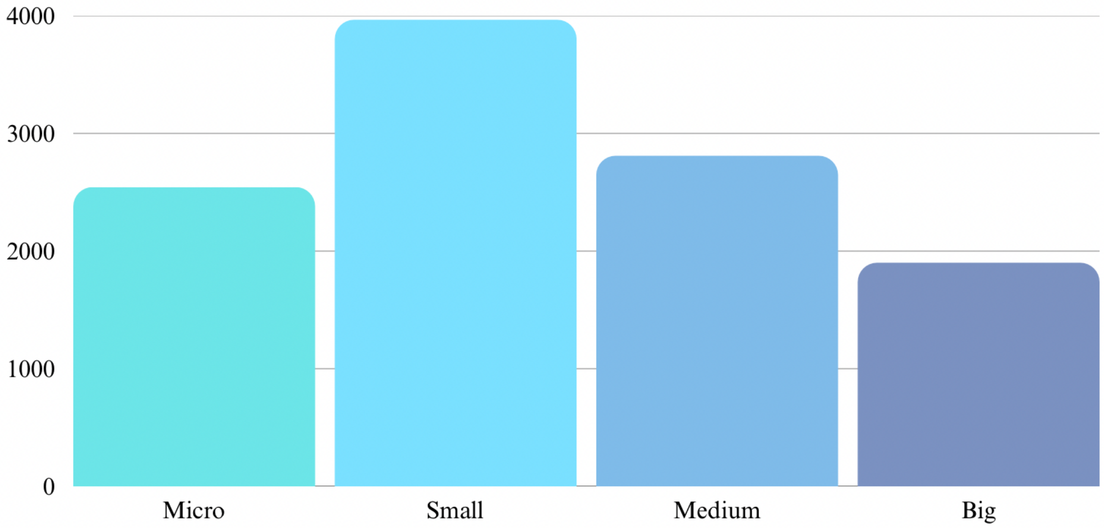

Figure 3.22: Graph of the distribution of the sample by size

The database reflects the reality in a good way, knowing that for instance in Italy just the 0,7% of the companies are considered "big companies", although they operate with 1/3 of the workers of the country.

In the dataset we can find also some multinational companies, that are included into the "Big companies" category, but that effectively are considered as outliers as they move all statistics of the financial KPIs up.

The biggest companies included in the sample are the following:

- Veolia environment: a French company that operate in more than 57 countries and that counts a total of about 260 000 employees. It operates in three main sectors: water management, waste management and energetic services. In the sample it is categorized as "Integrator".

Figure 3.23: Veolia environment

- E On: a multinational european company with german origin. It is a global leader in electric and gas distribution.

Figure 3.24: E.On

- ABB: als an important swiss-sweden company that was ranked at the 341° position in 2018 in the Fortune Global 500 ranking, a list of the 500 most powerful companies globally. It operates mainly in the automation sector and it is part of the innovator subgroup.

Figure 3.25: ABB Ltd

- Alstom: a French industrial group which operates in the construction of train and infrastructure.

Figure 3.26: Alstom

- BP: also known as British Petrolium, is an anglo-persian company operating in the energy and in the oil sector. It is the company with the highest value of annual revenues in our sample.

Figure 3.27: BP

These very big companies, along with other not cited have been considered as outliers in the analysis, as they would have biased the statistical values.

To avoid distortions due to multiple observations per company, the means of the variables for each company were calculated before starting the analysis.

	Mean (Mln €)	Standard deviation (Mln €)	Median (Mln €)	Q1 (Mln €)	Q3 (Mln €)
Total Assets	134.609	523.850	11.318	4.088	40.818

Table 3.10: Statistical analysis of the Total Assets of the Green Energy companies in the sample

The distribution of total assets is strongly asymmetrical with a significant positive skweness that moves the mean up to 134 Mln€ from the median of 11 Mln €. For this reason, the mean is not representative, instead the median can be considered a more robust measure of central tendency.

Some sectors of Green Energy companies have a higher need of assets as shown by the medians divided by label.

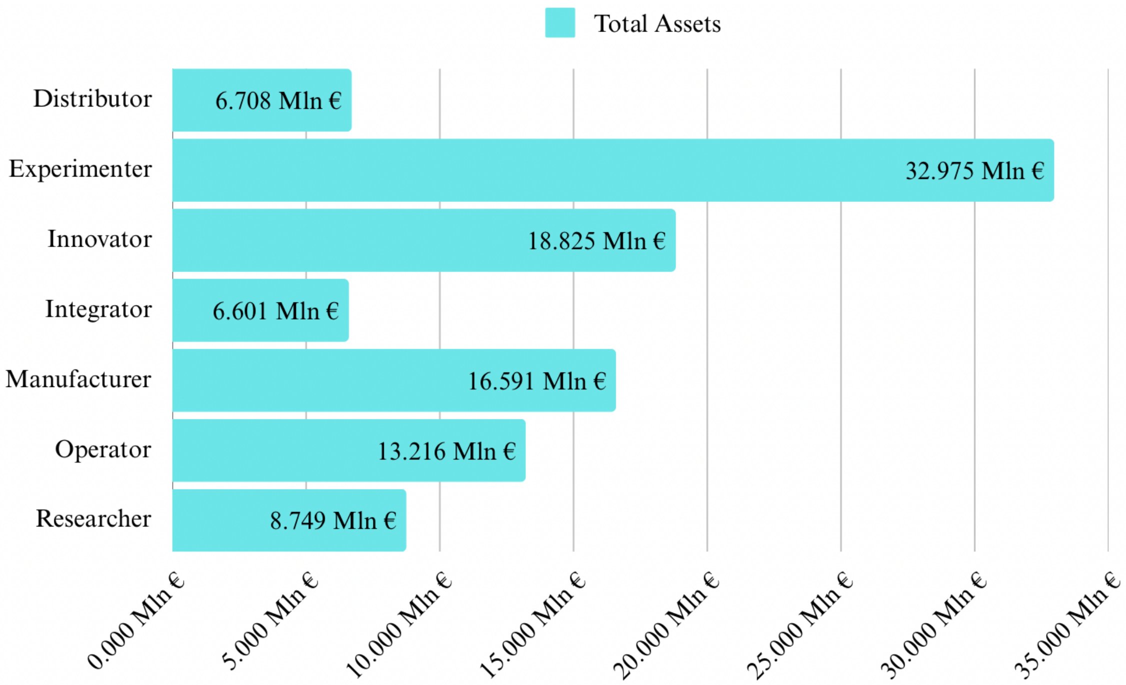

Figure 3.28: Total assets medians of Green Energy companies by sectors

Experimenters are the companies that own, on average, the highest amount of total assets, because of their need to be R&D intensive. Innovators have the same costs for research that they have to take into consideration into their business model. Manufacturers also tend to have high total asset because of their need to buy machinery, plants, and stocks. These results reflect the capital-based nature of these 3 categories.

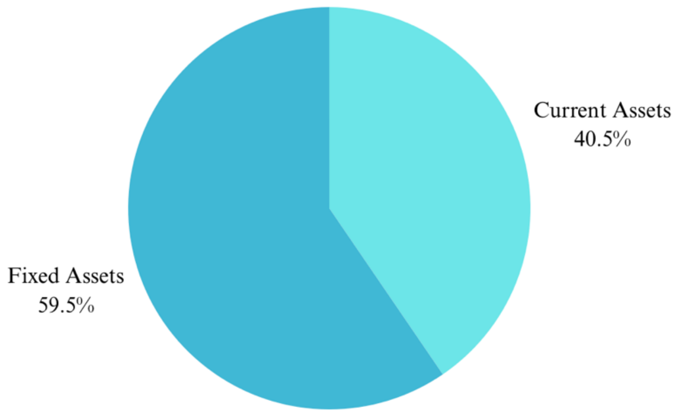

Figure 3.29: Total assets means divided into Current and Fixed assets

In the graph above it is shown how an average firm of the sample divide its assets into current and fixed. Fixed assets can be also furtherly divided into tangible, that represents about 80% of fixed assets and intangible.

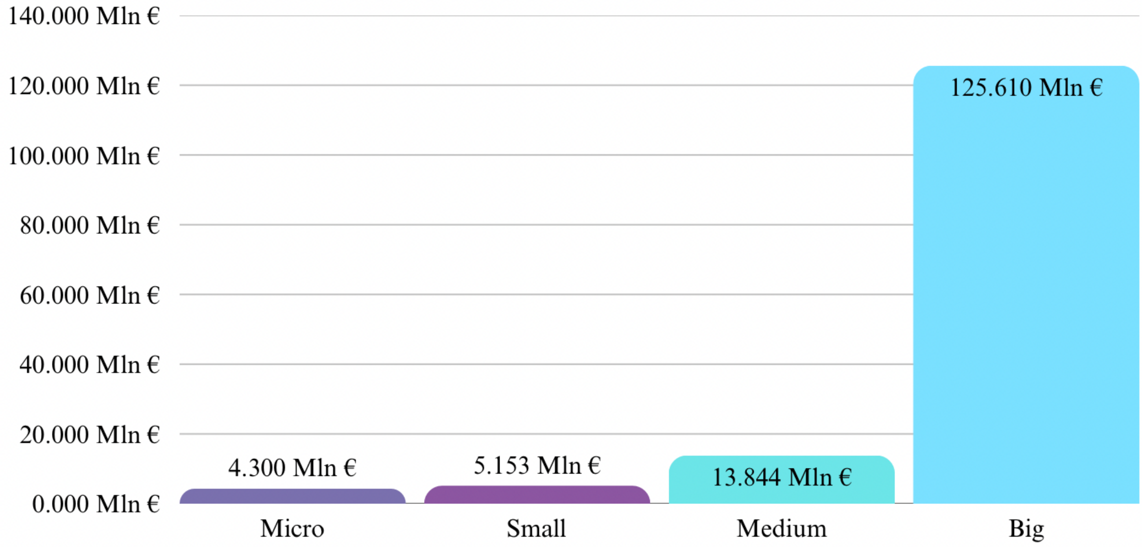

Figure 3.30: Distribution of total asse medians by size of the firm

The medians of total assets divided by size of the enterprises reflect the expected one. The “big” category takes most of the value of the variable. Having a certain amount of annual revenues, it is easier for bigger companies to invest in assets such as plants, machineries and intellectual properties.

KPI	**Mean (Mln €)**	**Standard deviation (Mln €)**	**Median (Mln €)**	**Q1 (Mln €)**	**Q3(Mln €)**
Sales	101.844	394.587	10.517	4.564	32.419
EBITDA	11.325	46.623	0.873	0.226	3.309
Net profit	4.052	17.012	0.269	0.011	1.231

Table 3.11: Statistical analysis of financial KPI of the Green Energy companies in the sample

The distribution of these KPI is also very asymmetrical and the mean is biased up by the big companies that have a net profit significantly higher with respect to SMEs, this is also reflected by the high standard deviation. For this reason, the mean is again not a reliable value and it is advisable to use the median to make comparisons.

The limited profitability shown by the 3rd quartile suggest that most of the companies in the sample don't benefit from a high profit.

To deepen the analysis the KPI were divided into size categories.

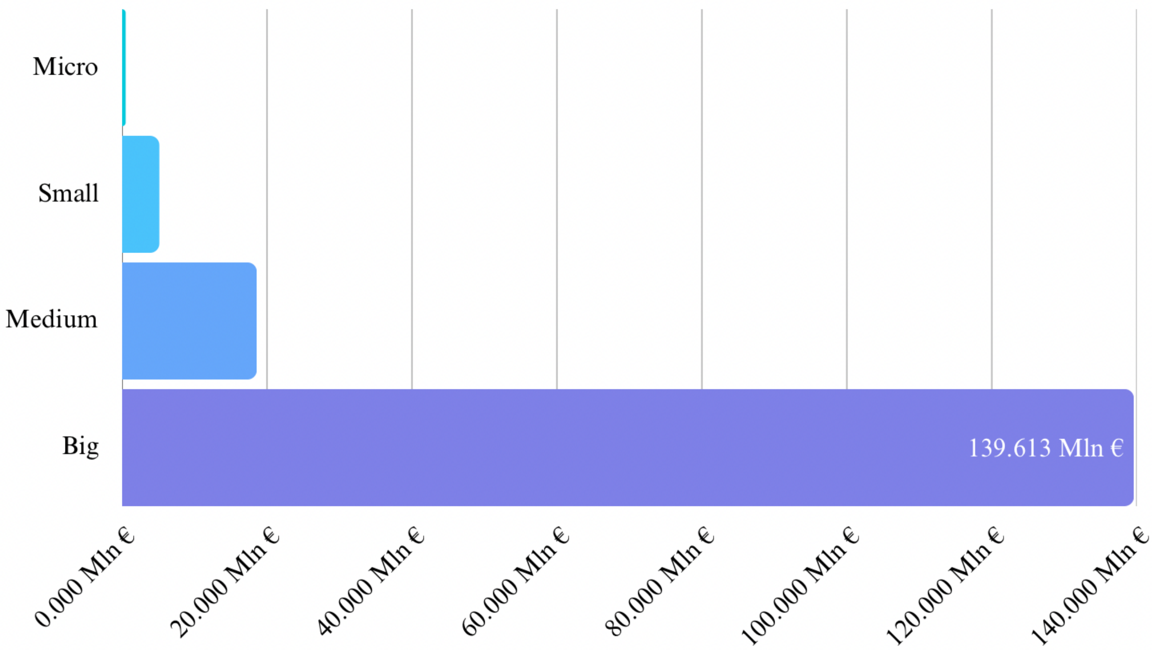

Figure 3.31: Sales medians distribution of Green Energy companies by size

Sales reflect the categorization used to define the companies. But it is important to notice how much the "big companies" data separate itself from the other, to understand what influence it had on the means. Even more by looking at the means, where the one of the big companies reach 526.279 Mln €. From this result it can also be deducted that consumers tend to trust more bigger companies, for their brand image, reputation or price competition, letting multinational firms getting most of the market share of the green energy sector.

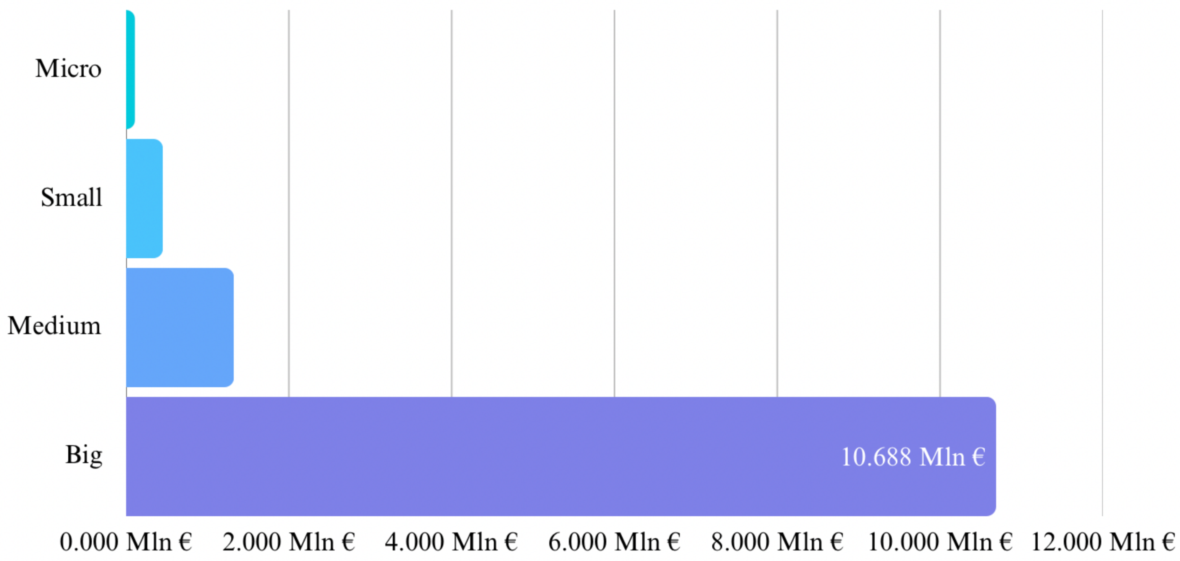

Figure 3.32: EBITDA medians distribution of Green Energy companies by size

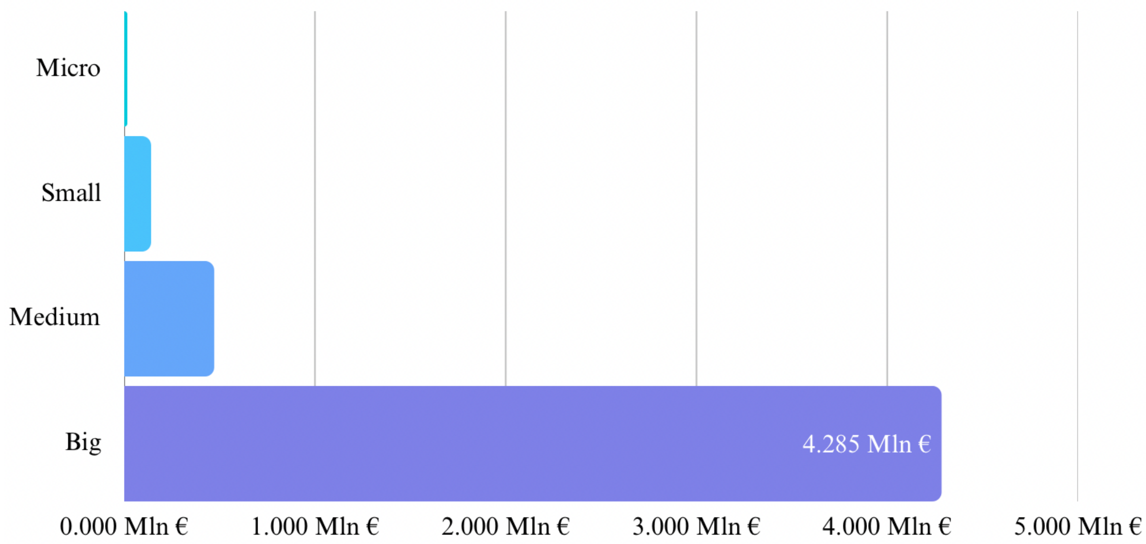

Figure 3.33: Net profit medians distribution of Green Energy companies by size

All graphs show the same trend with the big companies moving significantly away from the SMEs, ending up with a median of 4.3 mln € and a mean of 18.6 mln € of net profit, suggesting also that inside the big companies group some firms are a lot more important and profitable than others.

Although it may not seem bigger companies are also the one affected the most from depreciation costs, having a big plants and high tech machineries to count on.

To have an insight of SMEs another graph was made.

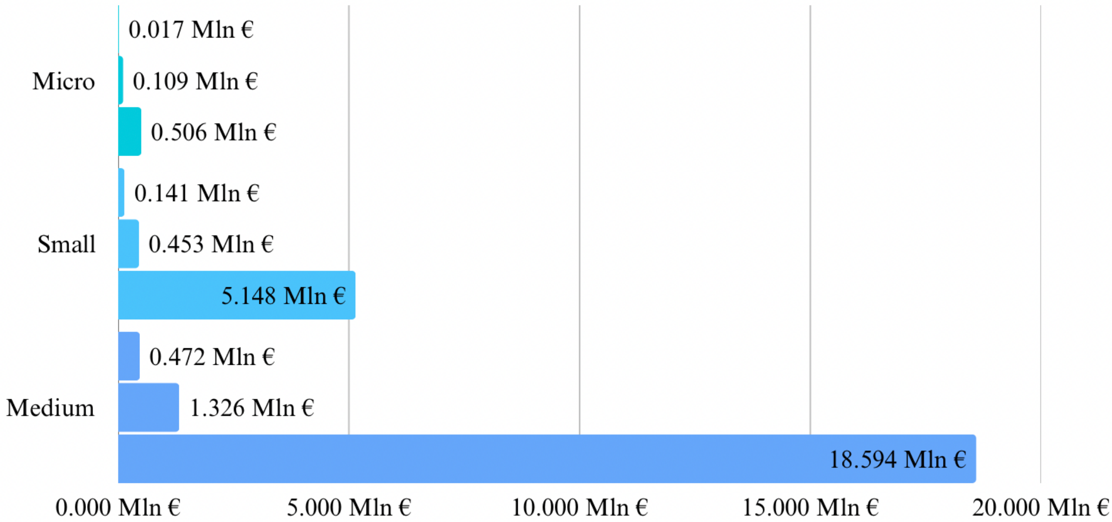

Figure 3.34: Net profit medians distribution of Green Energy companies by micro, small and medium size

Medium enterprises are the one that suffer the most cost of productions. This can be explained by their motivation to produce a high-quality product or service to try to compete with big companies, but not having an economy of scope well developed.

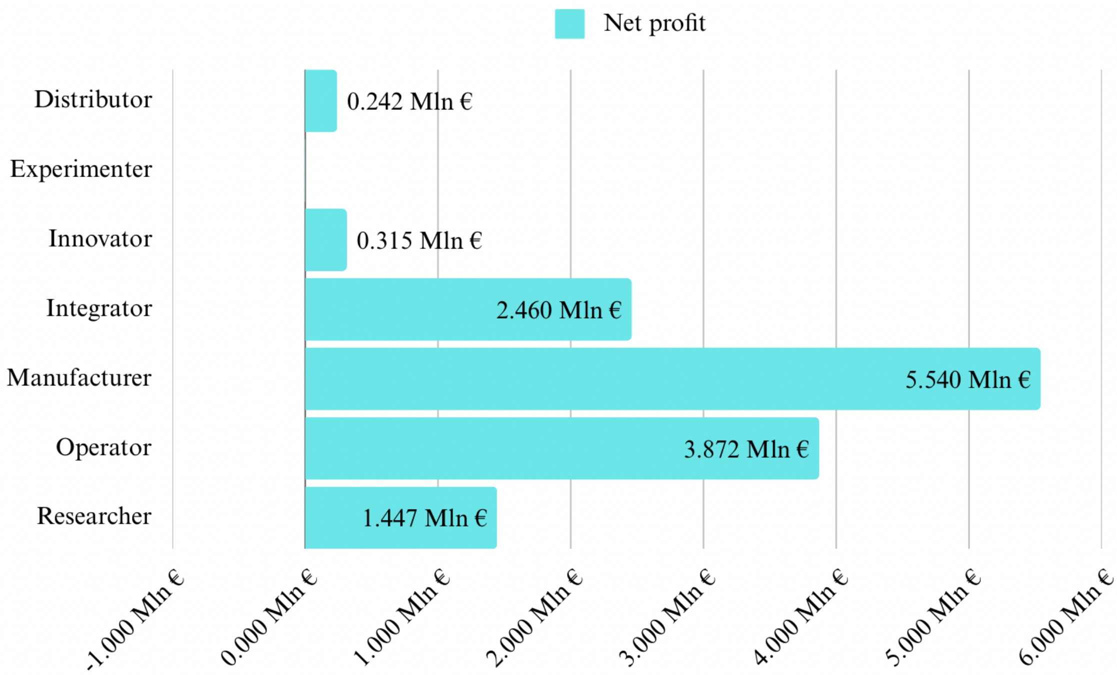

Figure 3.35: Net profit medians distribution of Green Energy companies by sector

By analyzing the sector in which green energy companies operate it is not surprising to acknowledge that manufacturers benefit from higher profits, being the most consolidated sector in the market and also the one that can wide the most.

Chapter 4 FINANCING SOURCES OF GREEN ENERGY COMPANIES

4.1 Financing sources in the green sector

The analysis of funding sources for companies operating in the Green Energy sector is a crucial aspect in the study. To understand how investors can influence the profitability and the growth of the firms in the sample in this chapter I will focus only on companies that received at list one funding in the time period taken into consideration.

Being the green sector still not consolidated in the global market, companies are considered very risky and with a high degree of uncertainty by investors. Moreover, innovative companies, as the ones in the dataset, need highly technological assets, along with high initial investments and long payback period. These factors don't invite investors to put their money in investments easily.

The public sector plays an important role in financing the sector, but as for private investors, there are still many barriers that limit the expansion of clean energy. This should change with the help of governments, new subsidies and regulatories to break those barriers, since it has been studied that to decarbonize the global energetic system and make the green sector reach an efficient economy, the need is to double the actual investments, bringing them to 2 billion dollars a year. (Kamiker & Stewart, 2012)

The public sector invest in green companies using pension funds, public banks and, lately, Green Bonds, financial instruments issued by governments, international financial institutions, public entities, or private companies to raise capital exclusively for projects that have a positive impact on the environment and climate.

Also new models and source of financing have been born lately, in order to meet the global need of the sector. These models don't have the economic return as their first objective, but are mainly interested in getting a social and environmental return. The aim is to give "individuals more control over their money as well as new outlets to invest or donate it." (Nesta, Understanding Alternative Finance)

One of these newly financial instruments is Social Impact Investing / ESG financing. Social impact investors find the right trade-off between social and financial return, integrating environmental, social and governance factors into the investment process. These instruments have been exponentially grew and in short time they succeed in reaching 17% of the financing market share.

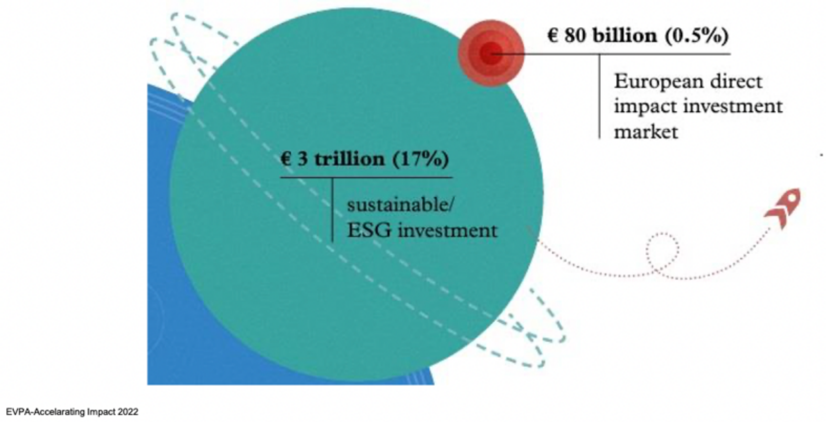

Figure 4.1: Size of European Impact investment market

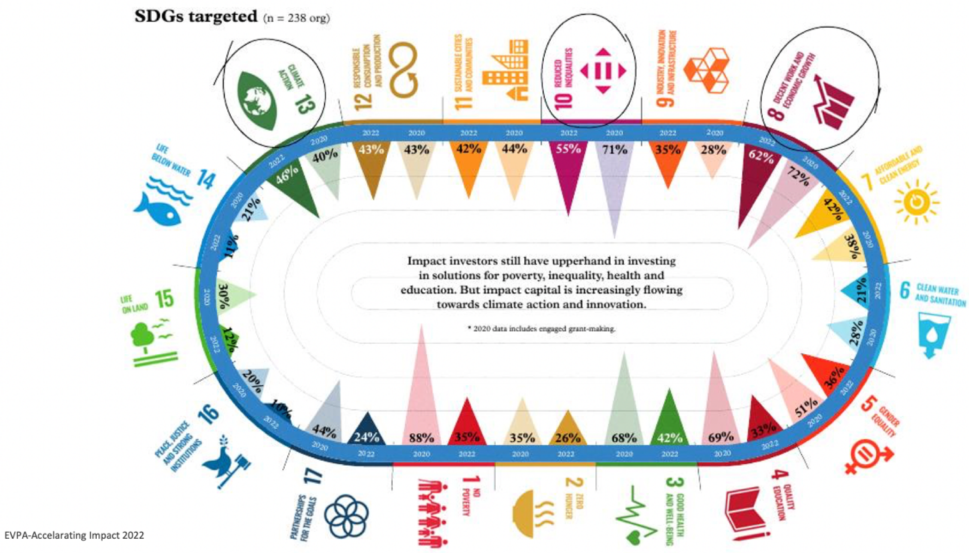

Figure 4.2: SDGs targeted by ESG investors

ESG and Social impact investors operate in all SDGs of the 2030 agenda, but in particular there was an increasing interest in SDG 10 "Reduced Inequalities", SDG 8 "Decent work and economic growth" and SDG 13 "Climate action", the SDG where Green Energy companies mostly operate and for this reason, they are a solid investment point for these users. Social impact investors don't invest only in green sectors or companies related to environment, they also care for other topics such as education, health, or poverty reduction.

This type of investment is mainly made by VC and PE impact fund, that represents 36%, , followed by 20% of financial institutions and 10% of foundations (Gaggiotti, G., and Gianoncelli, A., 2022).

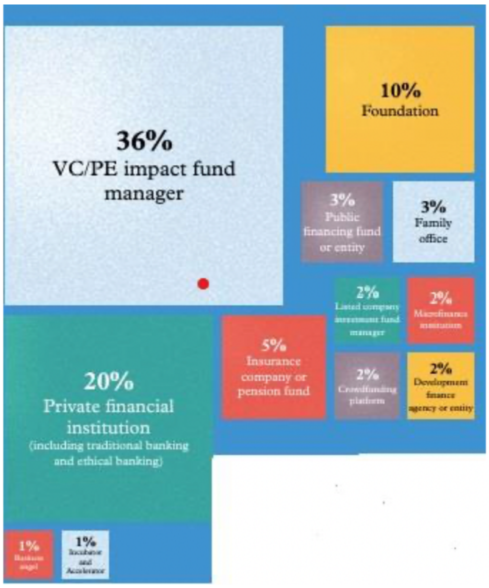

Figure 4.3: Main ESG investors

Apart from this innovative financial instrument, there are many other ways in which Green Energy companies can be financed:

- In the initial phases, many startups rely on Family, Friends & Fools (FFF), financial support from family, friends, and acquaintances who invest without necessarily expecting immediate returns.
- Crowdfunding, allows companies to raise capital from a large network of small investors through digital platforms, often using donation-based, loan-based, or equity-based models, also in exchange of feedback and information about the client demand.
- Business Angels, private investors who finance the early stages of a company's development, providing capital, experience, and networking opportunities.
- Venture Capital (VC), specialized funds that invest in innovative startups with high growth potential, in exchange for equity.

In this research we focus on the last two financial instruments cited: Business Angels and Venture Capital, the most important financing sources for a firm that yearn for growth.

Startups typically turn to Business Angels in the very early stages of development, when they have a promising idea but have not yet validated it in the market and struggle to access bank loans or structured funds. Business Angels are private investors that decide to finance emerging businesses, offering, apart from money, expertise, experience and network connections. BAs make smaller investments, usually ranging from tens to hundreds of thousands of euros (more if talking about Business Angels Groups).

Venture Capital (VCs) is the most suitable source of capital for high-tech entrepreneurial firms, including born-green ventures. Venture Capital (VCs) are investment funds that pool capital from multiple investors Unlike BAs, VC come into play at more advanced stages of a company’s development, when the business model has already been tested and the company needs significant capital to expand rapidly. VCs provide strategic and operational support, but they often require equity stakes and a direct influence on business decisions. VCs have clear return objectives for their investors and plan for exits (company sale or IPO) within a defined timeframe, typically between 5 and 10 years (Block et al., 2019).

In particular, given that the research is focusing on Green Energy firms, it can be assumed that Venture Capitals financing this kind of companies can be classified as “Green Venture Capital (GVC)”, a sub group of the Social Impact Investors.

Green Venture Capitalists (GVCs) are investment funds that specifically finance businesses that develop green technologies, meaning innovations that provide environmental benefits. They often carry higher risks compared to normal VCs, due to the high uncertainties of the sector and to the nature of the technologies. They they monitor more closely the business they finance, to be sure they don’t lose the environmental focus once they receive the money.

When a company uses green technologies the probability to get financed by a Green VC increase of the 7% (Mrkajic et al., 2019).

Other studies about how Venture Capitals influence the growth of clean companies have been carried. In particular the paper of Ambrois et al. (2025), shows that cleantech companies that received money from VCs have a significant growth in the short term, with an increasing of the total assets and of the sales. Moreover, it highlights that GVCs usually prefer to finance companies that are already growing and have more potential to give a higher return, mitigating the risk of uncertainty and maximizing the return on the investment. The paper suggest also that

VCs is the most suitable financial instruments for cleantech companies, and of course of green energy ones, offering along with money also expertise and strategic support.

4.1 The origin of the data in the sample

The data of the companies in the sample analyzed are collected from 4 main reliable platforms.

- VICO: a pan-European dataset on venture capital (VC) investment activity, developed as part of the RISIS2 project, funded by the European Union under the Horizon 2020 program. (Ambrois et al., 2023) It contains geographical, financial and industrial information about start-ups that received at least one Venture Capital investment in the time period from 1998 to 2021 (Montanaro, 2023).

Figure 4.4: VICO's logo

- Crunchbase: one of the main platforms of the business analysis sector, it is recognized as primary source of information by more than 31 million users globally. (Dalle et al., 2017) It is an online platform that collects and provides detailed information about companies, their structure, investors and tech stack. It is primarily used by Business angels, venture capitals and Private Equity investors that are looking for their new investment.

Figure 4.5: crunchbase's logo

- Preqin: a private-held financial analysis platform specialized in alternative investments such as private capital and hedge funds. It provides detailed data on funding deals, institutional investors, investment funds, and target companies and it is a key tool for investors.

Figure 4.6: Preqin's logo

- Pitchbook: a financial analysis platform specializing in tracking private capital investments. It allows conducting financial valuations, comparing investment deals, and monitoring market activity in real time. It is widely used by venture capital and private equity funds, financial analysts, investment banks, and companies seeking funding or expansion opportunities.

Figure 4.7: Pitchbook's logo

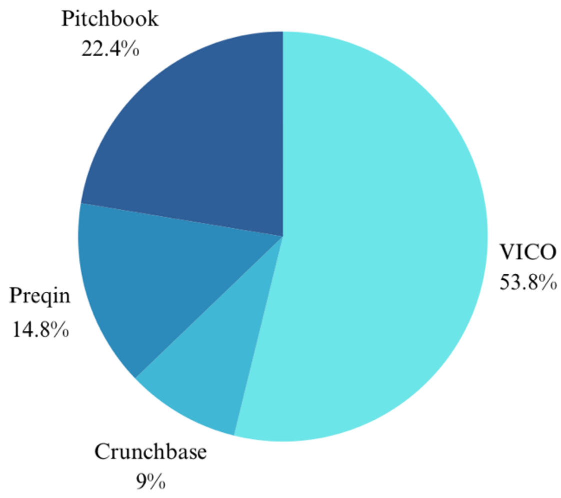

Figure 4.8: Distribution of the extraction of the data used in the study

More than half of the data are extracted from VICO, since being part of the European project it was easier to get information from it. Pitchbook also contributed a lot, with the 22.4% of the information. Some companies, having been observed in different years, can have obtained data from more than one platform.

4.3 Classification of the investors in the sample

The companies in the sample have been financed a total of 2363 times by 307 different investors. Some firms were only financed once, while other companies have been financed even 30 times, that, considering that the study was conducted on observations made from 2000 to 2022, it means more than once a year, as for “stage-financing”.

The 307 investors can be divided into:

- Business Angels;
- Independent Venture Capital (IVC);
- Corporate Venture Capital (CVC);
- Governmental Venture Capital (GVC);
- Bank-affiliated Venture Capital (BVC);
- University Venture Capital (UVC);
- Others.

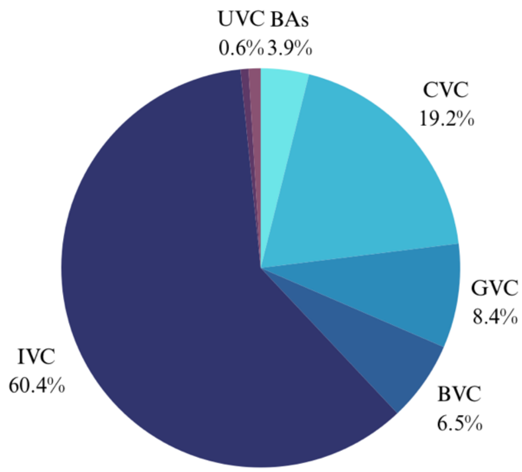

Figure 4.9: Distribution of the investors by typology of investor

Out of 302 investors 186 are Independent VCs, the most spread type of Venture Capital, as well as the most effective one. In fact, Independent VCs are known for having the best general partners, the managers responsible for the good outcome of the investment.

Following we find the Corporate VCs, firms that decide to invest in emerging firms to capture their technological innovation before other competitors. The CVC counts 59 investors out of 302, for instance: Bosch, Siemens, Hitachi or Volvo.

Understanding the origin of investors is another key factor to fully analyze the sample.

Country name	**Investors**	
	Number of investors	**Percentage**
Australia	1	0,34%
Austria	4	1,69%
Belgium	14	4,75%
China	2	0,68%
Czech Republic	1	0,34%
Denmark	9	3,05%
Finland	24	8,14%
France	82	27,80%
Germany	44	14,92%
Greece	1	0,34%
Ireland	1	0,34%
Italy	3	1,02%
Japan	2	0,68%
Kenia	1	0,34%
Lithuania	1	0,34%
Luxemburg	2	0,68%
Monaco	1	0,34%
Netherlands	8	2,71%
Norway	8	2,71%
Panama	1	0,34%
Poland	3	1,02%
Portugal	3	1,02%
Qatar	1	0,34%
Russia	2	0,68%
Singapore	2	0,68%
Slovakia	1	0,34%
Spain	7	2,37%
Sweden	27	9,15%
Switzerland	6	2,03%
United Arab Emirates	1	0.34%

United Kingdom	16	5,42%
United States of America	16	5,42%

Table 4.1: Geographical distribution of investors

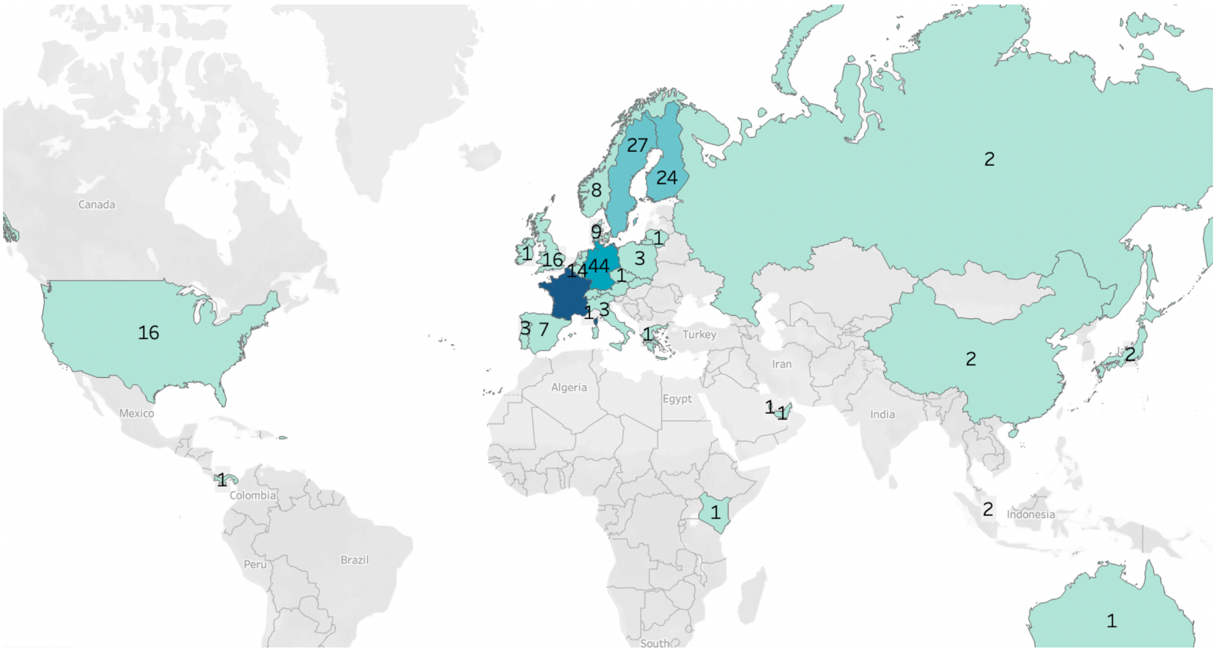

Figure 4.10: Geographical distribution worldwide of the investors in the sample

Analyzing the origin of the green investors it can be seen that 29 (9,83%) have extra European provenience. In particular, 16 investors come from USA. America is an important country as it is the country where most of VCs worldwide are located, as well as where modern Venture Capitalists were born after World War II, with the establishment of American Research and Development Corporation (ARDC) in 1946, founded by Georges Doriot, often referred to as the "father of venture capital".

The globalisation allowed venture capitalists to invest also outside their domestic view, without losing the control they need of the firm. Thanks to this the non-domestic investments are in expansion nowadays.

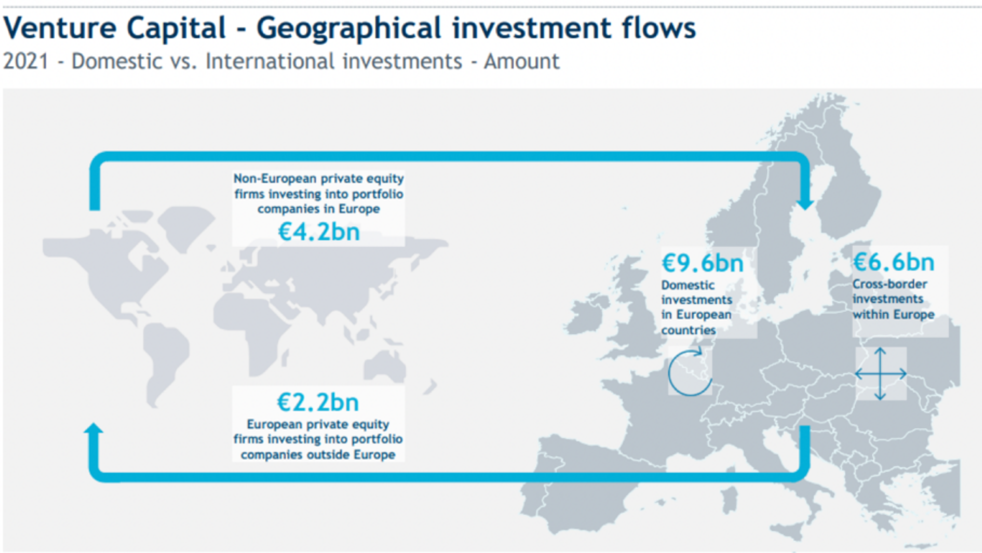

Figure 4.11: Geographical investment flows of Venture Capital, Invest Europe / EDC

To assess whether there are significant differences in the amounts invested by European and non-European investors, some tests were performed. To address the high skewness of the total amount invested variable, that implied a non-normality condition, a logarithmic transformation was applied. A two-sample t-test was then performed to compare the means of the log-transformed investments between European and non-European investors.

Group	Observations	Mean (log-transformed) (Mln €)	95% Confidence interval (Mln €)
European investors	1154	8.3377	[8.2392; 8.4361]
Non-European investors	235	8.0898	[7.8827; 8.2969]
Difference	-	**-0.2478**	**[-0.4850; -0.0107]**

Table 4.2: T-test on the total amount invested by origin

The p-value of the T-test is 0.0406, which indicates that there is a statistically significant difference between the log-transformed means of the two groups. Specifically, the negative t-value suggests that non-European investors tend to invest less than European investors, proving that far located investors still shows some hesitations in financing European start ups.

To confirm this result I also conducted a Mann-Whitney U Test, test that doesn't require a normality assumption.

Both the t-test on log-transformed data and the Mann-Whitney U test indicate a statistically significant difference between the investments of European and non-European investors:

- The t-test (on log-transformed data) with a p-value of 0.0406.
- The Mann-Whitney U test with a p-value of 0.0032, providing even stronger evidence of this difference.

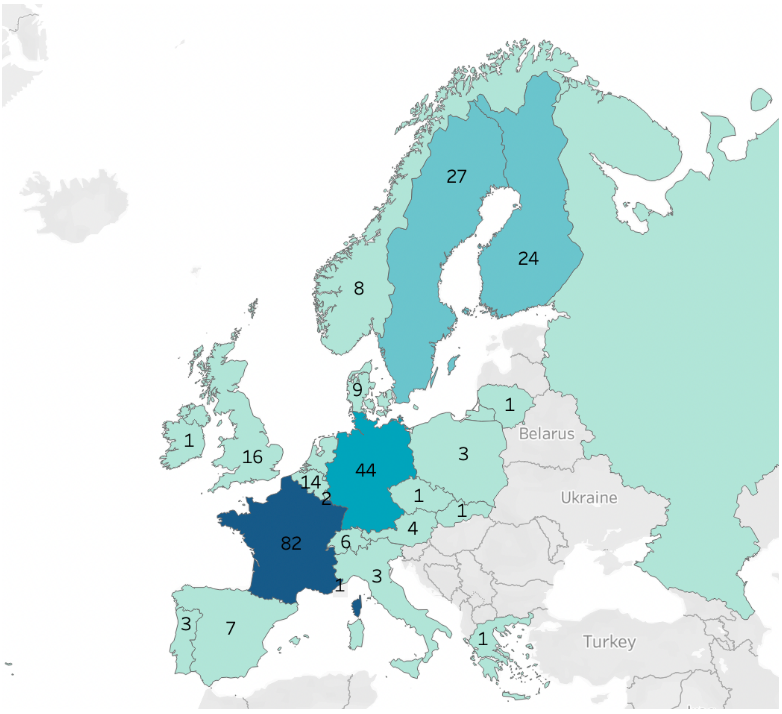

Figure 4.12: Geographical distribution of the investors in the sample, Europe

By focusing on Europe, it can be seen that France overtakes the other countries by far, reaching 27,80% of all investors, followed by Germany with 14,92% and by Sweden and Finland with 9,15% and 8,14% respectively. The distribution of our sample is coherent with the Invest Europe / EDC report, that highlight that in 2021 Europe most of VCs (37,2%) are located in France.

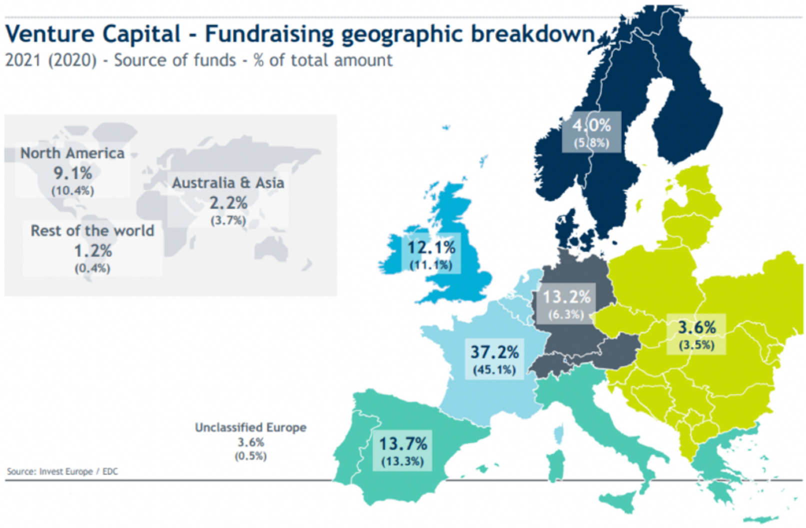

Figure 4.13: Fundraising geographic breakdown, Invest Europe / EDC

France has indeed overtaken Germany and Italy in terms of VC-backed investments. (Bottazzi & Da Rin, 2002) This development has been driven mainly by government policies such as public funds for the risk capital to support start-ups, tax incentives or opening the biggest start-ups station in the world “La French Tech”.

Some of the main French investors present in the sample are the following:

- BPI group, Banque Publique d'Investissement, is an example of public venture capital. It is indeed a french government investment fund that co-invest in start-ups and SMEs. In the study BPI group results having invested in 3 companies: Finsecur, Total Eren, but, above all, Solipac, with 17 rounds of 700k€ each.

BPI group

Figure 4.14: BPI Groupe’s logo

- Sofinnova Partners, one of the oldest Venture capital company in Europe, founded in 1972. It is active in the social topics, and it invests mostly in nanotechnologies and healthcare companies. In the sample Sofinnova Partners invested in two companies: Corwave, for a total of about 62 mln € and Mcphy Energy for a total of 23 mln € .

Sofinnova partners

Figure 4.15: Sofinnova partners’s logo

- Idinvest Partners, independent from 2010, before it was part of the Allianz group. It is a very active firm in the investment of SMEs, with a particular focus on capital risk and PE.

Figure 4.16: Idinvest partners's logo

Germany is positioned on the second place for VCs' presence in the country. The VCs in Germany registered a great increasing in the last years, making the nation a central hub for investors. In 2024, about 7,4 bln € were invested in German start ups, overtaking the data of the previous year of 4%.

In particular, Germany is the headquarters of several CVC (Corporate Venture Capitals) and funds, such as Siemens, BMW and Bosch.

Some of the main investors in Germany, that are also cited in the dataset are:

- High-Tech Gründerfonds (HTGF): a private-public partnership of venture capital firms based in Bonn focused on high tech start-ups. Some of the investors include: the Federal Ministry of Economics and Technology, KfW banking Group (another federal group) and 39 industrial firms (ex. SAP, Robert Bosch, CEWE, Deutsche Post DHL). It manages about 886mln $ and it has invested in more than 490 firms. In the sample this investor has financed the company Heliatek Gmbh with a total of 140mln € in 5 rounds.

Figure 4.17: High-Tech Gründerfonds' logo

- KFW Group, one of the biggest public investors in Germany. It is a public bank with a great impact on the sector. It focuses on start-ups and SMEs.

Figure 4.18: Kfw group's logo

To test the hypothesis of the so-called "Local Bias", several analyses were conducted. The Local Bias refers to the tendency of investors to prefer financing companies located closer to them, as this allows for easier monitoring and control, due to greater familiarity, reduced informational barriers, or other country-specific factors. This hypothesis is supported by two key findings:

1. The proportion of domestic investments, which account for approximately two-thirds of the total investments in the sample, as shown in figure 4.9.
2. The average amount invested by local investors in domestic firms compared to foreign firms supported by a T Test and a Mann-Whitney U Test.

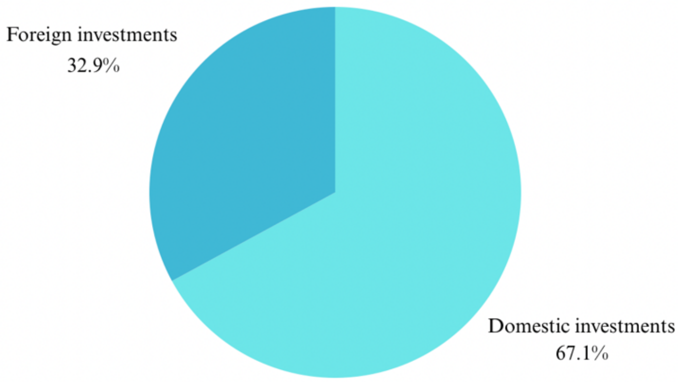

Figure 4.19: Distribution of domestic and foreign investments

Group	Observations	Mean (log-transformed) (Mln €)	95% Confidence interval (Mln €)
Local investors	899	8.4014	[7.9514; 8.2524]
Foreign investors	490	8.1019	[8.2914; 8.5114]
Difference	-	**-0.2995**	**[-0.4852; -0.1138]**

Table 4.3: T-test on the total amount invested by same origin

Both the t-test on log-transformed data and the Mann-Whitney U test indicate a statistically significant difference between local and foreign investments, with a p-value of 0.0016 and of 0.0028 respectively. The negative t-value suggests that foreign investors tend to invest less than local investors, aligning with the "local bias" hypothesis.

For this reason, we'll expect a similar density trend in analyzing the companies invested.

4.3 Classification of the companies backed by VCs in the sample

The results indicate that 251 firms of the sample have been financed either by VCs or by BAs. Of this 251 the 62,94% are classified as Ecosystems, while the 37% are innovators. This data is obviously influenced by the higher number of ecosystems companies considered and it follows the trend of the sample taken on its whole. Not to be biased by the numerosity of the whole dataset, I studied the single sectors compared only to their category.

Green Energy segment	Number of companies backed by investors	Total number of companies	Percentage of backed companies
Green Energy Innovators	93	1911	4,86%
Green Energy Ecosystems	158	9310	1,69%
Operators	31	2875	1,08%
Integrators	41	2747	1,49%
Manufacturers	63	2253	2,8%
Distributors	21	1403	1,5%
Researcher	0	29	0%
Experimenters	2	3	66,7%

Table 4.4: Sectorial distribution of investors-backed companies

The data reports that investors are more easily convinced by innovators companies, thanks to their focus on research and innovation and their higher potential for growth moreover investors look for high return in the long run and technological innovation, indeed they represent 4,86% of the total number of green energy innovators a number almost three times higher than the percentage of green energy ecosystems.

Inside the Ecosystem sector, investors tend to prefer firms that operate in the manufacturing area, this can be explained with the higher demand Manufacturers benefit from. The decreasing trend moves on with integrators, operators and distributors. Something interesting is that this distribution is in contrast with the one analyzed in chapter 3 concerning the total number of companies in the sample, as shown in the table 4.3 and 4.4.

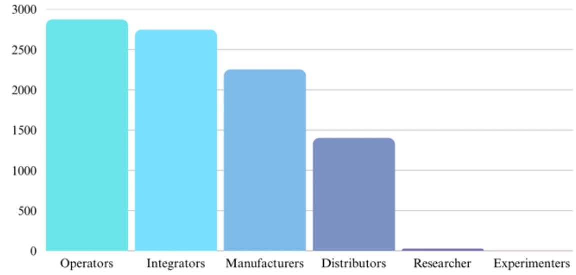

Figure 4.20: Green energy Ecosystems sectorial distribution of the whole sample

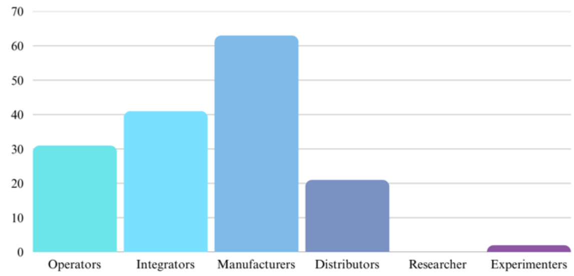

Figure 4.21: Green Energy Ecosystems sectorial distribution of investor-backed companies

On the other hand, by looking at the technological categories, the distribution of the sub-group of the companies backed follows the trend of the whole sample, having its peak in the category of 3.1 Sustainable energy production category, the main category for Green Energy companies.

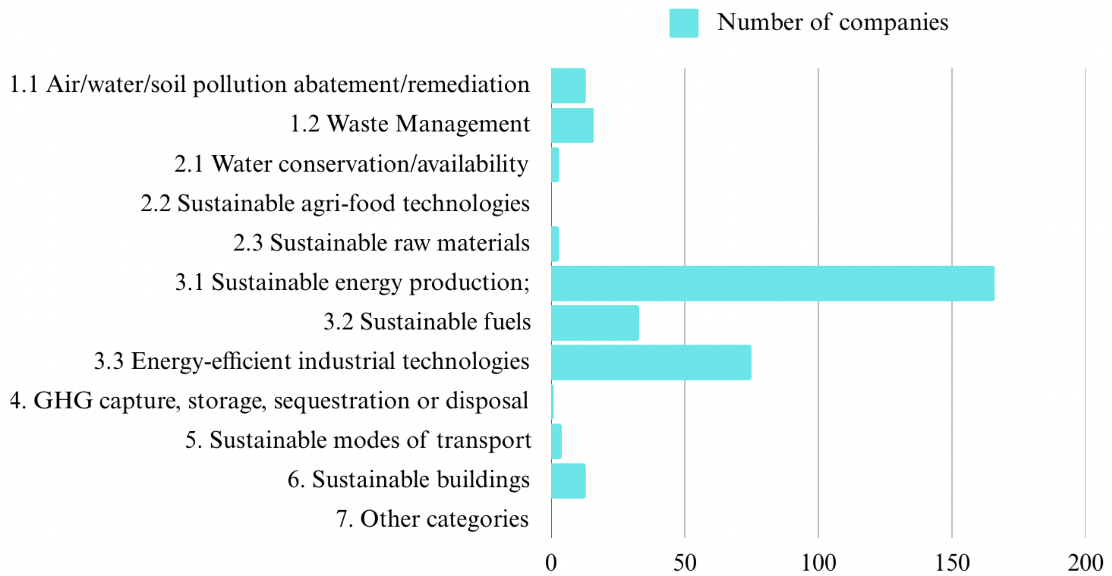

Figure 4.22: Green energy ecosystems technological category distribution of investor-backed companies

By looking at the NACE, the sector with the highest percentage of backed companies is surprisingly the J sector (Information and communication), meaning that VCs are very active, likely due to the potential of the sector. But, given that the sample is small (10 out of 101), the data is not very significant. For sector M (Professional, scientific and technical activities) the same happens. The high percentage give a clue of the interest of VCs but the sample is relative small to be meaningful.

Taking the highest absolute number of the companies backed by investors the distribution shows that the sector with the highest number, even if the percentage is relatively low, (65 out of 2555) is C (Manufacturing). Investors see in this sector a highest probability of growth, given the size and the potential. This data will be confirmed in chapter 5, where it will be demonstrated a great importance of the sector in the profitability and growth.

Sector M, D and G follow with 53, 42 and 31 backed firms. Following the distribution of the sample.

NACE rev.2 section	Number of companies backed by investors	Total number of companies	Percentage of backed companies
A – Agriculture, forestry and fishing	0	65	0%
B - Mining and quarrying	1	73	1,37%
C - Manufacturing	65	2555	2,54%
D - Electricity, gas, steam and air conditioning supply	42	1643	2,55%
E - Water supply; sewerage, waste management and remediation activities	13	1576	0,82%
F - Construction	17	1449	1,17%
G - Wholesale and retail trade; repair of motor vehicles and motorcycles	31	1941	1,6%
H - Transportation and storage	1	143	0,69%
I - Accommodation and food service activities	0	30	0%
J - Information and communication	10	101	9,9%
K - Financial and insurance activities	8	289	2,76%

L - Real estate activities	0	135	0%
M - Professional, scientific and technical activities	53	850	6,23%
N - Administrative and support service activities	8	256	3,12%
O - Public administration and defense; compulsory social security	0	7	0%
P - Education	0	8	0%
Q - Human health and social work activities	1	25	4%
R - Arts, entertainment and recreation	0	11	0%
S - Other service activities	1	46	2,17%
Total	**251**	**11203**	**2,24%**

Table 4.5: NACE Rev.2's distribution of investors-backed companies

Another important insight is the geographical distribution of the firms backed by the investors. To confirm the hypothesis that investors prefer to finance companies located close to them to be on site, we expect that the density will follow the one of Figure 4.12.

Country name	**Number of companies backed by investors**	
	Number of investors	**Percentage**
Austria	6	2,39%
Belgium	27	10,76%
Bulgaria	2	0,80%
Czech Republic	1	0,40%
Finland	18	7,17%
France	64	25,50%

Germany	34	13,55%
Greece	1	0,40%
Hungary	3	1,20%
Iceland	1	0,40%
Italy	10	3,98%
Lithuania	1	0,40%
Netherlands	9	3,59%
Norway	11	4,38%
Poland	7	2,79%
Portugal	3	1,20%
Slovakia	2	0,80%
Slovenia	1	0,40%
Spain	17	6,77%
Sweden	20	7,97%
United Kingdom	7	2,79%
Total	**251**	**100%**

Table 4.6: Geographical distribution of investors-backed companies

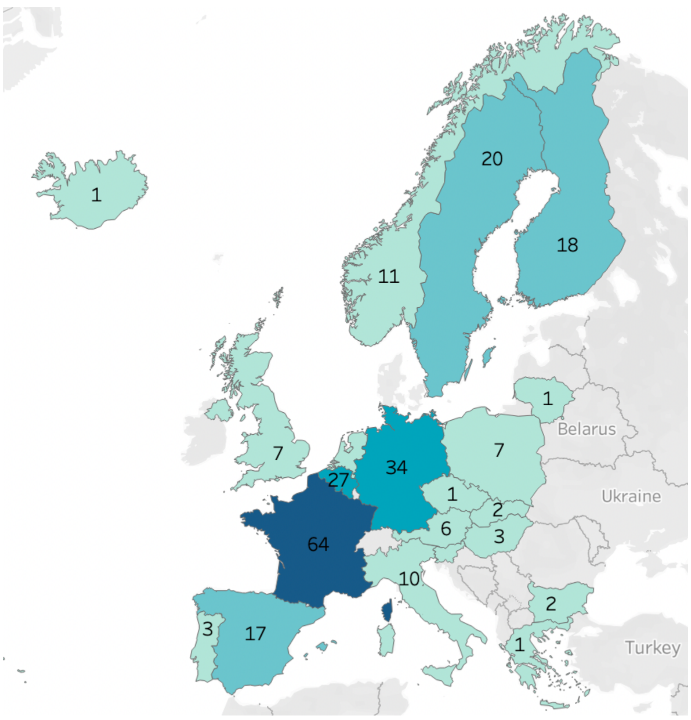

Figure 4.23: Geographical distribution of investors-backed companies

The distribution follows the one of the locations of the investors of the sample, with France the being the country with the highest number of investors and companies backed. Germany, Sweden and Norway also follow the trend. Belgium is the only country that is found to be very VC backed but with a lower number of investors. This can be related to the cultural and linguistic fact that attract, apart from Belgium, also French investors.

4.4 Analysis of the investments

In the dataset analyzed a total of 2642 investments rounds were made by a total of 302 investors in 251 firms.

The mean of the amounts invested is about 13 mln € and the median is equal to 6,7 mln €.

The following table represents the descriptive statistics of the total equity invested across different VC categories.

Group	Mean (Mln €)	Median (Mln €)	St. deviation (Mln €)	Q1 (Mln €)	Q3 (Mln €)
BA	5,870	1,300	11,699	0,500	3,370
CVC	15,605	9,160	20,557	3,476	18,000
GVC	16,555	8,120	24,245	1,780	16,650
BVC	16,451	6,700	25,324	3,000	15,000
IVC	11,915	6,700	17,603	2,014	15,000
UVC	5,376	1,780	7,050	0,850	13,499
Other	13,119	3,367	22,442	1,500	13,499
Total	**12,808**	**6,700**	**19,259**	**1,800**	**15,000**

Table 4.7: Statistical descriptions of investments made in green energy companies

The results are in line with the characteristics of each category. Business Angels invest less than Venture Capitals and finance early staged firms that don't need a high capital to approach significant high-cost investment, they just need to start to get them in the market.

Independent Venture Capitals is the category that has the highest average invested, being the most influencing group of VCs for a firm. Also, BVC and GVC have high means, making the total average to increase significantly.

To analyze whether VC backed companies results in higher profits some descriptive statistics were carried out.

To ensure that the results are not driven by extreme values, outliers were identified and excluded using the Interquartile Range (IQR) method. Specifically, values below Q1−1.5×IQR$Q1-1.5\times IQR$ or above Q3+1.5×IQR$Q3+1.5\times IQR$ were considered outliers and removed from the analysis. The analysis was conducted with and without outliers and it highlighted the important influence that outliers had on the analysis. In the table below the values without outliers are reported.

Variable	Group	Mean	Median	St. deviation
EBITDA	VC-Backed	873 350 €	569 500 €	2 352 410 €
	Non VC-Backed	1 214 040 €	572 000 €	1 862 550 €
Total Assets	VC-Backed	14 421 060 €	8 907 000 €	13 979 800 €
	Non VC-Backed	10 123 640 €	5 221 000 €	12 134 640 €
Mean Profitability	VC-Backed	7,66 %	7,38%	7,73 %
	Non VC-Backed	9,03%	7,31%	8,45%

Table 4.8: Statistical descriptions of financial KPIs compared between VC-backed and non VC-backed

The analysis reveals that non-VC-backed firms have a slightly higher mean EBITDA (1,214.04) compared to VC-backed firms (873.36). However, the median EBITDA is very similar between the two groups (569.5 for VC-backed vs. 572 for non-VC-backed), suggesting that most firms, regardless of VC backing, achieve comparable EBITDA levels.

VC-backed firms demonstrate significantly larger Total Assets, with a mean of 14,421.06 compared to 10,123.64 for non-VC-backed firms. This suggests that VC-backed firms tend to be larger in size, likely due to the additional capital and resources provided by venture investors.

Despite their larger asset base, VC-backed firms exhibit lower Profitability compared to non-VC-backed firms. This data will be confirmed in chapter 5 by the model. VC-backed firms may prioritize growth and market expansion over short-term profitability, leading to higher operational costs and lower profitability ratios.

Chapter 5 MAIN FACTORS INFLUENCING GREEN ENERGY COMPANIES' PROFITABILITY

In this section I wanted to highlight the influence of the factors already analyzed in the previous chapters on profitability and growth of the firms. The sample used in the following analysis counts 108 384 observations of the 11 221 green energy companies used in the thesis, with a time window from 2000 to 2022, for a total of 23 years, with gaps. A set of OLS model specifications is presented to study this influence and the effect on the performance of the companies.

To study the performance of the green energy firms operating profitability has been widely chosen in several studies (Scellato & Ughetto, 2013). For this reason, the mean operating profitability, calculated as EBITDA / Total Assets, was adopted as first dependent variable for the model. To get a further insight another model was implemented choosing the growth rate as dependent variable.

In the models, besides quantitative and categorical variables, some lagged measures were added, to analyze if events happened in the previous years have delayed effects in the performances of companies.

Before getting the results, some hypotheses were made to get more focus on some specific factors:

- Firms performing good don't get profitability falls from one year to the other (H_1);
- VCs financing means higher profits (H_2);
- Bigger firms perform better (H_3);

In table 5.1 the variables used in the regression are defined and explained, along with their main statistics.

Variables	Definition	Mean	Median	St. dev	1^{ST} cent	99^{TH} cent
PROFITABILITY	EBITDA / Total assets	- 0.104	0.085	64.979	-0.588	0.578
TOTAL ASSETS	Total assets scaled by 1 000 000	0.229	0.007	4.09	.00008	2.528
EMPLOYEES	N_employees scaled by 1 000	0.501	0.049	4.866	0	6.873
VC – BACKED	Dummy variable that is equal to 1 if the company has been financed by VCs or by BAs	0.01	0	0.1	0	1
INNOVATOR	Dummy variable that is equal to 1 if the company is categorized as innovator	0.16	0	0.366	0	1
BACKED BY IVC	Dummy variable that is equal to 1 if the company has been financed by a Individual Venture Capital	0.0014	0	0.0374	0	1
NO PATENTS	Dummy variable that is equal to 1 if the company never had a patent	0.871	0	0.335	0	1

Table 5.1: Statistical descriptions of variables used in the OLS models

In the first scenario, table 5.2, the mean operating profitability was studied by doing several tries.

In model I, only the quantitative independent variables were added. Then in model II and III, some categorical variables were added. In model IV only the meaningful variables were taken into consideration.

The table reports models for the sample of 11 221 green energy companies. For the sake of synthesis, estimated coefficients of sector, country and year of incorporation dummies were omitted. Collinearity is not present. Hetero-skedasticity robust standard errors are reported in parentheses.

$***$: significant at the 1% level $**$: significant at the 5% level, $*$: significant at the 10% level.

Dependent variable	MEAN PROFITABILITY			
Model	I	II	III	IV
PROFITABILITY(t_{-1})	0.588*** (0.004)	0.550*** (0.004)	0.5524*** (0.0042)	0.5496*** (0.004)
TOTAL ASSETS	-0.00007** (0.00003)	0.00004 (0.00004)	0.000016 (0.000039)	0.000054 (0.00004)
EMPLOYEES	0.00012*** (0.00003)	0.00013*** (0.00004)	0.00019*** (0.000041)	0.00018*** (0.00004)
VC – BACKED (dummy)		-0.0345*** (0.003)		-0.0311*** (0.003)
INNOVATOR (dummy)		-0.0072*** (0.001)		-0.0066*** (0.00102)
BACKED BY IVC (dummy)			-0.0846*** (0.025)	-0.0564** (0.0255)
NO PATENTS (dummy)			0.0095*** (0.001)	0.007*** (0.001)
Country dummies	no	yes	yes	yes
NACE sector dummies	no	yes	yes	yes
Year dummies	no	yes	yes	yes
Constant	0.0355*** (0.00049)	0.0737** (0.029)	0.0658** (0.029)	0.0675** (0.029)
Adj R - squared	0.5148	0.5452	0.5431	0.5451
Number of Observations	66960	66360	66350	66350

Table 5.2: OLS regression factors that impact the mean profitability of green energy firms

From the models found related to the first scenario where the mean operating profitability was considered as independent variable the following results have been highlighted:

In all models the profitability of the previous year is the most significant factor, indicating a strong persistence in profitability of green energy companies. The coefficient remains around 0.5 and it indicates how much the mean profitability change in respond to a unitary change of the lagged profitability. This result is coherent with the theory that firms with good performance tend to maintain their competitive advantage. (H_1)

The coefficient related to the total assets is significant only in the first model. This suggest that once the categorical variables of years, country and sectors are added, the impact of the asset capital is significantly reduced.

The size of the companies, described as the number of employees is always significant. The coefficients confirm H_3 , suggesting that bigger companies benefits from higher profits, since they could already being consolidated and well-known in the market.

Companies backed by venture capital show lower average profitability compared to those not backed by VC. This unexpected result rejects the hypothesis that being financed by VCs always means higher profits, especially in the short term. The negative coefficient may be explained by the fact that the firms backed are usually still in growth and not consolidated, in addition, VCs usually use aggressive strategies giving up short run profitability for the one in the long run. In particular, this happens when talking about Independent VCs (IVC). (H_2) It is however important to take into consideration that even in this case the number of VC backed companies is low and it can influence the result.

Companies classified as Innovator show lower average profitability. This can be due to the high technological investments and high innovation costs they have to face. Even in this case usually the profits are expected mainly in the long run.

The coefficient related to patents is unexpected since it suggests that companies without patents benefit of higher mean profitability. This could be explained by the high costs for the process and for the resources to get patents. Despite that, the data is biased by the high number (87%) of companies without patents compared to those that have at least one patent. For this reason, the coefficient is not reliable in the analysis but left for improving the robustness of the model.

From these findings the starting Hypothesis had the following outcomes:

- **H_1 Profitability Persistence:** Consistent with the literature on firm performance dynamics, profitable green energy firms are expected to maintain their competitive advantage over time. The positive and significant coefficient of the profitability of the previous year ($\beta \approx 0.55$, $p<0.01$) supports this hypothesis, indicating that firms with higher profitability in the previous year tend to sustain their performance. This persistence may reflect operational efficiencies, economies of scale, or the presence of entry barriers in the green energy sector.
- **H_2 Venture Capital and Performance**: Contrary to conventional expectations, VC-backed firms exhibit lower mean operating profitability ($\beta = -0.031$, $p<0.01$). However, this result aligns with the theoretical argument that venture capitalists prioritize rapid growth and market expansion over short-term profitability (Hellmann & Puri, 2000). Further analysis shows that the negative profitability effect is particularly pronounced for firms backed by independent VCs (IVCs) ($\beta = -0.056$, $p<0.05$), likely due to their aggressive investment strategies. This reinforces the view that VC involvement shifts firm priorities toward growth and long run return, indeed VCs usually stay in firms about 10 years, to assure that long run profits are achieved.
- **H3 Firm Size and Performance:** larger firms, measured by employee count, demonstrate significantly higher profitability ($\beta \approx 0.00018$, $p<0.01$), supporting the hypothesis that scale advantages, such as better access to financing, brand recognition,

economies of scale, enhance performance in the green energy sector. This finding aligns with Coad et al. (2016)'s paper where he sustains that resource availability (typical of larger firms) matters more than maturity for growth in knowledge-intensive sectors. Notably, the effect of total assets becomes insignificant once sector and country controls are added.

To further investigate the influence of these factors I carried out an analysis dividing the companies of the sample into start-ups (firms aged <7 years) and mature companies (firms aged >7 years). Although conventional start-ups use the limit of 5 years, I adopted 7 years considering the green energy sector a on growing market that requires a longer life cycle to get consolidated. The analysis reported the following results:

START – UPS

Dependent variable	**Mean Profitability**
Model	I
PROFITABILITY(t_{-1})	0.6925*** (0.0595)
EMPLOYEES	0.00046 (0.0019)
VC – BACKED (dummy)	0.0019 (0.067)
Country dummies	yes
NACE sector dummies	yes
Constant	-0.0905** (0.035)
Adj R - squared	0.6004
Number of Observations	318

Table 5.3: OLS regression factors that impact the mean profitability of green energy start-ups

MATURE COMPANIES

Dependent variable	**Mean Profitability**
Model	I
PROFITABILITY(t_{-1})	0.553*** (0.0044)
EMPLOYEES	0.00017*** (0.000025)
VC – BACKED (dummy)	-0.0315*** (0.0028)
Country dummies	yes
NACE sector dummies	yes
Constant	-0.051*** (0.0044)
Adj R - squared	0.5207
Number of Observations	54741

Table 5.4: OLS regression factors that impact the mean profitability of green energy mature companies

Startups show 13.4 percentage points stronger profitability persistence than mature firms (0.692 vs 0.553), suggesting early-stage performance is more path-dependent, probably because their smaller error margin and the fact that if they want to receive money from investors, they have to demonstrate consistency to them. The coefficient for mature firms is still high but weaker.

This data furtherly confirms H_1 stating that firms with good performance tend to maintain them, above all during the early stages.

An interesting data emerge from the analysis of the start-ups: the VC-backed dummy results not significant for the mean profitability, in contrast with the output found taking the whole group. This can be driven by the fewer observation taken into consideration that can bias the data. In the meantime, mature firms still show a negative impact on profits when being financed by VCs, maybe due to the type of expansion seek by VCs (ex. new markets).

In this case we partially reject H_2 saying that the negative impact in the short time of the VCs is particularly evident in mature firms.

Also the coefficient related to the number of employee doesn't seem significant for the start-ups but only for mature firms. We partially reject H_3 saying that only consolidated firms find a light impact on their profits depending on their size. The bigger the company the higher will be the profits.

Conclusion

This thesis has thoroughly investigated the green energy company sector in Europe, examining market dynamics, funding sources, and the main drivers of profitability. Through a data-driven analysis of a large dataset of 11,221 cleantech companies, this research has provided valuable insights into the financial and operational characteristics of this rapidly growing sector.

The results, as described in Chapter 3, highlighted a concentration of green energy companies in countries such as Germany (19.71% of the sample), Italy (16.95%), France (13.56%), and Spain (10.11%), reflecting the significant role of national policies and incentives in promoting a green economy. The analysis also revealed that companies supported by venture capital (VC) tend to have higher levels of innovation, as measured by patenting activity, with 22.78% of "Innovative" companies holding at least one patent compared to only 9.23% of "Ecosystem" companies. The analysis of financial KPIs showed that companies with solid ESG practices tend to outperform their competitors, and that manufacturing companies on average show a Net Profit of €5.540 million, compared to €0.242 million for distributors. Additionally, larger companies show a median EBITDA of €10.688 million, compared to €0.017 million for micro-enterprises.

In Chapter 4, the study delved into the role of various investor types, including business angels and venture capitalists, in funding green energy companies. The analysis found that 60.4% of investors are "Independent Venture Capital" firms, and 27.8% of investors are based in France, followed by Germany with 14.92%. While VC-backed companies may show lower average profitability compared to non-VC-backed ones, this can be attributed to their focus on long-term growth and market expansion.

Finally, Chapter 5 analyzed the factors influencing the profitability of green energy companies, segmenting the analysis between startups (less than 7 years old) and established companies. The results indicated that prior-year profitability is a significant factor ($\beta \approx 0.55$, $p<0.01$), implying that companies with strong past performance tend to sustain it over time. Contrary to expectations, VC-backed companies showed lower average profitability ($\beta = -0.031$, $p<0.01$), possibly due to their emphasis on growth and market expansion. Interestingly, the separate analysis for startups showed that VC funding does not have a significant impact on profitability, while for established companies, the negative effect is more pronounced, suggesting that expansion strategies pursued with VC capital may not yield immediate returns in profitability. Company size, as measured by the number of employees, had a positive impact on profitability ($\beta \approx 0.00018$, $p<0.01$), suggesting that larger companies benefit from economies of scale, a result more evident in consolidated companies.

Overall, this research contributes to a better understanding of the green energy sector in Europe and provides original quantitative data and analysis to inform industry strategies, public policies, and investment decisions. In an era of energy transition, it is essential to support the development of a sustainable and competitive economy, and this thesis has sought to contribute to that end. Further research could focus on the impact of specific policies on the growth of green energy companies and on exploring the role of emerging technologies in shaping the future of the sector.

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