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Sustainability, Profitability and Recent Shocks: Evidence from the European Energy Sector

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Table of Contents

I. Introduction

Climate change is one of the major challenges of our time, and consequently it has been a great source of scientific and political discourse, resulting in great progress and ambitious goals set. However, there is still much to be accomplished and understood of this topic, especially regarding how economies can grow complementarily with more sustainable practices. Arguably the most important players in the "Green Transition", second only to governments, are the companies that make up the economy. In recent decades, standards have been elaborated to assess the degree to which a company is committed to sustainability. The most noteworthy and widely recognized are Green Revenues and the Environmental Social and Governance (ESG) score. There exists extensive albeit conflicting research on the profitability of green initiatives, both on the stock market and on the company's books, as the financial burden of these investments sometimes outweighs the positive effects of these decisions, especially in the short run.

In this paper, we chose to concentrate on the European energy sector, as it is the global leader in the green energy transition, and carry out two main analyses, using a dataset of 16 firms between 2016 and 2023. In the first, we will examine the effects of two main shocks, COVID-19 and the Russia-Ukraine conflict, on the energy sector, considering both the variations in profitability and sustainability. In the second we will examine if higher Green Revenues or ESG scores have a negative or positive impact on profitability. Conclusively, we find that ESG and Stock Prices are not significantly impacted by the crises examined, aside from a few exceptions. On the other hand, Return on Asset and Return on Equity yield more variable results. When looking at overall trends, there are positive correlations between profitability and sustainability measures, with a few outliers.

We will proceed in this order: in section II. we will examine the past and current international agreements and goals regarding climate change with a short introduction on the importance of the energy sector in the green transition. Then, in section III. a more thorough presentation of green metrics, the effects of macroeconomic shocks and the role of the energy sector will be carried out. Section IV. will showcase our empirical analysis and its results and section V will give concluding remarks and limitations of our study.

II. Climate Change and Progress Towards a Net Zero Economy

Climate change is defined as long-term shifts in temperatures and weather patterns (UN, 2024). It has been at the center of most governments', people's, and companies' discussions and actions in the past decades mainly because, while this could have happened for natural causes in the past, this is not the case today. It has been proven that human activity is responsible for essentially all global heating over the past 200 years. Scientists confirmed this by creating climate model simulations and found that the model corresponds to the observed data only when human-caused factors are included. As a matter of fact, due to human activities, a higher temperature increase of 1,5°C was expected, as opposed to the current 1,2°C with respect to pre-industrial temperatures (IPCC, 2021:7). This is explained by the cooling effect of pollutants called aerosols, small particles or droplets in the air caused by wildfires, exhausts and other natural and non-natural factors (NASA Science Editorial Team, 2023). On the other hand, the primary pollutants causing the rise of temperatures are greenhouse gases, released mainly due to the burning of fossil fuels such as coal, oil, and gas (UN, 2024).

The global climate situation is not promising, as the data clearly shows. For example, in 2023, the atmospheric concentration of carbon dioxide and the other two main greenhouse gases reached the highest levels in the last 800 000 years, and still today maintain their upward path (WMO, 2024:1). This trend is then translated in each of the past ten years (2015-24) being individually the ten warmest years on record, reaching the highest temperature of 1,55°C (WMO, 2024:3).

However, climate change is not only an increase in temperatures, it also disrupts many systems and resources affecting societies and ecosystems around the world.
First of all, water resources, fueled by precipitations, have shown to be very unpredictable, causing droughts and floods. Since 2000, flood-related disasters have increased by 134% compared to the two previous decades, causing deaths and economic losses, especially in Asia (Nullis, 2021). In many regions worldwide, access to a clean drinking water supply is not a given, as roughly half of the global population is experiencing severe water scarcity for at least part of the year (UN, 2022). Water scarcity also affects, among other factors, food supply and human health.

Health is put at risk by extreme heat, which also increases the geographical ranges of disease-carrying organisms such as mosquitos and causes ocean temperature rise, closely linked to increasingly more destructive hurricanes (NOAA, 2024).
Some regions are more at risk than others, in fact, sea-level rise will drastically affect coastal areas, eroding the coastline and increasing the risk of floods. This rise is mainly caused by the thermal expansion of the oceans exacerbated by melting ice from glaciers and the Atlantic ice sheet. Experts calculated an approximate 30cm global rise above 2000 levels, by the end of the century even if greenhouse gases are moderately contained (Lindsey, 2023).

So far we have seen direct impacts of climate change on humans, however, as of now, plants and animal species are the most affected, already showing clear responses to their rapidly changing environment. Many species are gradually migrating towards higher altitudes and latitudes or facing extinction. This implies that over time, humans and animals will be sharing smaller and smaller regions of the globe that are still suitable for life. It should be in our best interest to preserve animals and their ecosystems, as they could potentially account for 37% of the reduction of carbon needed to slow temperature rise. Healthy ecosystems filter water, absorb carbon, and reduce the impact of disasters, among other things (IFAW, 2022).
Overall, the effects of human activity endanger all forms of life, and it is important to adequately and quickly respond to this widespread threat.

International and European Agreements

So far we have shortly discussed the causes of climate change and the extensive damage it causes to ecosystems and human life across the globe. However, it is also true that scientists and governments have been aware of these effects and have been working towards a more sustainable future for many decades. In this section, we will examine what has been achieved so far and what still has to be done to reverse the global rise in temperatures.

Although the first mention of the warming effects of greenhouse gasses (Arrhenius, 1896) dates back to the end of the 19th century in a paper written by Arrhenius, a Swedish scientist, it was not until the second half of the 1900s that governments and international organizations started actively acknowledging the issue. In fact, the first major United Nations Conference on the Human Environment, also referred to as the Stockholm Conference, was held in 1972,

and marked a turning point for environmental politics. Just over a decade later, the Intergovernmental Panel on Climate Change (IPCC) was instituted, with the aim of providing clear and up-to-date scientific knowledge on climate change and its potential impacts, both socioeconomic and environmental.

A fundamental milestone in climate action was the Kyoto Protocol in 1997, which represented the first greenhouse gas (GHG) emissions reduction treaty (EU Parliament, 2018). It operationalizes the United Nations Framework Convention on Climate Change (UNFCCC), which entered into force in 1994 *with "the aim of preventing "dangerous" human interference with the climate system"*. The Kyoto Protocol fulfilled the need to compel countries to act on what was agreed on in the UNFCCC. More specifically, the targets overall add up to about 5% emission reduction compared to 1990 levels for the five-year period 2008-2012, also called the First Commitment Period.

Furthermore, an innovative approach displayed in the Protocol is the uneven distribution of the onus of fighting climate change. This means that developed and therefore industrialized countries have a greater responsibility and more stringent and binding regulations, as they have been the source of most of the polluting factors in the past and the present (UNFCCC, 2025). This reasoning is based on the principle of *"common but differentiated responsibility and respective capabilities"* (UNFCCC, 2020). The Second Commitment Period, from 2013 to 2020 had even more ambitious targets of reducing emissions by at least 18%.

The natural question would be whether the Protocol was successful or not. This does not have a black-or-white answer, however, a study conducted in 2019 proved that in the First Commitment Period, thanks to the agreement, there was a 7% decrease in emissions compared to a "no-Kyoto" counterfactual scenario (Maamoun, 2019). On the other hand, Todd Stern, the former United States Special Envoy for Climate Change, stated that one of the Protocol's main shortcomings was the excessive and rigid divide between developed and developing countries, which revealed its unsustainable nature when major emerging economies became significant emitters. This specific issue will be then solved with the Paris Agreement, which we will shortly discuss later on, where the binding nature of the agreement was universal, meaning that it was enforced in all countries, both developed and developing (European Chair for Sustainable Development and Climate Transition, 2025).

In January 2005, another important tool for emission reduction was introduced by the European Union, the Emissions Trading System (ETS) (EU Parliament, 2018). It is the first and largest emissions trading scheme, a "carbon market" which helps decrease emissions while generating revenues to finance the green transition. The EU ETS works based on the *"cap and trade"* principle. The cap is the maximum amount of GHG that can be emitted, which decreases every year to guarantee a gradually lower amount of emissions. The cap is translated into emission allowances which are sold in auctions and can be traded, implying that polluters must pay for their GHG emissions (EU, 2024).
This program helped bring down emissions caused by European power and industry plants by about 47% compared to 2005 levels. The next objectives are to decrease emissions further up to 62% (compared to the same baseline) by 2030 and become climate neutral by 2050 (EU 2024).

A turning point in the global cooperation against climate change was the adoption of the Paris Agreement on December 12th, 2015. The Agreement is a legally binding international treaty, which, today, counts 195 parties (194 countries and the European Union). The three main long-term goals are to keep global temperature increase well below 2°C above pre-industrial levels, aiming at limiting it to 1.5°C, and to periodically, every 5 years, assess the collective progress made towards the goals through a document called Nationally Determined Contributions (NDC). Finally, to provide financing to developing countries to contribute to climate mitigation (UN, 2015). As explained above, the Paris Agreement represents an important step forward especially from a diplomatic point of view, because it's the first time that all countries are considered more or less equally in regulations and have to cooperate towards a common goal. However, based on the first report, released in September 2023, the world is not on track to meet the long-term goals established in the Agreement (Council on Foreign Relations, 2025).

The most recent development in climate action is the Green Deal, implemented through the European Climate Law, which entered into force on July 29th, 2021, almost two years after its first presentation by the European Commission in 2019. The Green Deal represents an ambitious goal of Europe becoming the first continent to be climate-neutral by 2050, with a halfway target of decreasing emissions by 55% by 2030 (with respect to 1990 levels). However, the Plan and subsequent Law do not simply set targets, they construct a framework for a *"just and clean transition"* by supporting those most vulnerable on the path to a net

zero continent, such as those mostly affected by extreme climate events and those most reliant on polluting industries. The latter is and will be supported with a fund dedicated to the development of new skills to thrive in the green economy (European Commission, 2025).

As of 2023 emissions have decreased by 37% in the EU with respect to the baseline and experts project, by 2030, a 43% or 49% reduction (Figure 1, EU, 2024). The first was achieved with current measures and the latter with the adoption of additional, more ambitious regulations, however, both predictions would miss the 55% target. Most of the progress has been driven by shifts in energy production methods, especially a significant decline in coal use and an important growth in the renewable energy sector. Other achievements worth mentioning are a modest reduction in total energy consumption and a substantial fall in GHG emissions caused by specific industrial processes (European Environment Agency, 2024).

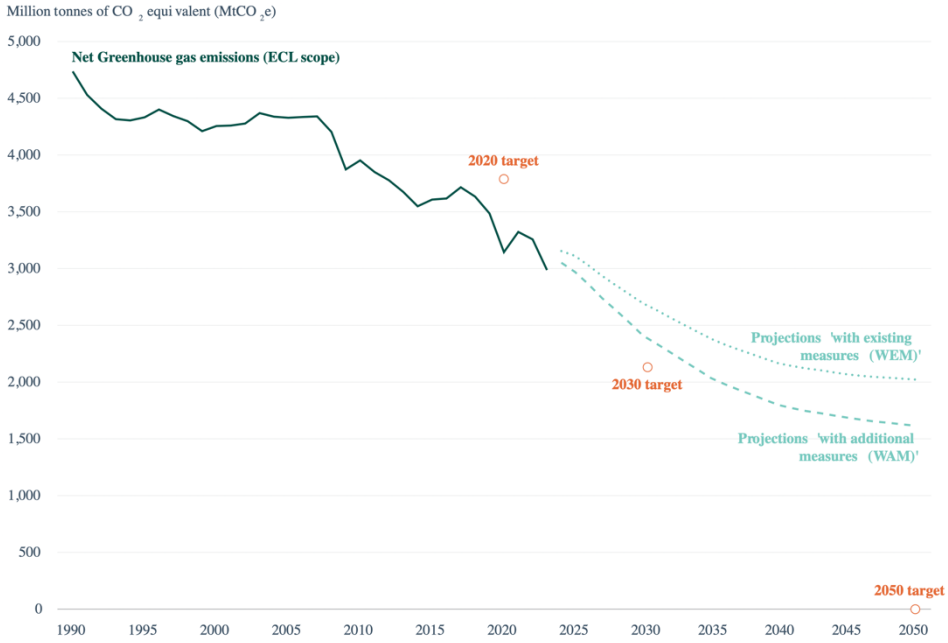


Figure 1

Metrics and Corporate Involvement

By observing the main factors that helped drive the fall in emissions, it is clear that regulating the industry and all its actors is a fundamental step towards a climate-neutral economy. The main player is the Energy sector, as it is at the center of the transition away from fossil fuels towards renewable energy sources. In this next section, we will examine the impact of the previously mentioned measures and additional regulations on companies and industries, followed by a more in-depth analysis of the energy sector. We will also go over how

companies are classified as “green” or not, introducing metrics such as Green Revenues (GR) and Environmental, Social, and Governance (ESG) scores.

The first requirement we will analyze, elaborated as a result of the Green Deal, is the EU Corporate Sustainability Reporting Directive (CSRD). This is an EU Law that requires companies above a certain size to disclose audited information on what they perceive are risks and opportunities arising from social and environmental issues and the impact of these activities on people and the environment. Companies with more than 1000 employees will be subject to the CSRD starting from 2025 reports. The rationale behind the size limit is the promotion of competitiveness, in fact, only larger companies which are more likely to have the biggest impact, are burdened with these stringent reporting obligations (EU Finance, 2024).

Under the CSRD, large companies must be transparent regarding their impact on the environment and stakeholders, however, it is also important that the information reported is clear, widely recognized, and comparable across companies. Some of the most accredited are ESG scores and Social Development Goals, Green Revenues, and the EU Taxonomy. These metrics are also fundamental for investors, to create portfolios that align with their values and for investment banks to create cohesive “green” funds. Furthermore, they are useful for management to understand the company’s position and impact on stakeholders, enabling them to make decisions to attract investments and improve performance. This last point is achieved through greater attention to detail regarding sustainability, for example through the implementation of a more energy and therefore cost-efficient production plan or through strategic investments in R&D or innovative sustainable processes (Henisz et al, 2019). Moreover, studies show that having strong ESG ratings and therefore a strong focus on sustainability is a source of resilience in crises such as the COVID-19 pandemic (Habeeb, 2023). We will now briefly go over each of these metrics underlining their strengths and weaknesses.

Virtually all efforts towards a more sustainable future, both socially and environmentally, are guided by the UN’s 2030 Agenda for Sustainable Development. At the core of this plan, adopted by all United Nations member states in 2015, are the 17 Sustainable Development Goals (SDGs), each addressing a specific issue, such as poverty, education, climate, and equality (UN Department of Economic and Social Affairs, anno). This program is innovative

because it provides a framework that recognizes that growth in one area requires and affects development in another, implying that truly successful progress is possible only through a balance of social, economic, and environmental sustainability (UNDP, anno).

However, the 2024 Report did not depict a promising scenario, describing the numerous challenges hindering progress towards the 2030 targets. The lingering effects of the COVID-19 pandemic, escalating conflicts, rising geopolitical tensions, and a growing climate crisis have caused a significant setback. Nonetheless, remarkable headway has been made in areas such as child mortality and access to water and energy, and a material increase in funding and efforts could bring the world back on track to achieve the goals set ten years ago (UN, SDGs Report, 2024).

In the effort to create a more sustainable world, there are many actors involved, such as governments, regulators, financial institutions, and even corporations and companies. It is these last two actors that, in the past decades, have gradually been more and more involved in the work towards the SDGs. These efforts are measured using Environmental, Social, and Governance (ESG) Scores, which assign numbers to each pillar (E, S, or G) based on how much the company is positively impacting the considered area. The aim is to have an overview of the contribution that a company makes to the cause (Radu et al., 2023).

The term “ESG” was first introduced in 2004 with the “Who Cares Wins” Report signed by a group of twenty companies, supported by the UN Secretary-General at the time, Kofi Annan, who believed that quality management of environmental social, and government issues is of vital importance to maintain a competitive environment. The report pushes to manage risks, anticipate regulatory changes and even improve company image and value, while also contributing to the development of surrounding communities and societies (World Bank, Who Cares Wins, 2004). Although this was a big step forward at the time, until 2015 with the introduction of SDGs there was little to no practical application of the sentiment displayed in the 2004 statement. The introduction of the Goals, coupled with the Paris Agreement and the introduction of the Global Reporting Initiative (GRI) Standards, marked the formalization of ESG Reporting (Macesar, 2024). Today, ESG reporting is mandatory for large companies in the EU, according to the CSRD, in the UK and other countries (Euronext Corporate Solutions, 2024).

Another metric often used to determine the “greenness” of a company’s activities is the percentage of Green Revenues with respect to total revenues reported. Revenues are considered green when they come from the sale of environmentally friendly products and services (Klausmann et al., 2025). A model developed by Inderst and Opp (2025) suggests that a taxonomy of sustainable activities can facilitate the green transition by addressing concerns related to greenwashing and providing transparent information. This is one example of how this metric has an impact on investors, consumers and the companies themselves. A strong increase in green activities was registered after the Paris Agreement, in fact, between 2006 and 2015, the share of green revenues was stagnating at around 4%, and in the period after the Agreement until 2023, the percentage increased by 2 points. While this data might seem underwhelming, the 6% recorded represents more than 3000 companies generating green revenues worldwide, amounting to $4 trillion, about the size of the global oil and gas sector (Klausmann et al., 2025).

A measure similar to that of Green Revenues is the EU Taxonomy, a green classification system that translates the EU’s climate and environmental objectives into criteria for specific economic activities for investment purposes. Essentially, it recognizes as green any activity that makes a substantial contribution to at least one of the EU’s climate and environmental objectives, while at the same time not significantly going against any of these aims and meeting minimum social responsibility requirements. In practice, larger companies are compelled to disclose the percentage of Taxonomy-aligned activities carried out, to consent comparison between entities and informed investment decisions. As Green Revenues, the EU Taxonomy was elaborated to represent a reliable and transparent tool to help companies on the path towards climate neutrality and create a frame of reference for investors, to promote already sustainable organizations and initiatives and at the same time help others in their transition (EU Commission, 2021).

The Energy Sector in the Green Transition

When planning a green transition all sectors of the economy and all aspects of how a country is run are important, however, some activities have more weight and green revenue growth potential than others. One example is the energy sector, as the production and use of energy account for more than 75% of the EU’s greenhouse gas emissions. Therefore, decarbonizing the energy system is critical to achieving the net zero goal by 2050 (EU Commission, 2022). This process is denominated the “sustainable energy transition”, and describes the change in

how energy is produced, distributed, and consumed, aiming to move away from fossil fuels towards renewable energy sources. Examples of renewable energy sources are solar, wind, hydropower, and geothermal (UNDP, 2024). Providing energy through these sources is not only “eco-friendly” but also represents the cheapest option in the majority of countries, expanding energy access to underserved communities. Furthermore, projections show that renewable sources could account for 90% of electricity generation by 2050, greatly speeding up the transition to climate neutrality. Access to clean energy also serves as a starting point for the transformation of other sectors, such as transportation and industry (UNDP, 2024).

When it comes to technology development and deployment, the EU is the global leader, reaching a 24,5% share of renewables in energy consumption in 2023 and with a binding target of at least 42,5% within 2030. These numbers are a result of a massive increase in renewables, having almost tripled from 2004 levels (9,6%) (EU Statistics, 2024). Scandinavian countries are those with the most developed renewables sector, with the highest consumption percentage of around 66 in Sweden (EU, 2023).

Energy consumption and production are highly sensitive to geopolitical factors, and we have seen a clear example of this phenomenon with the Ukraine war. Before the conflict, most of the natural gas consumed in Europe (about 45%), which made up about one-quarter of energy consumption, was imported from Russia. The invasion of Ukraine represented a huge shock to gas imports, which had to be sourced elsewhere, leaving Europe dependent on Russia for only 15% of gas consumption (European Investment Bank, 2024). This was achieved mainly thanks to the European Commission’s REPowerEU plan launched in May 2022, directly triggered by the recent outbreak of the war. However, this plan is not only about decreasing gas dependency from Russia, it also boosted investment in renewables and energy efficiency, all while keeping energy prices at manageable levels. Although great progress has been made, Europe is still highly dependent on natural gas, which must be imported, but renewables are a significant strategy to overcome this vulnerability (EU Energy, 2024). This case study proves how developing and investing in renewable energy sources is not important only in curbing climate change but is also fundamental in making sure that Europe is more resilient to and independent from outside shocks while keeping energy prices under control for its citizens.

III. An Overview of the Green Transition

Measuring Sustainability

Climate change and the Green transition are very relevant topics today, and are consequently studied in depth, resulting in the availability of extensive and high-quality research. The large number of papers published provide insights in every aspect of the green economy, especially focusing on how regulations and metrics are related to firm performance.

A study conducted by Huang et al (2024) applies a radical approach, questioning the very foundation and rationale of these metrics. The authors pose the question of whether green strategies adopted by firms actually translate into green revenues, seeking to verify the very core of how we think of sustainable business. As a matter of fact, two theories exist, the first, based on neoclassical economic theory, supports the idea that environmental regulations impose burdens on economic entities, hindering their competitiveness, innovation and productivity growth. On the other hand, other theories hold that strict environmental regulations foster competition and innovation, benefiting both the environment and the economy. The research conducted by Huang used the case study of the introduction of ETS in China, and proved that, although the ETS program is in its earlier stages globally, it already yields promising results. In fact, the data shows how green strategies do effectively contribute to an increase in green revenues and therefore to greater competitiveness and propensity towards innovation.

Since innovation is a integral part of the green transition, many experts have proposed using green patents or trademarks to identify firms who are leading the path to sustainability (Burhan et al, 2017), however, more recent research shows how this could be misleading. As a matter of fact, it has been found that patents are not an appropriate measure of green innovation for a number of reasons. First of all, not all companies seek Intellectual Property Protections (IPRs), because of high costs and long application processes. Secondly, some innovations may not even be eligible for such protections, or they might be of a completely different nature, such as systemic changes and collaboration between entities that have nothing to do with technological innovation. Furthermore, it is important to remember that seeking IPRs hinders the diffusion of the product or process which could have a significantly positive effect on the environment if widely adopted (Block et al., 2024). The task of classifying green assets is in fact still in the hands of rating agencies, and their reports.

Green Metrics and Corporate Performance

Whether investing in increasing green revenues and improving ESG scores issued by said agencies actually provides an economic benefit to the company, has yet to be determined. Although this seems like a relatively straightforward task, this is not the case. As we already discussed, one of the main motives behind classifying and assigning sustainability scores to companies is to facilitate investment choices to those who wish to contribute to sustainable enterprises. This new "style" of investing has become increasingly popular, and is defined as a form of investing that seeks to achieve non-traditional investment outcomes, such as the satisfaction of ESG criteria, apart from pursuing traditional financial objectives (Bassen et al., 2023). However, the absence of a singular rating agency for ESG scores causes ambiguity when comparing companies or analyzing the impacts on financial performance.

What makes the work that much harder is that this information is self-reported, mostly supported by non-transparent data and subject to varying national standards. To solve this issue, the European Union has imposed rating agencies to disclose methodologies used to calculate scores, starting from January 2025, to be implemented before mid 2026. However, it still remains true that scores of a same company issued by different agencies have only a 66% correlation, while in matters such as credit scores the correlation is 99%. These inaccuracies will then also interfere with the creation of transparent and reliable Green Exchange Traded Funds (ETFs), which have become extremely popular among investors, attracting 10.4 billion USD just in the last quarter of 2024 (D'Ecclesia et al., 2025).

While the methodologies behind ESG scores remain cryptic, Green Revenues offer a more transparent tool. This is mainly due to its greater simplicity, as they simply represent a percentage of reported revenues, determined by specific thresholds and metrics. It allows to control for company size, and therefore output, and gives an instant snapshot of the company's sustainability efforts. When it comes to the effect that Green Revenues can have on performance, it was found that there is a positive correlation. Interestingly though, this is not the only factor to be considered (Bassen et al., 2023). As a matter of fact, it was proven that also national culture is an informal determinant of corporate activities. A study by Cheung et al., proved that countries with higher levels of egalitarianism and harmony have superior Corporate Social Responsibility (CSR) performance, which is then transposed also

in metrics such as those we have discussed (Cheung et al., 2020). Consequently, this element strengthens the positive effect of Green Revenues on performance.

For the reasons stated above, carrying out the same study using ESG scores is not as immediate. In fact, past research has yielded a variety of results. While most researchers found that ESG had a positive impact on the company's finances, others found no or negative effects. However, these divergences may be due to heterogeneity in samples, especially regarding the methodology leading to the score.

A 2023 paper presents a deep dive into the consequences of ESG performance, providing a wider prospective on the subject. First of all, the authors point out that while there is a positive correlation between ESG and financial performance, this relationship works also inversely. This implies that also ESG performance is determined by firm financials, it is in fact straightforward that if a company is experiencing losses, it will not have funds to set aside for social or environmental issues. While this might seem obvious, this "inverse logic" is not explored in the majority of research available. It also comes as a consequence that larger firms, having more resources at their disposal, tend to have higher scores, compared to smaller sized counterparts. This thinking can be expanded to the national level, as different countries contribute to ESG at different levels, even though it is not always true that this is only driven by GDP or country wealth. An explanation for this can be found in the positive correlation between ESG and Return on Assets for companies in developed economies, and the absence of correlation of the two in developing countries (Chen et al., 2023).

In general, it is important to remember that ESG commitment can improve performance not only through the financial and economic channel but through others, which then ultimately benefit the company's bottom line. For example, corporations with high ESG scores are less vulnerable to litigation risk since they keep up to date with environmental regulations. Furthermore, closer attention to stakeholders in the context of corporate actions has positive effects on company reputation and customer loyalty, which also contributes to increased competitiveness in the market. Companies with good scores are more resilient to risk and have higher growth potential and better financial health (Chen et al., 2023).

ESG and Resilience During Periods of Crisis

We have seen that, although controversial, there is some consensus on the positive effects of CSR practices on financial performance. However, another relevant point to address is whether investing in socially and environmentally focused projects improves or worsens the hit of widespread crises on the company. The past five years have offered two opportunities to address this gap in research, which are the COVID-19 Pandemic and the Russia-Ukraine war. These periods of economic instability have brought many hardships for businesses, causing supply chain disruptions, inflationary pressure and extremely high volatility. In these circumstances, companies have to balance financial performance with investments in ESG initiatives, often facing a trade-off between the two. However, it is also true that risk management, attention to governance and long-term resilience are all core pillars of sustainable business.

The first paper we will discuss examines the effect of ESG on firm performance in the EU "Blue Banana", which includes Italy, Switzerland, Germany, Belgium, The Netherlands and the UK, during periods of economic instability. More specifically, the author considers the COVID-19 pandemic and the Russia-Ukraine conflict. The results show that there is a negative relationship between ESG and performance, measured through Return on Assets (ROA), Return on Equity (ROE) and Return on Investment (ROI), in periods of crisis. This is in line with previous research which held that ESG has a detrimental effect on financial performance in the short-term, when the company is burdened with compliance and reporting costs. More importantly, in times of crisis, investing in CSR diverts funds from profitable activities, which with the added pressure of a volatile environment, are fundamental for firm health. The pillar that is the most consistently negative is Governance, as it is the one which requires the highest expenses for implementation. The main point is that, during periods of economic instability, investments should bring short-term profits and benefits to face outside threats, and investing in sustainable projects, most of the times, has a long-term perspective, meaning that in that geopolitical and economic context it is not the most convenient strategy. This point may be exacerbated by the chosen sample, European countries with robust institutions and stringent regulation, which implies larger investments to comply with the high standards set (Hansen et al., 2025).

Another determinant worth noting is firm size. As described in the previous section, sustainable practices tend to have a greater positive impact on larger firms, which at the same time are the ones most equipped to invest in such activities. This resilience is evident also in times of crisis, where logically, larger companies are able to adapt more easily to economically stressful situations. This strength derives also from the fact that probably larger companies were able to invest into higher-quality ESG initiatives and reporting and then reap the benefits of these projects in times of need (Hansen et al., 2025).

We will now examine the effect of the same geopolitical and economic events, not on the single company's performance, but on the financial market. More specifically, the effect of ESG on price jumps of Exchange-Traded Funds (ETFs) during these periods of turmoil. The author chooses to conduct the study using ETFs because they offer diversified exposure and enhance portfolio diversification, mitigating individual security risks, giving a general overview of the market responses. Price jumps are a symptom of volatility, meaning that less jumps imply more financial stability. Among 205 ETFs analyzed, there is strong evidence that high ESG funds outperform their counterparts. More specifically high ESG ETFs displayed smaller and less volatile price jumps, so lower volatility, while exhibiting the same or higher returns across most periods. This trend becomes even more evident during times of crisis, making high ESG performance a buffer against sudden market shifts. This result has very practical implications as many investors seek low risk portfolios, without having to sacrifice returns, all while maintaining a sustainability-oriented profile (Supatgiat et al., 2025).

The Energy Sector in Times of Crisis

When looking at the effects of these crises on the energy sector, the Russia-Ukraine war was the most disruptive. In fact, as a response to the violent attack, many global actors applied sanctions to Russia resulting in a large cut in energy imports (Figure 2; Eurostat, 2024). As the country is a main energy exporter, the sanctions imposed lead to a spike in oil and gas prices as a result of their sudden reduced availability. These developments underlined the importance of energy security, especially for the EU which was one of the main importers of Russian gas and oil. During this time, data shows that renewable energy companies saw a greater increase in returns following these events than their non-renewable counterparts, probably indicating a shift to green energy sources in a time of increased prices and reduced

availability of oil and gas. Furthermore, companies with headquarters in countries with a larger availability of renewable energy assets had higher returns. This shows that renewables give financial stability in times of geopolitical unrest (Nguyen et al., 2024).

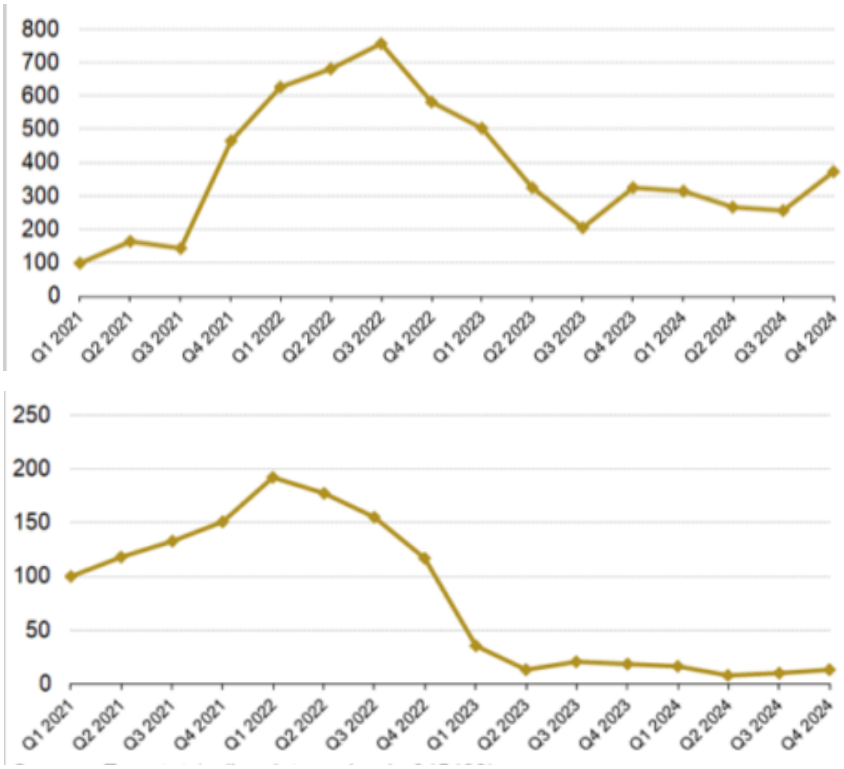


Figure 2 – oil EU imports from Russia

On the other hand, a study suggests that the risk of insufficient gas supplies due to sanctions on Russia pushed many European countries to turn back to fossil fuels, effectively taking a step back with respect to their net zero goals. Moving away from Russian gas, which constituted 45% of consumption, is costly and challenging. For this reason, initially it is possible that European countries, especially those more reliant on imported gas and oil, will revert back to coal. However, in the long-term there will be a return to the path towards decarbonization. The crisis obviously caused economic turmoil, as energy prices rose, and revenues of most energy companies spiked due to the decrease in competition coming from Russia. To rebalance the economy several projects were carried out by the EU such as setting out limits on energy companies' revenues, giving the excess to the most vulnerable consumers and energy-intensive industries (Borowski, 2022).

More recent research shows that when it comes to Russian energy exports to the EU, oil and gas have different effects on the green transition. As a matter of fact, gas imports tend to facilitate the green transition process, oil, instead has the opposite effect. This means that the increase in price and decrease in volume of gas imports during the conflict has had an adverse

impact on progress in renewable energies while the negative effects of oil decrease this effect. Natural gas is in fact an essential player in the transition for many reasons. First of all, it is the fossil fuel with the lowest GHG footprint and in the near future it can easily substitute more harmful fuels. More importantly, natural gas serves as a fundamental partner to renewable sources, especially in the effort to keep energy accessible and affordable (as set in SDG7) (UNECE, 2024). Gas is essential for an efficient production through renewable sources because the latter are variable and not "programmable" meaning that a baseline as flexible as gas is needed (S&P Global, 2024). In conclusion, this means that the sanctions imposed on Russia have hindered the EU's efforts towards the 2050 net zero goal (Zhu et al., 2023).

We can condense what discussed above in a very simple tradeoff that countries have had to face in the past years: energy security or green transition? The lack of energy security is generated by two main factors, political risk and diversification. It was these two factors that led to the 2022 energy crisis, as the EU did not dispose of diversified enough sources of energy, which were supplied mainly by Russia, a country with political risk. This market concentration has been partly caused by the green transition itself, as, when demand for fossil fuel decreases, the highest cost producers leave the market. However, overall, the rise in renewable energy has greatly increased energy security as it allows an increase in the share of domestically produced energy, causing a fall in dependency on importers. We must also remember that there are many other factors contributing to the level of energy security in a country such as infrastructure and the cost of using renewable, domestic energy sources that we will now discuss (Kim et al., 2025).

Constructing an energy mix with a large share of renewable sources is a fundamental step towards energy security, however especially for countries in the global south, this is more challenging due to their limited financial resources. In fact, the most efficient way to employ renewable energy is to develop the technologies domestically, nonetheless, in situations of limited resources, developing countries must rely on foreign Intellectual Property (IP), largely owned by the global north (Figure 3; WIPO, 2019). This constraint implies higher costs to integrate sustainable energy, making it overall less attractive than traditional sources. This price margin between green and conventional technologies is called the "Green Premium", which remains active until the technology is mass produced globally. The Green Premium (GP) is significantly slowing down the transition in the global south leading to large

inequalities, but there are some solutions which can be adopted to close the gap. First of all, we must give equal access to knowledge through investments in human capital, raw materials and finished products. Moreover, most least-developed countries' isolation from global supply chains further deepens the divide. Recent shocks to global supply chains as COVID-19 and the Russia-Ukraine conflict have made the situation more challenging. Essentially, the Global South should receive financial support to unlock its development and manufacturing potential in the green sector. If GPs are not lowered, this could further thwart the efforts toward net zero due to the impossibility of an optimal adoption of green technologies globally (Allam et al., 2022).

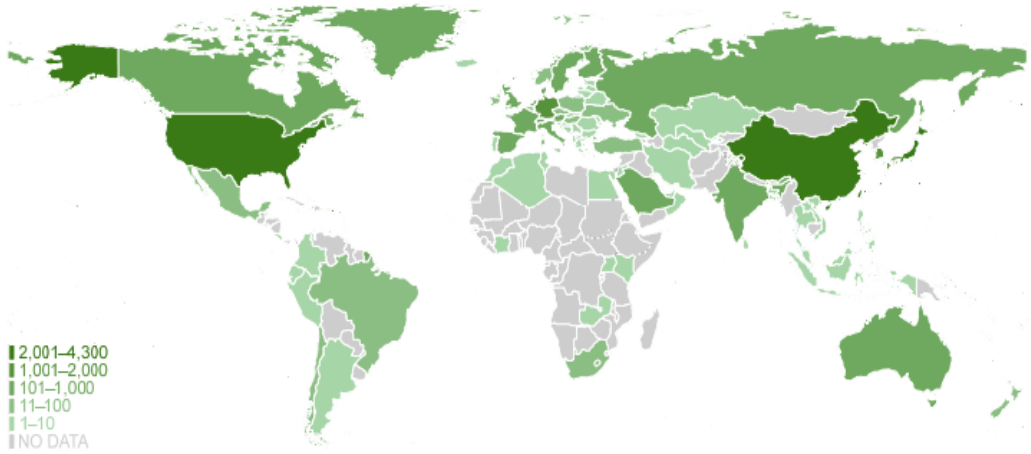


Figure 3 – Green Patent Applications

Diving deeper in the global divide regarding the progress towards greener energy, researchers have compiled a list of the global top investors in renewable sources (Figure 4; Statista, 2025). As observed below, China is the leader in investments, followed by Europe and the US, however these numbers hide different driving motivations. In the US and EU, renewable power expansion is closely linked to a decline in coal use, the most damaging for the environment, meaning that there is an ongoing substitution of carbon-intensive energy with lower or zero impact options. On the other hand, in countries such as China and India, the increase in investments in renewables is purely driven by a rise in power demand. This implies that, alongside renewables, also coal-based power is increasing to meet demand, effectively hindering any progress made with the investments. Even more alarming are regions, such as South and South-East Asia, that have increased coal use to meet rising demand but have not had the possibility of developing a renewable sector, which is in fact lacking in most regions.

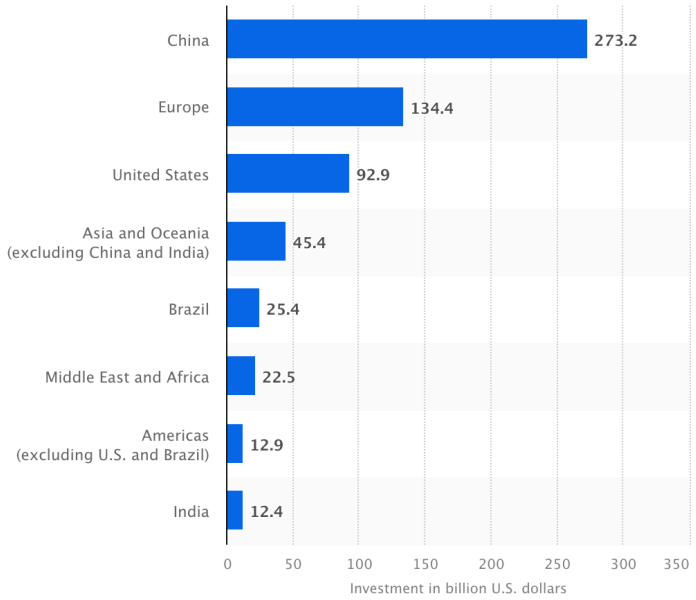


Figure 4

This was the global landscape before the outbreak of COVID-19, which played a role in exacerbating the gap between leaders and laggers. In fact, because of the pandemic, there was a sharp fall in power demand globally, however countries responded differently. Countries with significant renewable power capacities in place experienced a drop in coal use and a consequent increase in the share of renewables. This is explained by the low operating costs of renewables, making them the obvious choice in times of crisis. Furthermore, advanced economies were able to respond with policies to stimulate the economy and employ recovery plans, 37% of which, in the EU, had to be destined to climate action. At the same time, developing countries experienced a further deterioration of the already critical investing environment for renewables, caused by a need to redirect funds towards the health sector, social protection or economic stability policies, and the lack of considerable preexisting renewable energy plants. As a result, the pandemic reinforced preexisting trends, affirming the leadership of advanced economies, with Europe at the top, and the Global South lagging behind (Quitzow et al., 2021).

The Role of Nuclear Energy in the Green Transition

So far, we have discussed various aspects of the Green Transition, highlighting the importance of the transformation of the energy sector. While there is a general consensus on the use of renewables such as solar, wind or hydroelectric, the use of nuclear power is still

very controversial. In this next section we will try to determine whether nuclear power can promote economic growth without increasing carbon emissions.

Nuclear power plants produce no greenhouse gas emissions during operation, and in general, over their life cycle, it is one of the cleanest energy sources available (Figure 5; World Nuclear Association, 2024). Moreover, it is a reliable source which can be deployed on a large scale, significantly decreasing the price for consumers, making nuclear one of the best alternatives on paper (World Nuclear Association, 2024). This hypothesis is confirmed by a study conducted by Wang et al. which proves that nuclear and renewable energy are the only two energy sources which both greatly limit carbon emissions and promote economic growth and sustainable development (Wang et al., 2023).

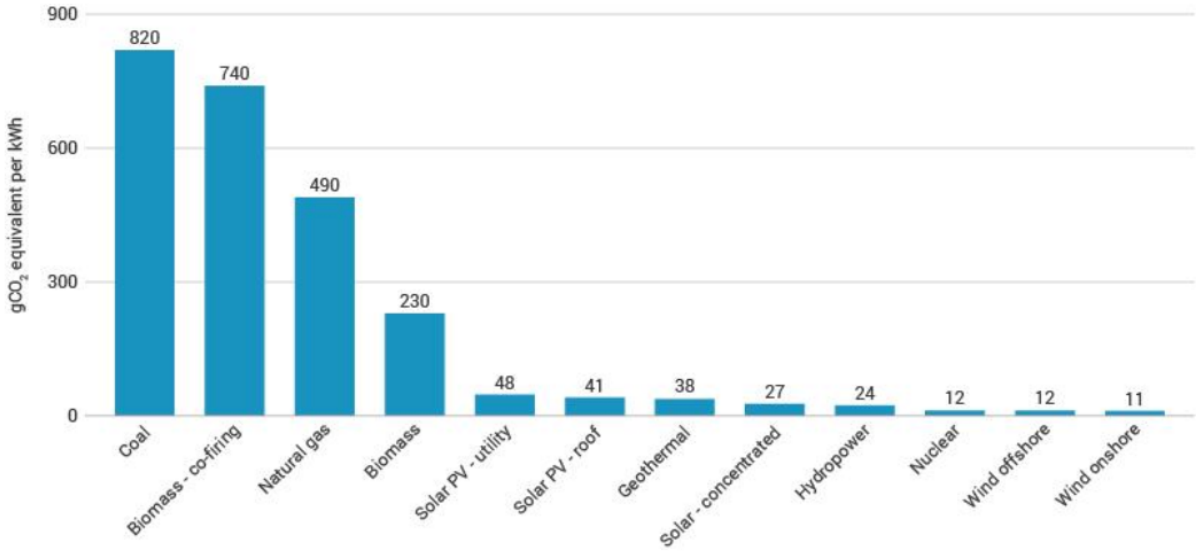


Figure 5

As of today, nuclear energy provides about 9% of the world's electricity, generated by 440 reactors, representing one quarter of global low-carbon electricity (World Nuclear Association, 2025). However, the main concern raised by those opposed to the adoption of this energy source is safety and security. In the past, two major accidents, Chernobyl (1986) and the more recent disaster of Fukushima in 2011, have scarred the memories of the general public. Furthermore, issues of security are often brought up, implying that the technology or waste material could me misused. These were some of the causes behind the shutdown of 37

plants in Europe from 2011 to 2024 with the expectation of further decommissionings in the future (Renewable Energy Industry, 2024). Nevertheless, data on European plants suggest that generation of nuclear energy is not dangerous, as it accounts for just 0.03 deaths per terawatt-hour of electricity production (annual consumption of 150,000 people in the EU) compared to the most dangerous, brown coal, with 32.7 deaths (Figure 6; Ritchie et al., 2024).

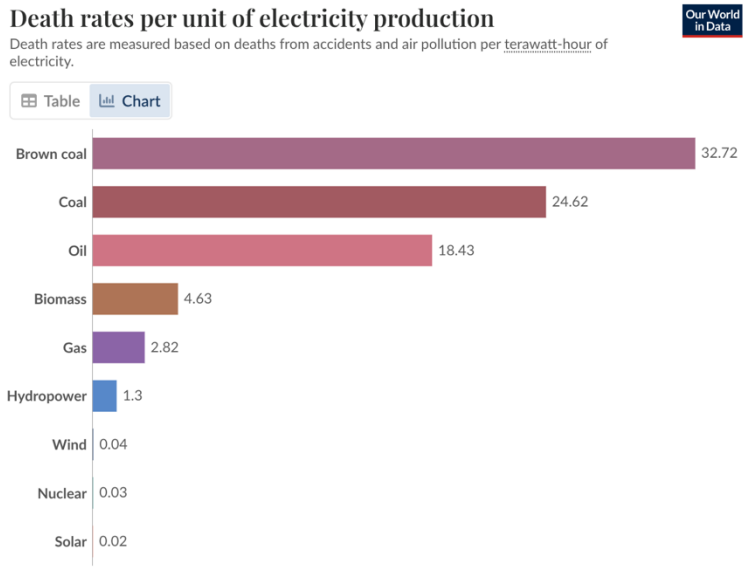


Figure 6

Another concern is the economic feasibility of reinstating nuclear energy production in countries which have phased it out. Due to the large amount of decommissioned plants, especially in Europe, put the region in a difficult position if this energy source was to be reinstated. In fact, construction is extremely expensive, basically infeasible without any kind of subsidy or state funding, and extremely long, amounting to 10-15 years (Renewable Energy Industry, 2024). As a result, in countries where the plants have never been shut down and are still running, as for example the US, China and France, this is an excellent alternative (Nuclear Energy Institute, 2023) to fossil fuels. In these countries, the main objective at the moment is to increase the lifespan of the reactors to continue producing efficient energy. On the other hand, countries which have completely stopped the production of nuclear energy, rebuilding plants is an extremely expensive and lengthy endeavor, which would not bring any short-term benefits, although it would in the long-run (Deutschland.de, 2024).

IV. Empirical Analysis

Literature Review

Chapters I. and II. outlined the main difficulties and achievements of the past decades regarding the Green Transition, especially how the two big shocks of the last 5 years, COVID-19 and the Russia-Ukraine war with its consequent energy crisis, were navigated by the relevant sectors and governments. In this final chapter, we analyze the relationship between major "green" indicators previously discussed, and financial and corporate data from firms in the European energy sector. The European energy sector is an especially suitable setting to examine these relationships as it holds an important position in the global energy market and at the same time has implemented a well-developed and extensive set of policies regarding sustainability (Makridou et al., 2023).

Research on this topic is extensive albeit inconclusive, as different settings and studies frequently present diverging results in analyzing the profitability and market value of green practices in energy firms. In research conducted by Kruse et al., (2020) the authors underline the importance of policies in making green investing economically viable for firms by facilitating access to green capital. This statement is backed by the success of many policies in the utility sector, leaving the non-utility segment of the economy further behind in the transition and in a position where it is not feasible to derive tangible benefits from green investment. Also, within the utility sector there is some variation, as it is split in energy and non-energy. The study finds that Green Revenue share has a positive and significant effect on the corporate financial performance (CFP), proxied by Return on Assets (ROA) and Return on Equity (ROE), only in the energy sector, while it is not significant in the non-energy side. However, interestingly, the coefficients regarding the effect of green revenues on a measure of market valuation follow a different pattern. In fact, there is a strong positive correlation for non-energy firms and a lack of significance for firms in the energy sector. However, overall, Kruse et al., conclude that the utilities sector is experiencing positive tradeoffs between green investments and financial performance, likely driven by the abundance of policies addressed to the sector.

A notable departure from previous results is found in a paper by Makridou et al., (2023) which examines more closely the relationship between CFP, more specifically ROA, and

ESG and its individual pillars. The authors distinguish between firms involved in renewables and those who aren't, finding that the first have higher Social (S) and Environmental (E) scores, while the latter show an advantage in Governance (G) scores. More importantly, the authors report that the overall ESG score has a negative (but insignificant) impact on ROA, which becomes significant (while remaining negative) when considering only firms in renewables. While it is proven that E has a negative effect on profitability, the other two pillars do not yield significant coefficients.

To illustrate the effects of macroeconomic shocks such as COVID-19, Wanday et al. (2022) compare ROA and ROE indicators over time across seven large cap energy companies in Europe, especially focusing on their behavior around 2020. They observe that, as expected, ROE and ROA dropped for most companies in 2020, reflecting the financial hardships they were facing during the pandemic. These results could probably be also replicated in conjunction with other more recent shocks to the economy. Furthermore, the study finds positive correlations between ESG scores, and investor returns and financial performance, affirming that investment in ESG aids in attracting financial capital to the company and creating long term value.

As is quite clear from the papers cited above, research on this topic is rather limited and conflicting, as in some cases greater investments in sustainability, and therefore higher ESG and GR scores, result in improved financial performance, while in others, contradictory patterns emerge.

Methodology

The aim of this empirical analysis is to determine how the Energy sector in Europe is responding to widespread economic shocks, and more importantly to investigate whether higher Green Revenues and ESG scores have a negative or positive effect on stock market performance and the Corporate Financial Performance indicators, ROA and ROE.

To achieve this, data was collected from 16 European firms operating in the energy sector, all with Green Revenues above 0 for all years considered. The companies included have market caps which range between 4 and 143 billion, offering a wide range of sizes to analyze the

effects in multiple scenarios. We select the years between 2016 and 2023, for which all data were available.

To investigate the relationship between sustainability indicators and financial performance, the relevant data were collected as outlined in the Data section. The dataset includes both financial performance indicators (such as Return on Assets, Return on Equity, and stock prices) and sustainability metrics (ESG, including individual E, S, and G components, as well as Green Revenues shares).

To explore the time variations of the indicators, time-series graphs were constructed, comparing trends in financial and sustainability indicators across multiple years. These visualizations helped contextualize the data in relation to major economic shocks, in the effort to find common trends between companies.

Subsequently, pairwise correlations and covariances were calculated for every year between each financial performance metric and sustainability indicator. The following combinations were assessed:

i. ROA with ESG, E, S, G, and GR
ii. ROE with ESG, E, S, G, and GR
iii. Stock price with ESG, E, S, G, and GR

These correlations were split into tables categorized by indicator pairings (e.g., ROA-ESG), facilitating cross-company comparison. However, no consistent patterns or relationships were observed in this phase.

To control for the influence of economic shocks and enhance the clarity of observed relationships, a narrower time frame was selected, specifically the years 2016 to 2019. For each company and each indicator, the change from 2016 to 2019 was computed.

Scatterplots were then constructed for each of the same indicator combinations listed above, using the delta values. This approach revealed more distinct relationships between financial performance and sustainability metrics, providing a clearer basis for interpretation and subsequent analysis.

Data

Sustainability Measures

Green Revenues

One of our variables of interest is Green Revenues (%), which defines the percentage of revenues a company derives from “green” products and services. Their “greenness” is classified based on the FTSE Russel Green Revenues Classification System (GRCS), now available on the LSEG database. The database contains statistics on more than 21000 public companies, accounting for around 99% of total global market capitalization, spanning across 10 green sectors, 64 subsectors and 133 micro sectors (LSEG, 2024). The values are calculated on both direct company engagement and company-specific estimates assessed against seven environmental objectives such as climate change mitigation, transition to a circular economy and pollution prevention. To each objective a tier from 1 (the best) to 3 (the worst) is assigned with a specific percentage. The summation of the percentages assigned to each tier give the total Green Revenues (FTSE Russel, LSEG; 2024).

ESG

ESG, including its three separate pillars, are the other variables of interest when measuring sustainability. As already described, they are Environmental Social and Governance quality indicators, assigning a number to each section and then calculating a weighted mean to obtain the total ESG score. The scores range from 1 to 10 and the higher the number assigned to each category, the better the company is performing in that scope. Each pillar is given a weight based on the importance of the said pillar in the sector in which the company is operating. For example, for companies in the Automobile sector, the environmental pillar will be the one with to which the highest weight is assigned because it is the one which represents the highest risks and potential to grow in the scope of sustainability. The data was collected from the Bloomberg database, which contains ESG information on more than 15000 firms, calculated with the methodology explained above.

Performance Measures

ROA

Return on Assets is a ratio that measures how profitable a company is compared to its total assets, so the percentage of profit generated for every dollar invested in assets. It is calculated as: ROA= Net Income/ Assets. A high ROA indicates the firm's ability to efficiently use its assets, financed both through equity and debt, to generate profits. One pitfall of ROA is that it does not consider intangibles, a very important category of assets, especially in today's economy. The data was collected from the LSEG database.

ROE

Return on Equity is a ratio which measures the firm's ability to generate net income from its shareholders' equity. This measure is especially useful for investors as it also represents the return that they can expect from their investements in that company. It is calculated as: ROE= Net Income/Shareholders' Equity. The higer is the ROE, the higher the profits and the stock prices of the company. A pitfall of the ROE measure is that it does not account for the company's debt, which if unsustainable, could significantly negatively impact financial performance without changing the ROE. The data was collected from the LSEG database.

Stock Price

The final measure of performance measure used is Stock Price, which is calculated as the average between monthly close prices for each year, to obtain an annual average stock price. This is necessary because all other data used in this analysis is calculated and published on an annual basis. Stock price is included because it represents an indicator of investor expectations about future profitability and growth, company performance, market factors and much more. Once again, the data is collected from the LSEG database.

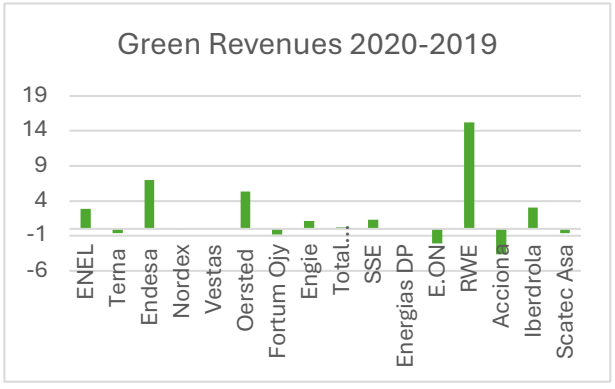
Results and Discussion

In this last section we will first of all examine the effects of macroeconomic shocks on all relevant variables through the observations of graphs. Two types of graphs have been constructed, the first depicts variation across time, including all years in the dataset, of the set of variables. The second set of graphs represent the variations in variables represented as the value in the critical year, in this case 2020 and 2022, and the values in the previous years. This clearly shows how companies in the european energy sector reacted to the shocks. The exact years of the shocks are chosen as those representing the height of the crises, following existing literature on the subject. In fact, especially concerning the Russia-Ukraine war, it was found that markets immediately reacted to the shock, in a much more immediate manner than even previous shocks like COVID-19 (Izzeldin et al., 2023).

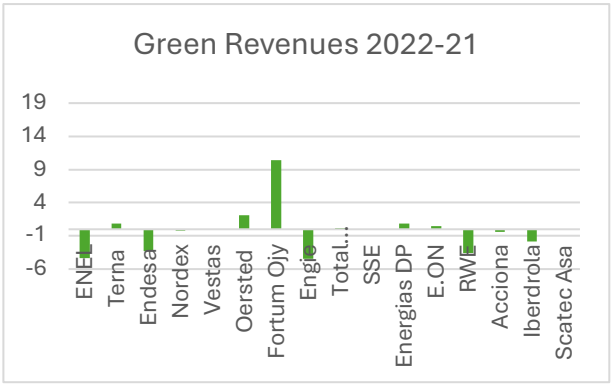
The Impacts of COVID-19 and the Russia-Ukraine war on the Energy Sector

First of all the time series and single year variation (in appendix) graphs will be examined, starting from Green Revenues. When observing the figures (Figure 7, Panels A and B), there is no evident pattern, however, there are some companies which responded to the crises quite evidentlty. The steep drops in green revenues are most evident in 2020 for Terna, Fortum Oyj, E.ON, Scatec Asa and Acciona, as also illustrated by the 2020-2019 variations graph. Following the same logic, ENEL, Endesa, Engie, RWE and Iberdrola suffered the most from 2022 events (see also variations figure). Drops in Green Revenues in times of crisis, especially if demand for energy goes up (as in the case of 2022), are to be expected. In fact the latter is one of two main drivers, the second being that in times of hardship, a company is more likely to invest in profit generating activities than in "green" activities (which are measured by GR) which are usually not as cost-effective especially in the short run.

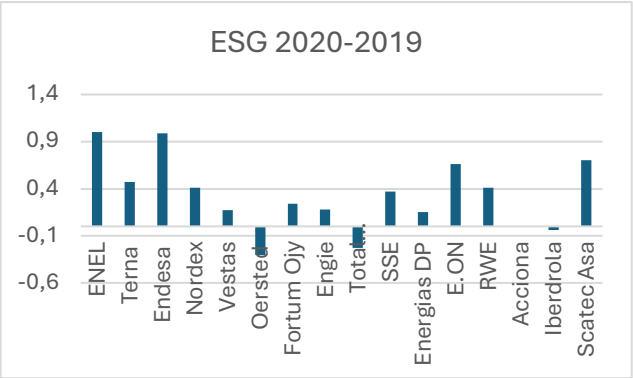
Figure 7



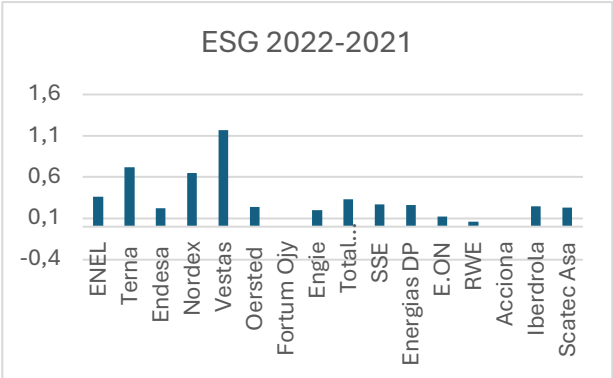
Panel A



Panel B



Panel C



Panel D

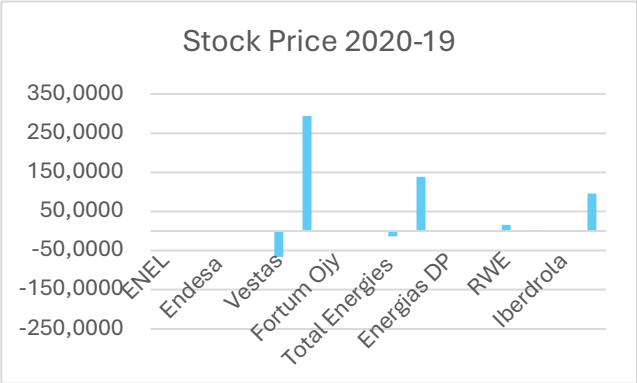
Moving on with ESG data, we notice that the shocks had no negative effect at all on companies' sustainability scores (Figure 7, Panels C and D), as only the scores of Total Energies, Iberdrola and Oersted suffered from the 2020 shock, leaving the others either untouched or improved (also in 2022).

These findings are in contrast with the logic that ESG scores should fall in times of crisis as companies divert investments to more short-term, financially useful projects. However, the energy sector, due to its very particular position, could behave differently for a set of reasons. For example, it could be that contemporaneously to the pandemic, there was an increase in consumer awareness regarding climate change and the green transition, making it more profitable for energy companies to continue investing in sustainability. Additionally, the increasing amount of regulations, especially within the EU, could have further incentivised financing sustainable activities also in times of economic hardship.

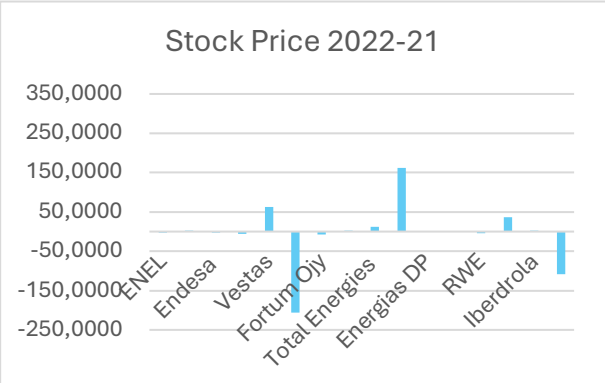
The same can be said observing the movements of stock prices (Figure 8), which are substaintially absent or irrelevant, with the exception of a few companies, which were either negatively hit or favoured. Based on the results we can make two observations, one for each shock. First of all, it has been proven in previous studies, that the energy market, and particularly the alternative ("green") energy market have shown great resilience to the COVID-19 pandemic compared to the overall market (Czech et al., 2021). This is reflected in low stock price variations in our dataset in that time period, as all companies have substantial investments in renewables. Secondly, a study by Nerlinger and Utz (2022) shows that globally, energy firms outperformed the stock market in the scope of the 2022 crisis, however this positive effect was much more evident in large North American firms than in European ones, explaining the scarce positive effects in our data.

There are no evident trends in ROA or ROE, as some observations are positive and others characterized by a negative sign. This could be explained by the nature of the shocks, especially in the case of the Russia-Ukraine conflict. In fact, as already extensively discussed in previous chapters, the conflict could have also pushed up company financials, especially for those firms that were able to switch to non-renewable to meet growing demand due to the limitations in supply of Russian energy. This could explain why companies such as Vestas, Nordex or Fortum Oyj were negatively hit by the shock, as they are specialised entirely or almost entirely on renewable energy, making it more challenging or impossible to turn to traditional energy sources as others did.

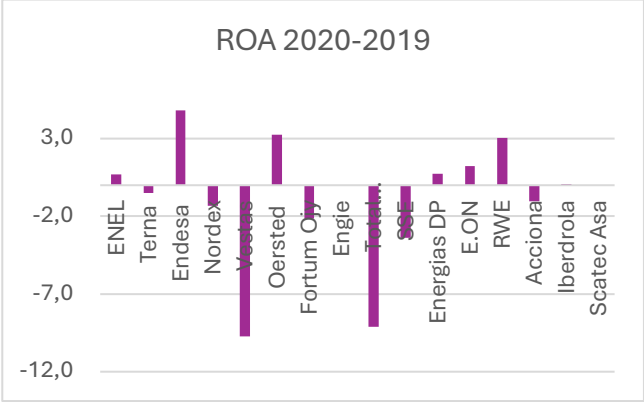
Figure 8



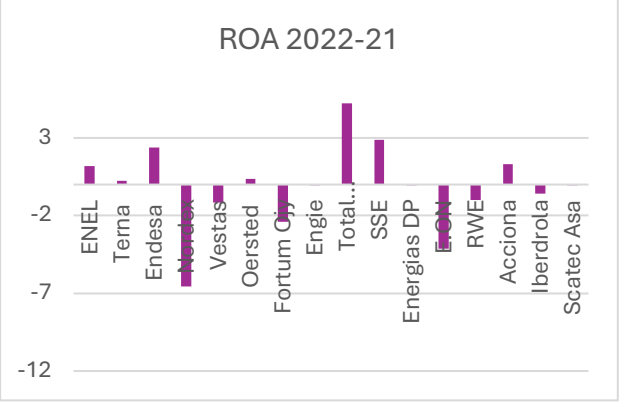
Panel A



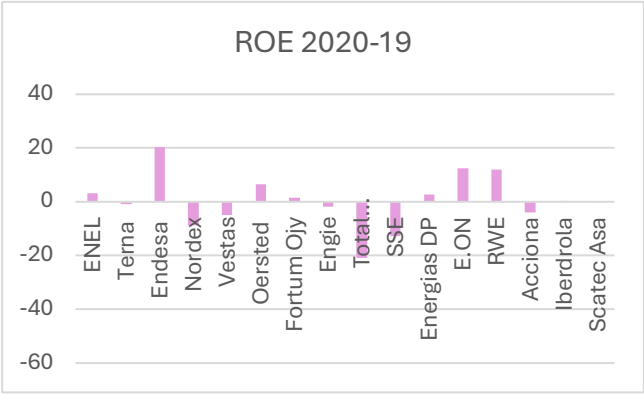
Panel B



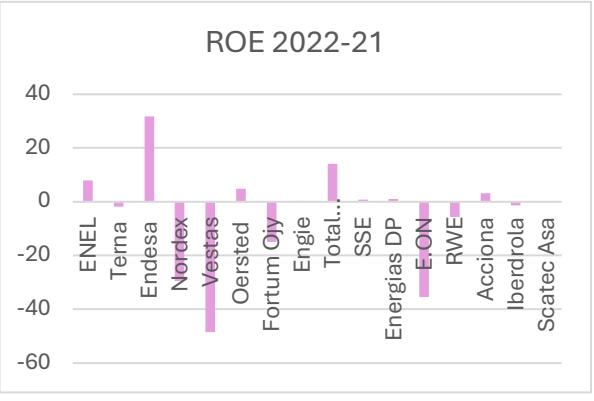
Panel C



Panel D



Panel E



Panel F

Correlation Analysis

Moving on with our analysis, we will now go over the results of our correlation investigation, based on the diffence in values between 2016 and 2019 to isolate the results from external shocks (for all figures see appendix sections V and VI) . We notice that there is a strong positive relationship between ROA and ESG, which is mainly driven by positive coefficients of Environmental and Social factors. On the other hand, Governance has a slightly positive but mostly insignificant correlation with Return on Assets. This is in line with what was found in the research carried out by Elianto et al., (2023) where E and S positively contribute to the financial ratio and G contributes negatively or not at all. When considering the correlation ROA-Green Revenues we obtain a negative coefficient. This result is in line with the very conflicting literature on the effects on green investment, as there are advocators of both negative and positive effects on profitability. For example, a study conducted by Ruggiero et al., (2017) supports our findings, stating that investments in renewables (which represents the largest percentage of GR in our sector) has a negative impact on firm performance, specifically in the energy and electric utilities sector.

The analysis using ROE yields similar results, with the exception of the correlation with the Governance pillar of the ESG score, which results in a positive coefficient. This result could be explained by considering that the governance pillar, which gives an indication of how well a company is run by its directors and managers, how transparent the information released by the company is and most importantly the degree to which the company is aligned to shareholder rights. All these factors significantly play into the shareholder's propensity to invest in the firm's stocks, therefore a better governance score would logically increase shareholder demand and therefore stock prices, ultimately increasing ROE (as a measure of the return the shareholders expect from their investment). This logic also explains the positive relationship between stock price and Governance score found in our analysis.

Moving on with Stock Prices, we notice a positive relationship for variables that indicate investment in environmentally focused projects (green revenues and environmental pillar), which is in line with the relatively recent but growing interest of investors in green alternatives, which are seen as a more ethical but equally profitable investment choice. Furthermore, we observe a negative coefficient deriving from the correlation between S and Stock Price. This finding diverges from many previous studies such as that by Potharla et al.,

(2024) which finds that an improvement in social initiatives is linked to higher stock prices. However, considering that our dataset spans across years of economic stress and a stronger commitment to environmental sustainability, this could reflect the fact that firms in the energy sector prefer to invest in renewables, and that this preference is also reflected on the shareholders' side. The counterbalancing effects of positive E and G and negative S, result in an ESG value weakly correlated with stock price.

V. Conclusions

We started this paper with an extensive overview of climate change, the objectives and efforts towards a net zero economy and the green energy transition in Europe. It is evident that the achievement of these goals faces many hurdles, such as economic feasibility, implying sufficiently high returns on investment, or external shocks to the economy. Despite the existence of extensive research on the topic, conflicting results make it difficult to establish wether investing in green innovation has positive or negative impacts on companies, and what effect specific external shocks have on the examined variables.

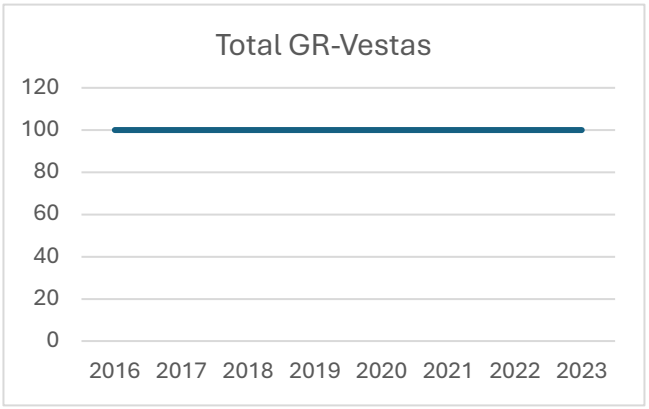
For our empirical analysis we chose a sample of 16 European energy firms of various sizes, using their stock price, ROA and ROE as profitability indicators and ESG scores and Green Revenues as sustainability measures. The first set of results derive from the observation of the behavior of the 5 variables (8 if we include the ESG pillars taken separately) in correspondence with COVID-19 and the outburst of the Russia-Ukraine war. From the graphs and tables constructed we can confirm that the schoks affected ROA and ROE, leaving ESG and Stock Prices mostly unchanged. The second set of results instead focuses on overall trends in correlations between profitability and sustainability measures. From this second analysis we conclude that with few exceptions, european energy firms benefit overall from investing in the green transition. This result is closely tied to the social and cultural beliefs of european investors and even more importantly to the policy landscape in Europe, which is incredibly andvanced and stringent, especially regarding the energy sector.

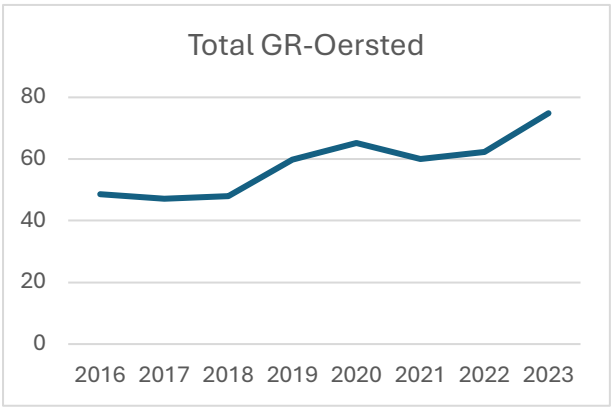
However, there are some limitations to our study. As just explained above, our results can be applied almost solely to the European situation, as it is a very complex and unique one, limiting the application of our conclusions on a larger scale. Secondly, our relatively small sample and time frame, consequence of a scarce availability of data, could expose our results to larger error, further exacerbated by the very turbulent years, economically and policy wise, chosen for the study. Furthermore, the variations of market capitalization and percentage of Green Revenues within the sample could skew the results. There is space for future research to control for all these confounding factors and extend the sample both in time and observations.

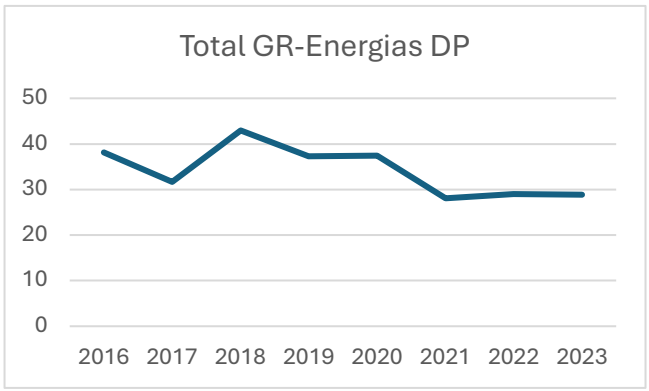
Appendix

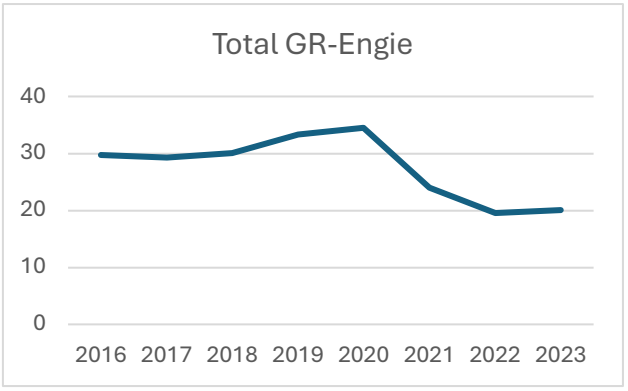
I. Green Revenues

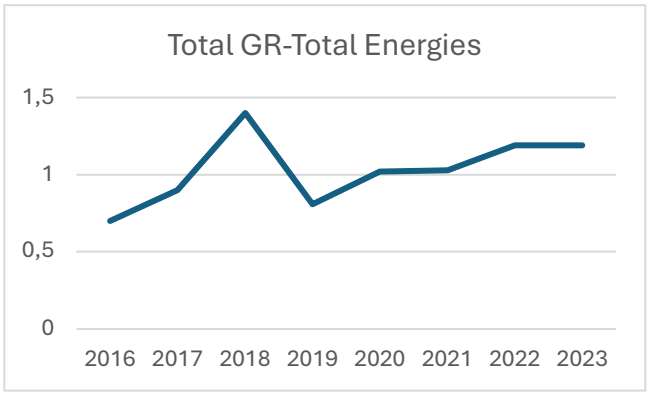
This section shows the trends in Green Revenues for each company.

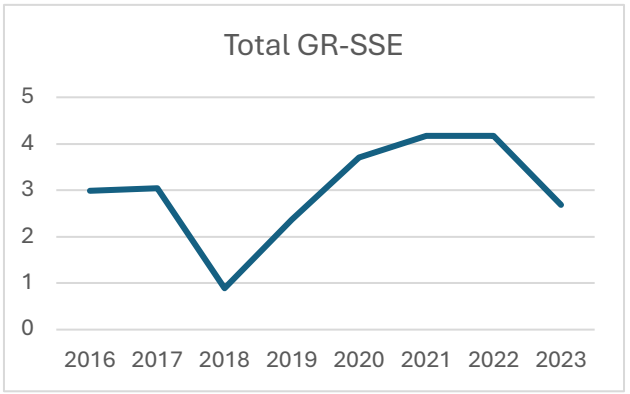


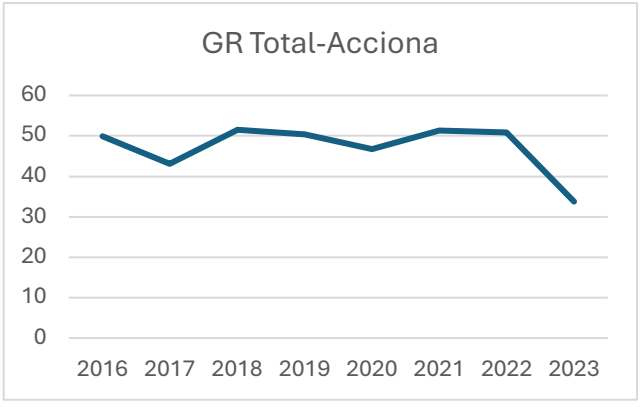


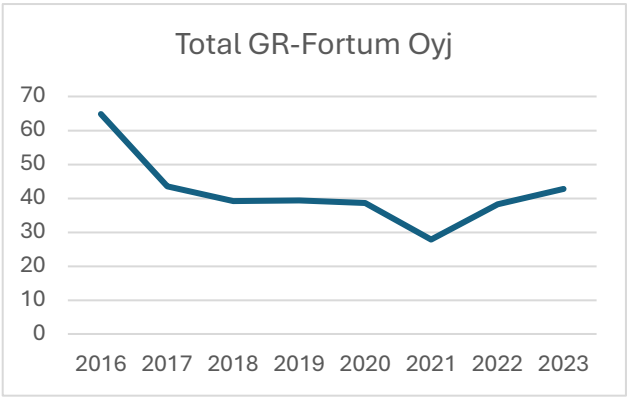


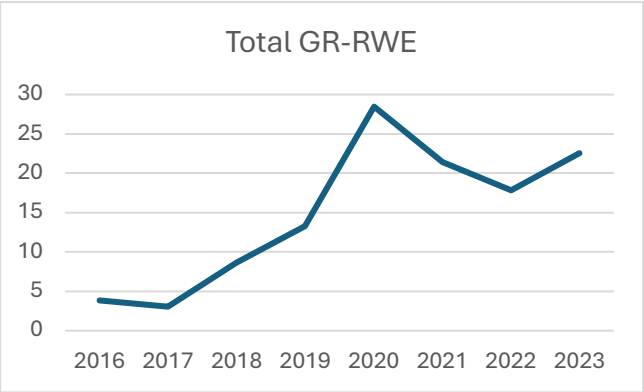


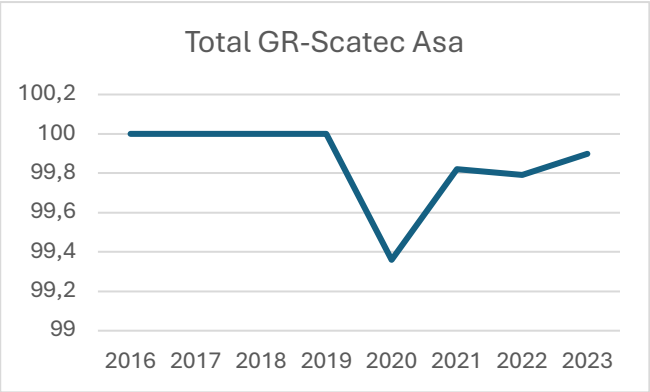


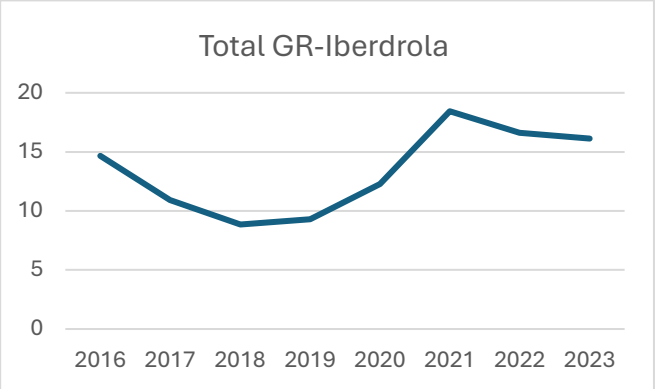


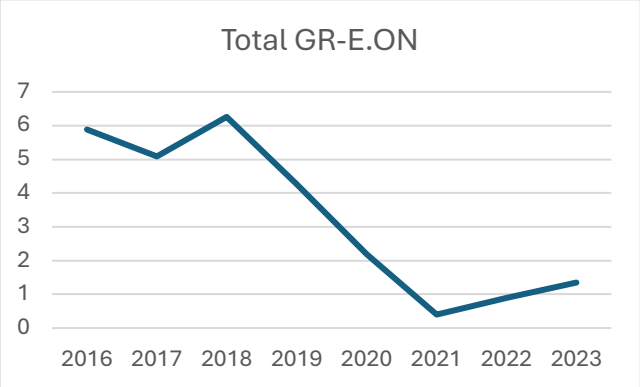


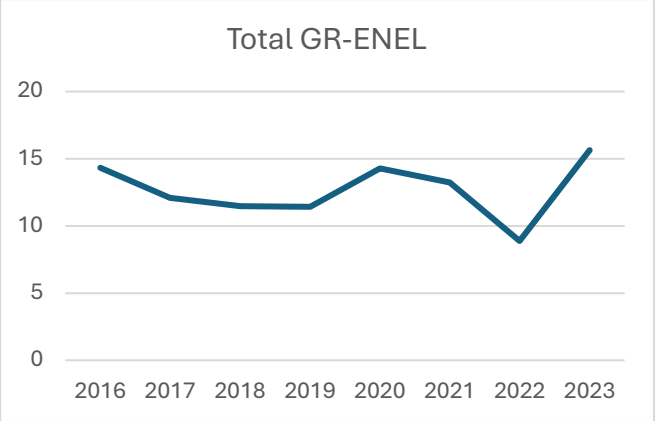


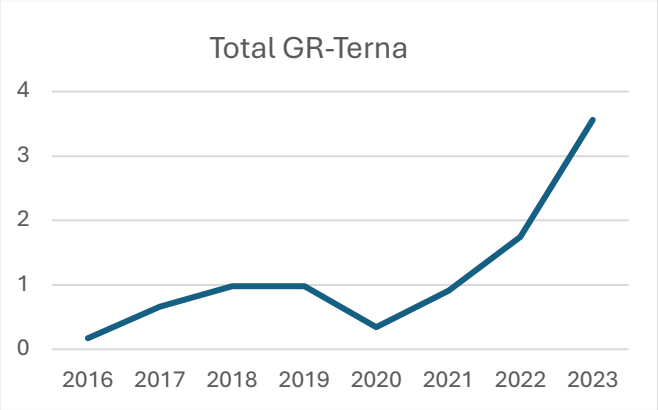

Total GR-RWE
30
25
20
15
10
5
0
2016 2017 2018 2019 2020 2021 2022 2023

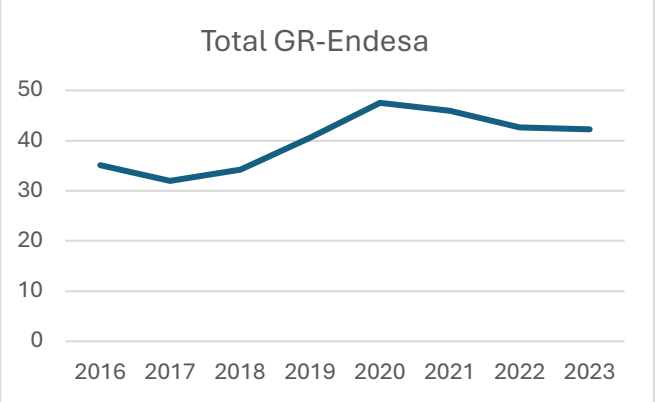

Total GR-Scatec Asa
100,2
100
99,8
99,6
99,4
99,2
99
2016 2017 2018 2019 2020 2021 2022 2023

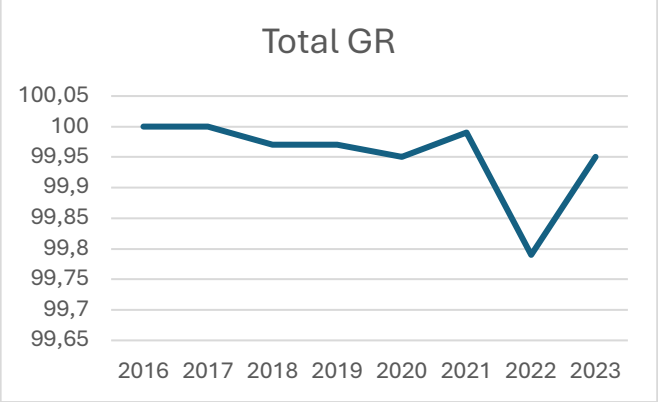

Total GR-Iberdrola
20
15
10
5
0
2016 2017 2018 2019 2020 2021 2022 2023


Total GR-E.ON
7
6
5
4
3
2
1
0
2016 2017 2018 2019 2020 2021 2022 2023


Total GR-ENEL
20
15
10
5
0
2016 2017 2018 2019 2020 2021 2022 2023

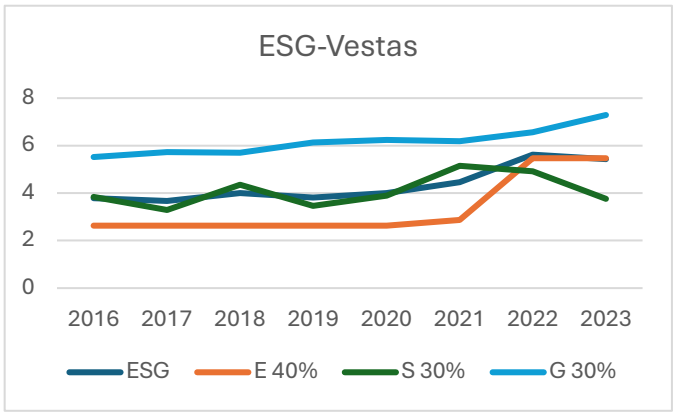

Total GR-Terna
4
3
2
1
0
2016 2017 2018 2019 2020 2021 2022 2023

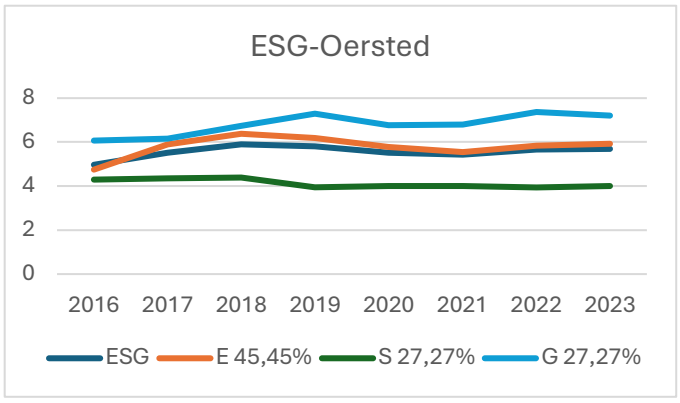

Total GR-Endesa
50
40
30
20
10
0
2016 2017 2018 2019 2020 2021 2022 2023

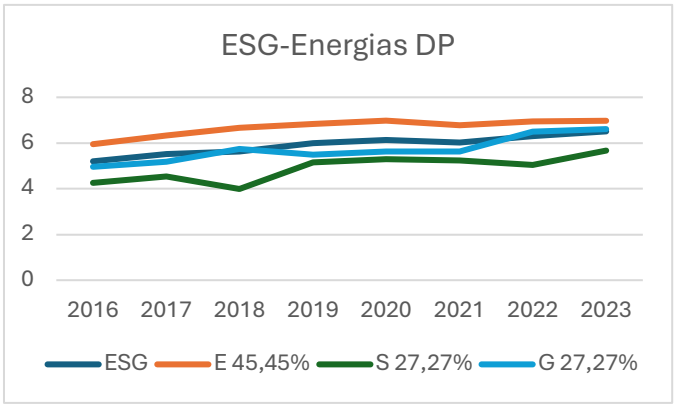

Total GR
100,05
100
99,95
99,9
99,85
99,8
99,75
99,7
99,65
2016 2017 2018 2019 2020 2021 2022 2023

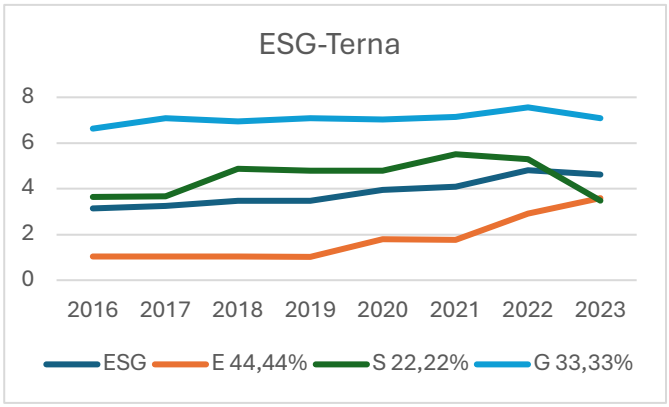
II. ESG

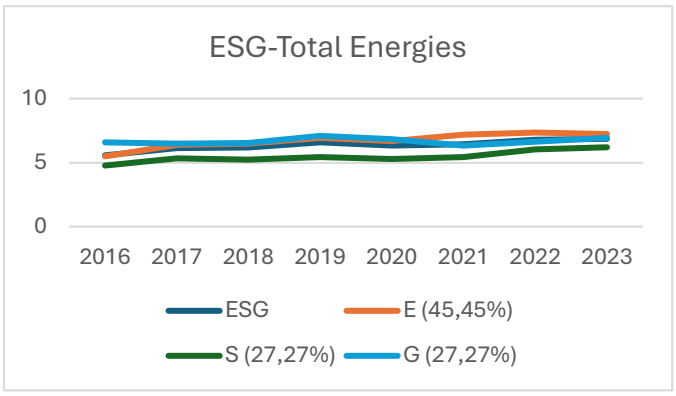
This Section shows ESG trends for each company, highlighting each pillar (E, S, G).

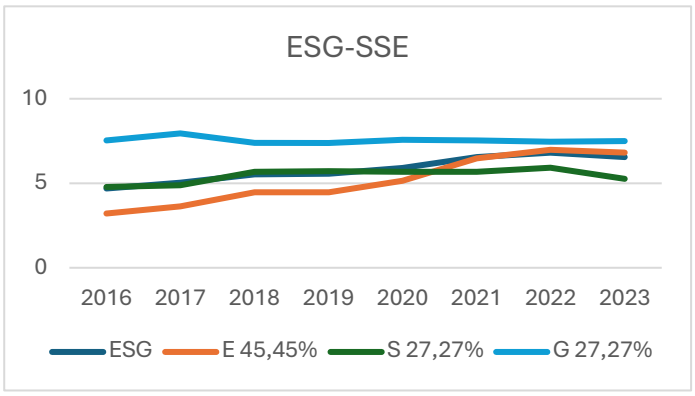


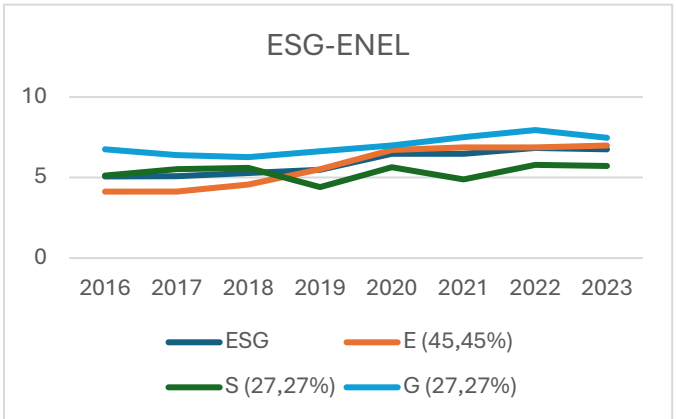


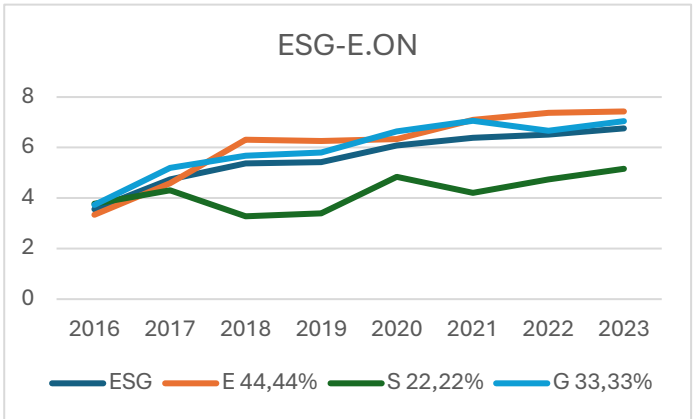


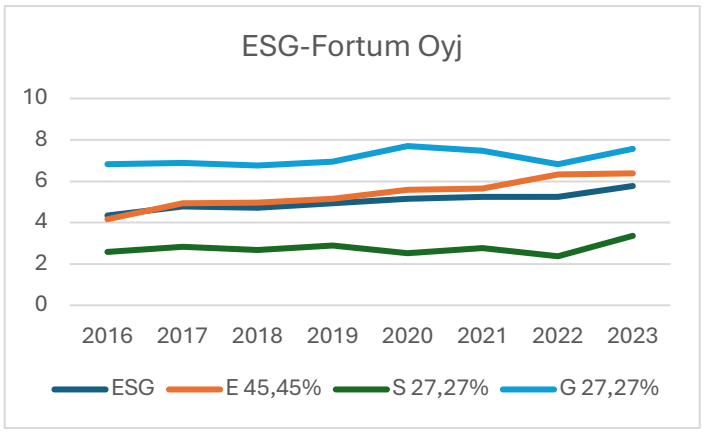


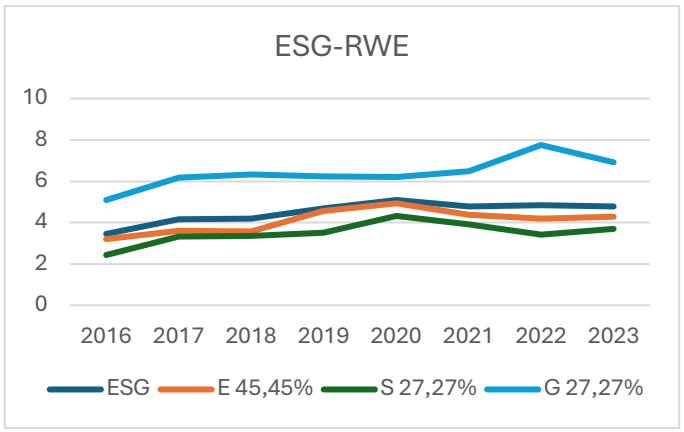


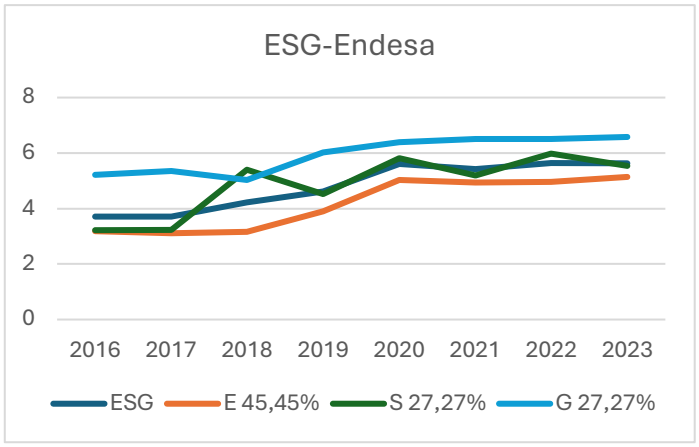


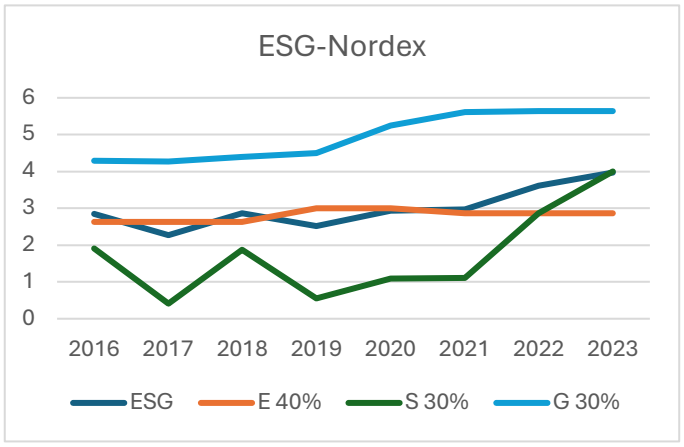


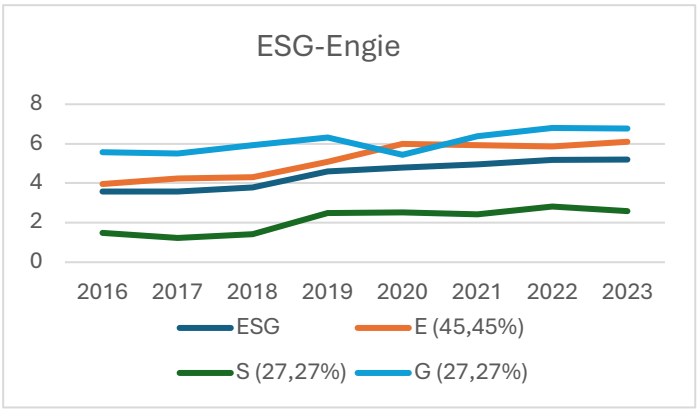


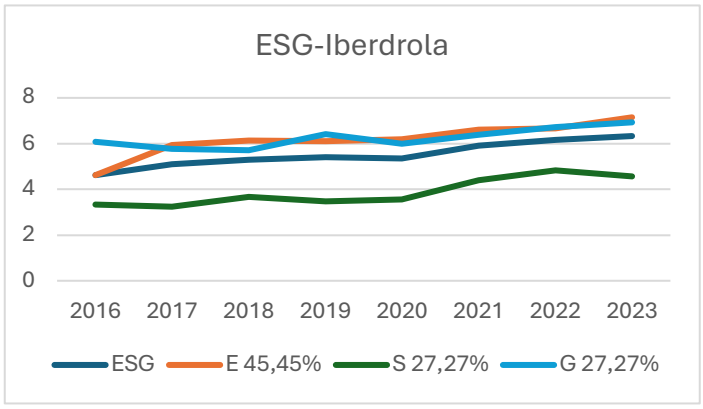

ESG-Fortum Oyj
10
8
6
4
2
0
2016 2017 2018 2019 2020 2021 2022 2023
ESG E 45,45% S 27,27% G 27,27%

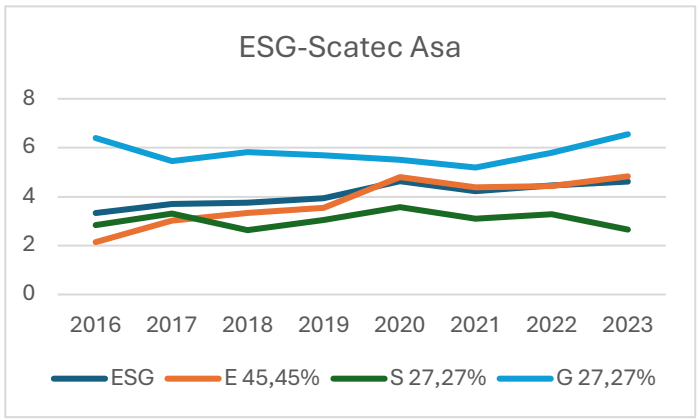

ESG-RWE
10
8
6
4
2
0
2016 2017 2018 2019 2020 2021 2022 2023
ESG E 45,45% S 27,27% G 27,27%

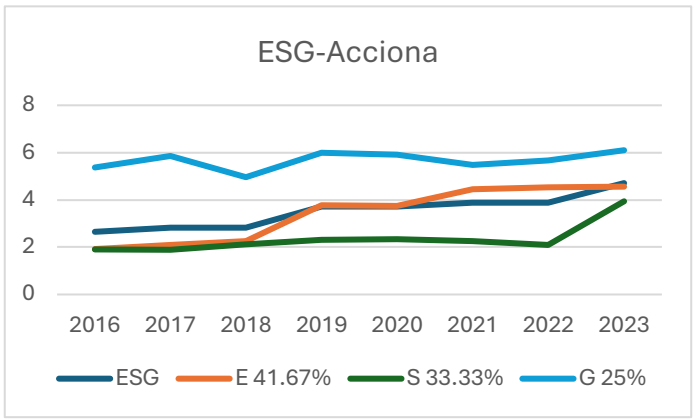

ESG-Endesa
8
6
4
2
0
2016 2017 2018 2019 2020 2021 2022 2023
ESG E 45,45% S 27,27% G 27,27%


ESG-Nordex
6
5
4
3
2
1
0
2016 2017 2018 2019 2020 2021 2022 2023
ESG E 40% S 30% G 30%


ESG-Engie
8
6
4
2
0
2016 2017 2018 2019 2020 2021 2022 2023
ESG E (45,45%)
S (27,27%) G (27,27%)

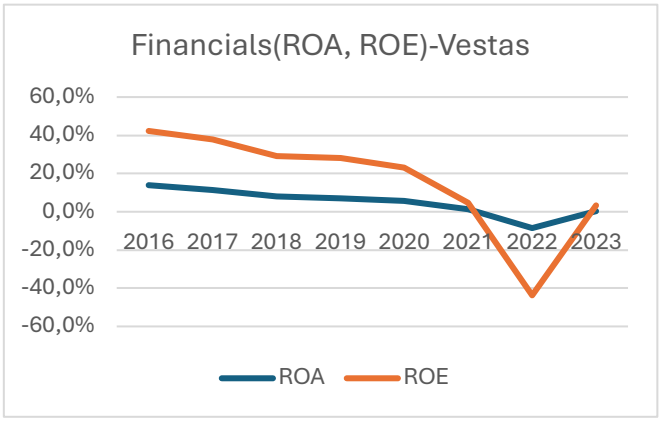

ESG-Iberdrola
8
6
4
2
0
2016 2017 2018 2019 2020 2021 2022 2023
ESG E 45,45% S 27,27% G 27,27%

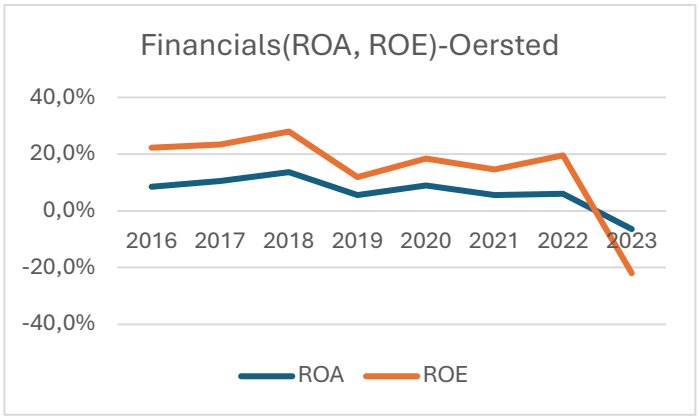

ESG-Scatec Asa
8
6
4
2
0
2016 2017 2018 2019 2020 2021 2022 2023
ESG E 45,45% S 27,27% G 27,27%

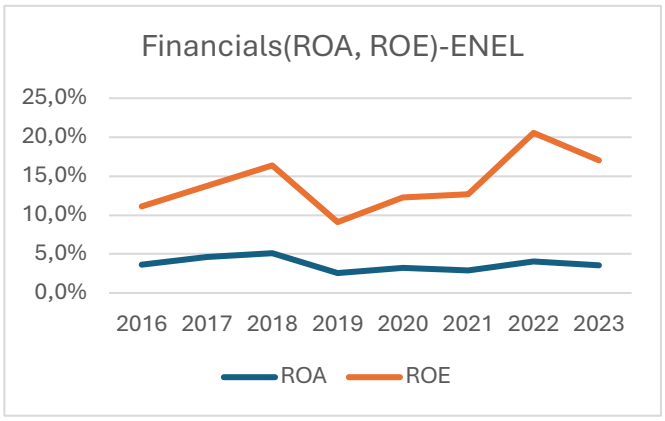

ESG-Acciona
8
6
4
2
0
2016 2017 2018 2019 2020 2021 2022 2023
ESG E 41.67% S 33.33% G 25%

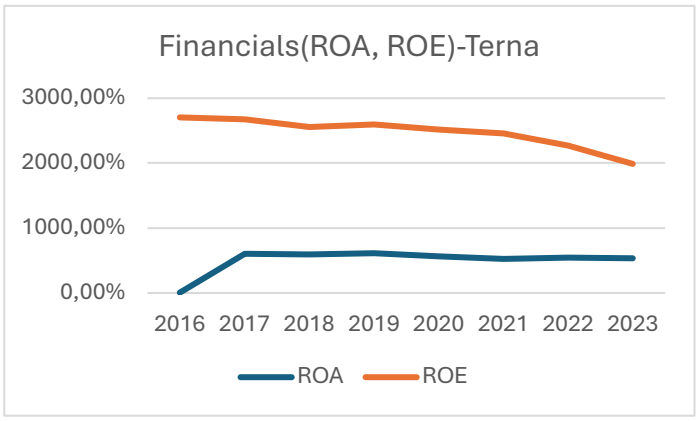
III. Financials (ROA, ROE)

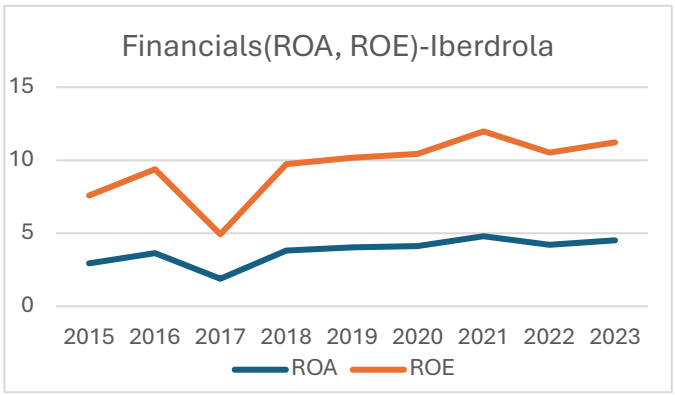
This section presents graphs on ROA and ROE trends for each company.

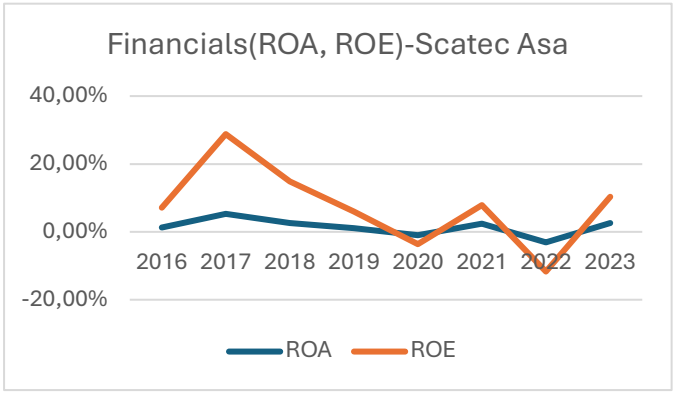


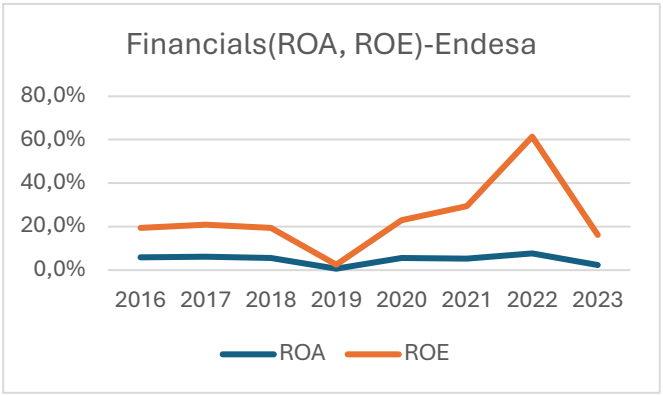


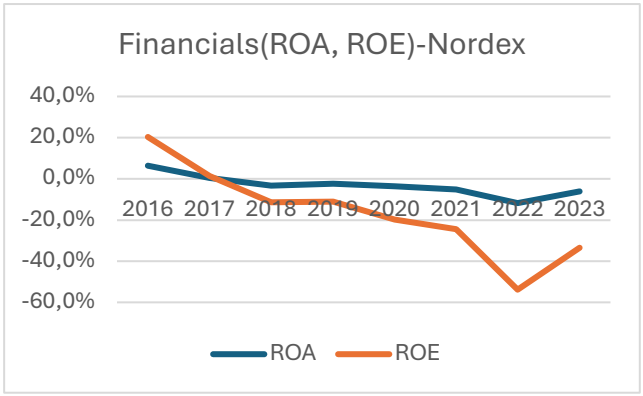


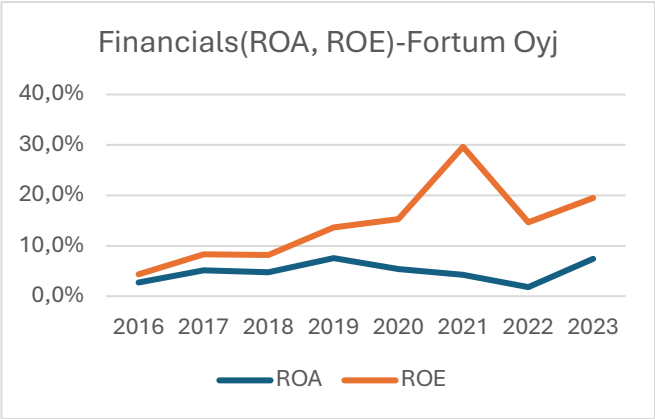


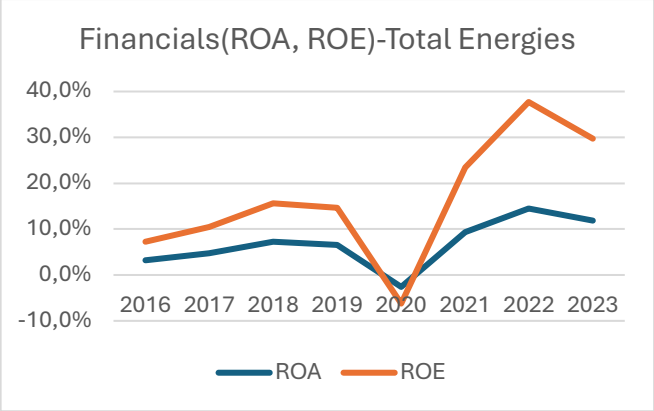


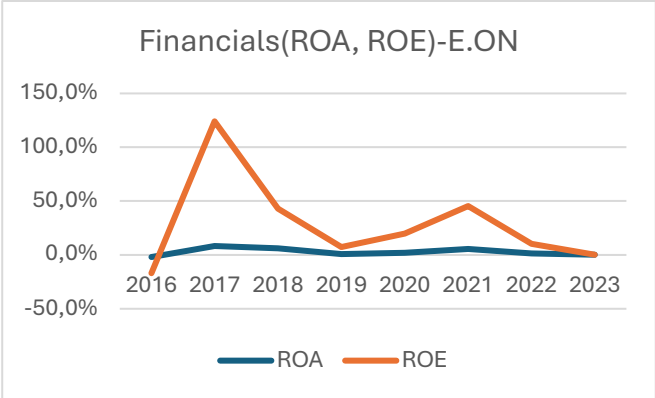


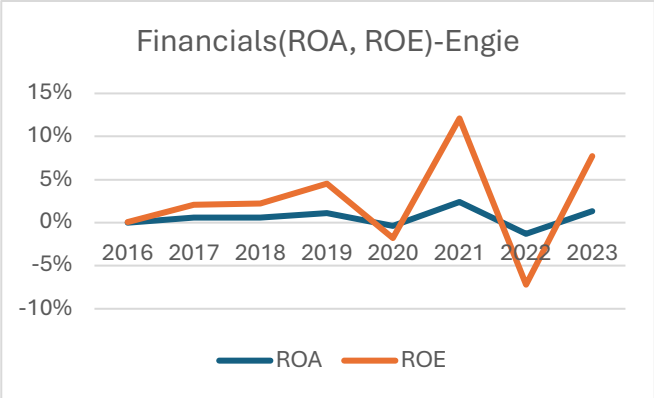


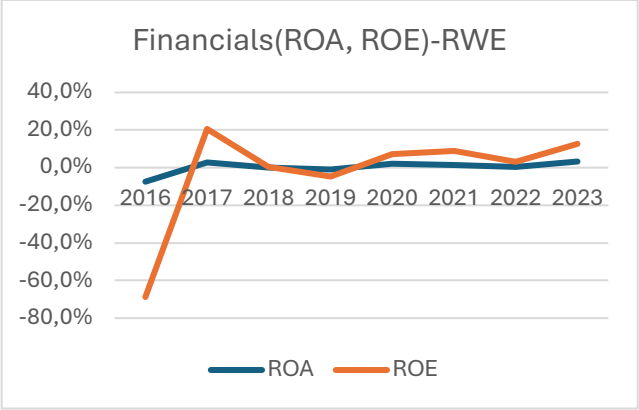


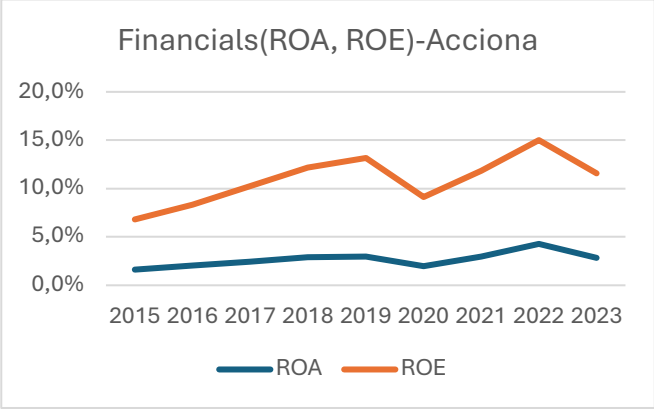

Financials(ROA, ROE)-Fortum Oyj
40,0%
30,0%
20,0%
10,0%
0,0%
2016 2017 2018 2019 2020 2021 2022 2023
ROA
ROE

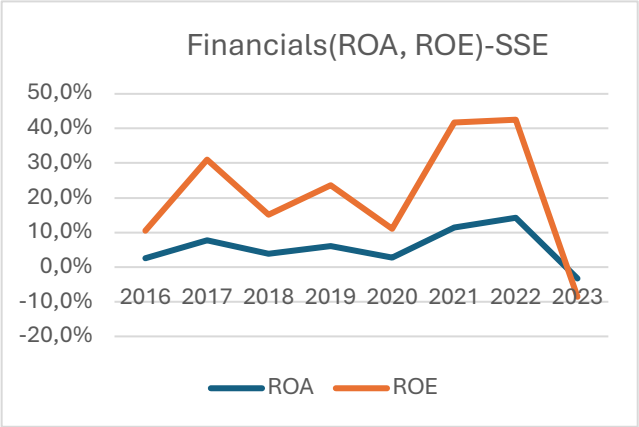

Financials(ROA, ROE)-Total Energies
40,0%
30,0%
20,0%
10,0%
0,0%
-10,0%
2016 2017 2018 2019 2020 2021 2022 2023
ROA
ROE

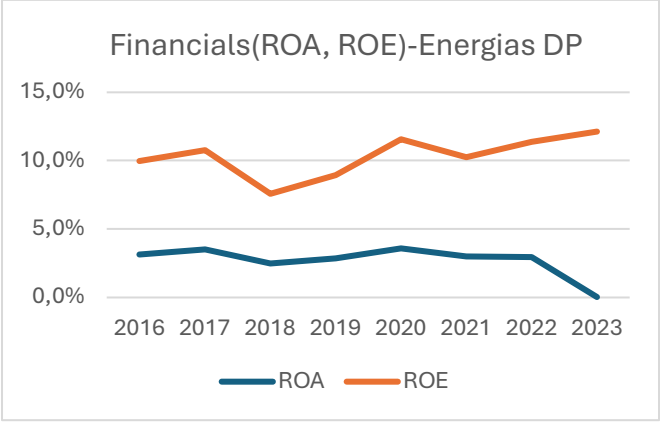

Financials(ROA, ROE)-E.ON
150,0%
100,0%
50,0%
0,0%
-50,0%
2016 2017 2018 2019 2020 2021 2022 2023
ROA
ROE


Financials(ROA, ROE)-Engie
15%
10%
5%
0%
-5%
-10%
2016 2017 2018 2019 2020 2021 2022 2023
ROA
ROE


Financials(ROA, ROE)-RWE
40,0%
20,0%
0,0%
-20,0%
-40,0%
-60,0%
-80,0%
2016 2017 2018 2019 2020 2021 2022 2023
ROA
ROE

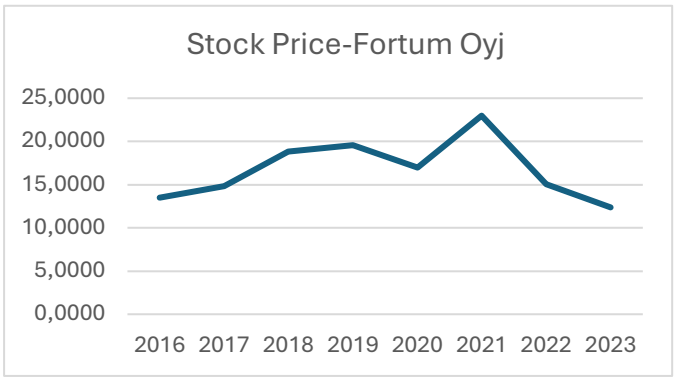

Financials(ROA, ROE)-Acciona
20,0%
15,0%
10,0%
5,0%
0,0%
2015 2016 2017 2018 2019 2020 2021 2022 2023
ROA
ROE

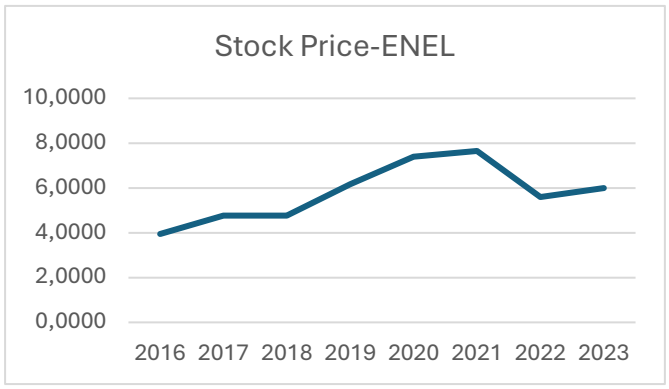

Financials(ROA, ROE)-SSE
50,0%
40,0%
30,0%
20,0%
10,0%
0,0%
-10,0%
-20,0%
2016 2017 2018 2019 2020 2021 2022 2023
ROA
ROE

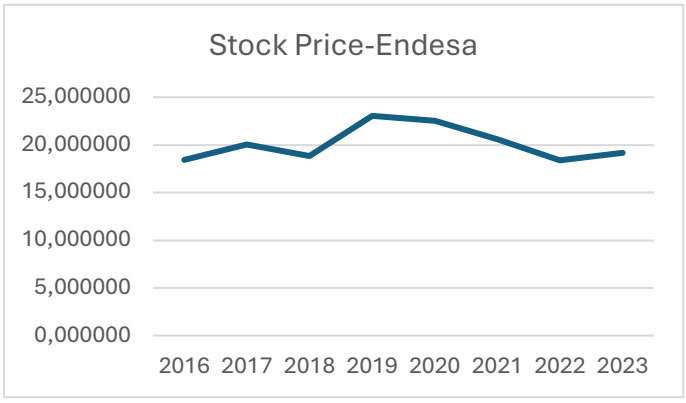

Financials(ROA, ROE)-Energias DP
15,0%
10,0%
5,0%
0,0%
2016 2017 2018 2019 2020 2021 2022 2023
ROA
ROE

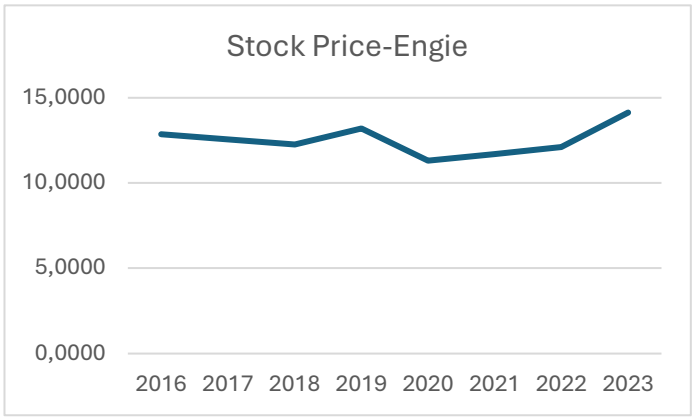
IV. Stock Price

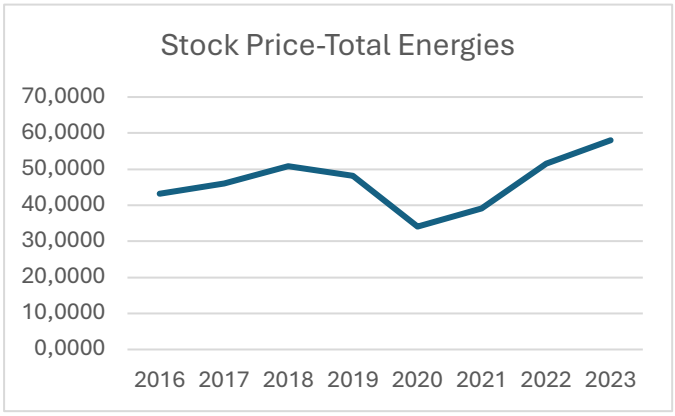
This section shows stock price trends for each company.

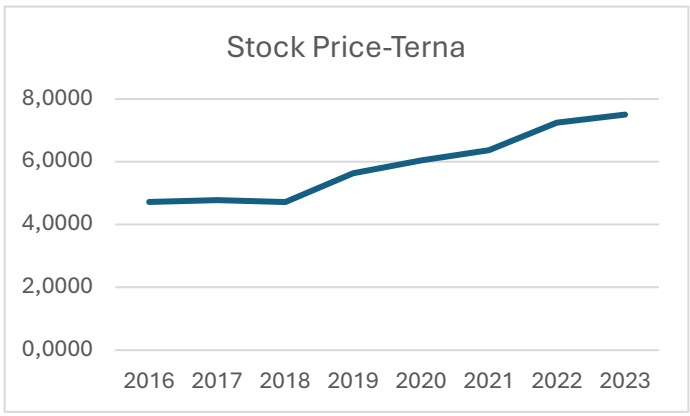


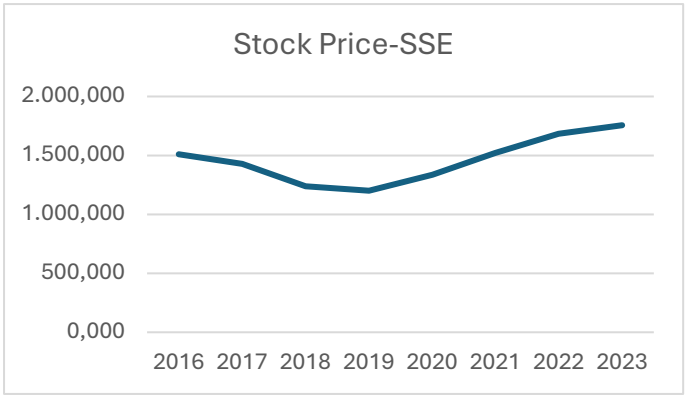


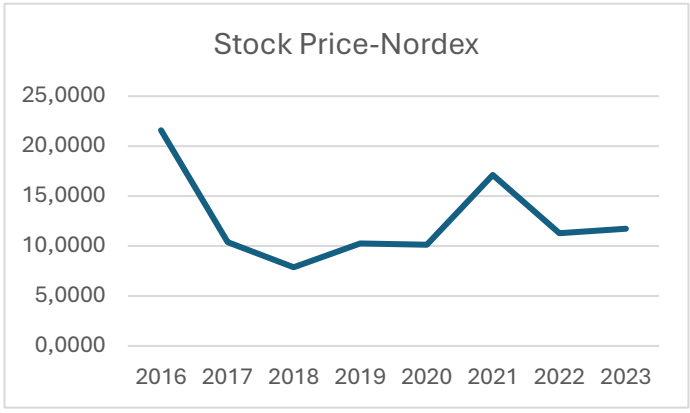


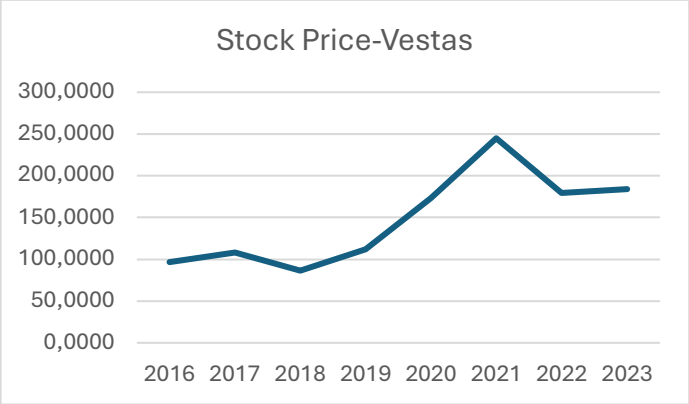








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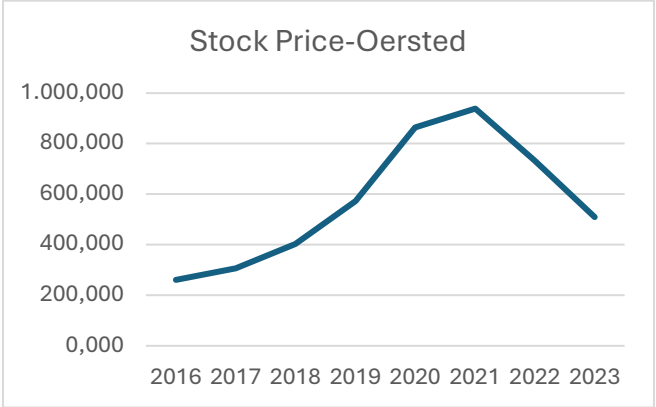
200,0000
150,0000
100,0000
50,0000
0,0000
2016 2017 2018 2019 2020 2021 2022 2023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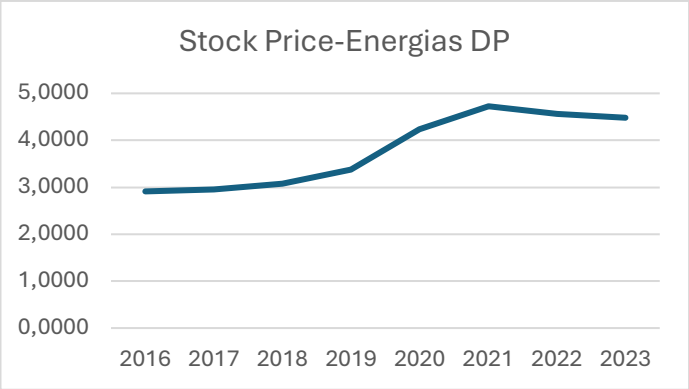
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1,0000
0,0000
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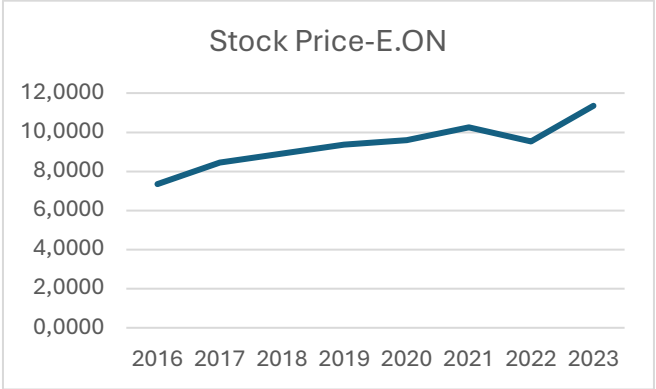
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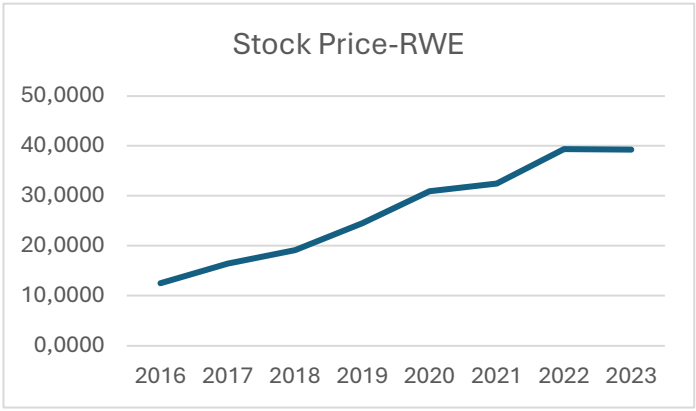
2,0000
0,0000
2016 2017 2018 2019 2020 2021 2022 2023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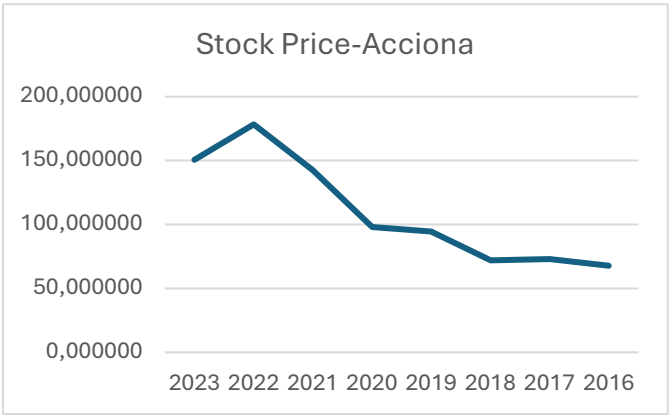
2016 2017 2018 2019 2020 2021 2022 2023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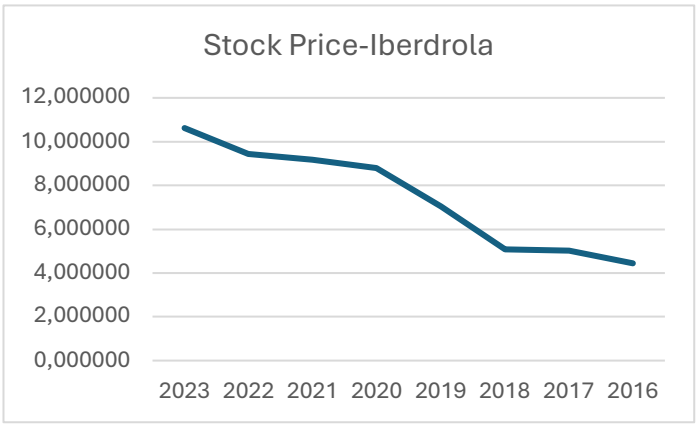
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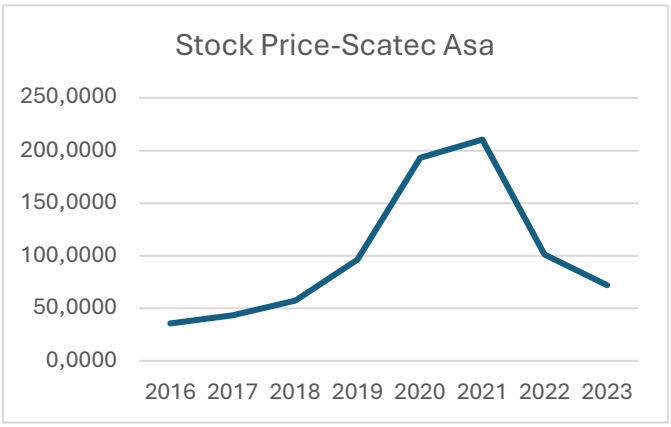
2023 2022 2021 2020 2019 2018 2017 2016


Stock Price-Scatec Asa
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150,0000
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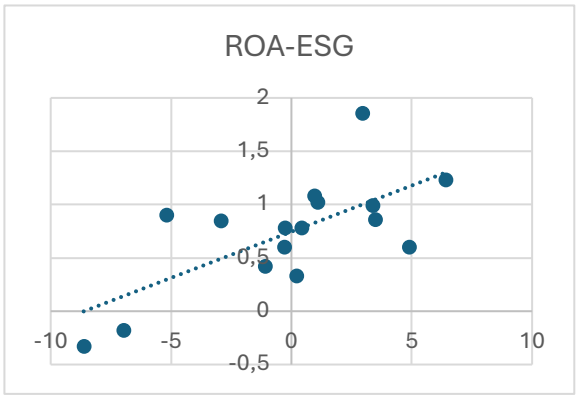
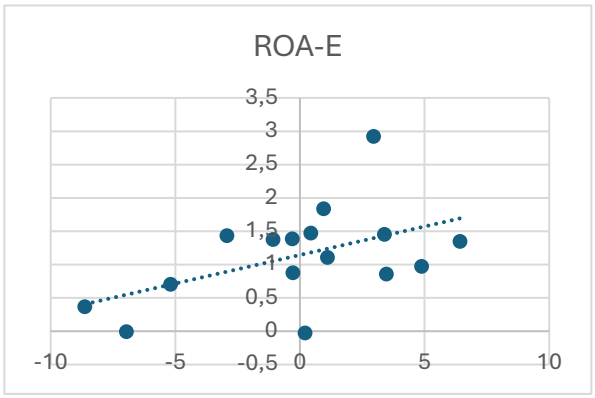
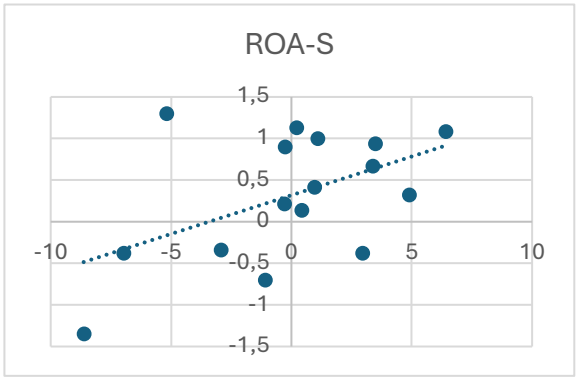
0,0000
2016 2017 2018 2019 2020 2021 2022 2023

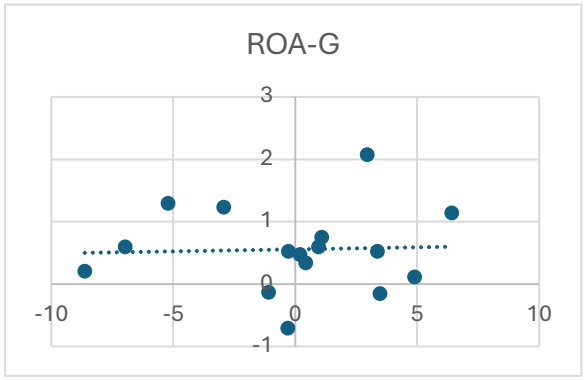
V. Correlation Analysis – ESG

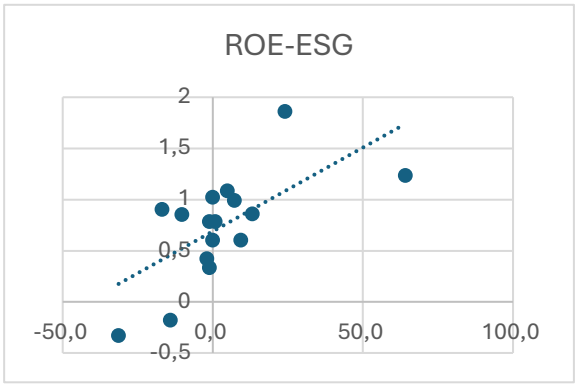
This section presents scatter plots as an aid to our correlation analysis, specifically using the ESG sustainability metric.

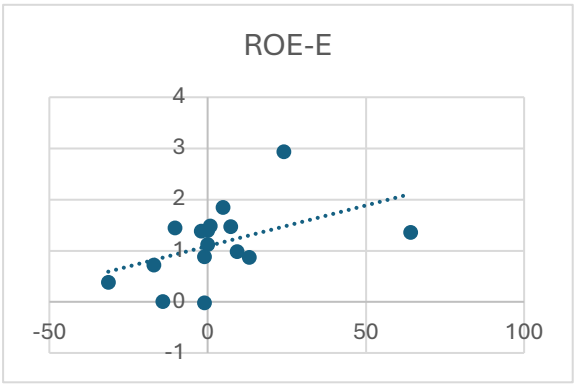


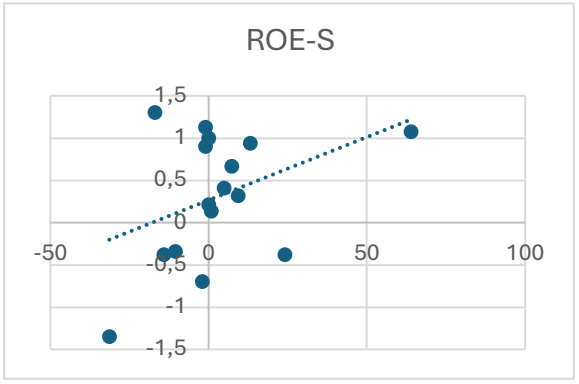


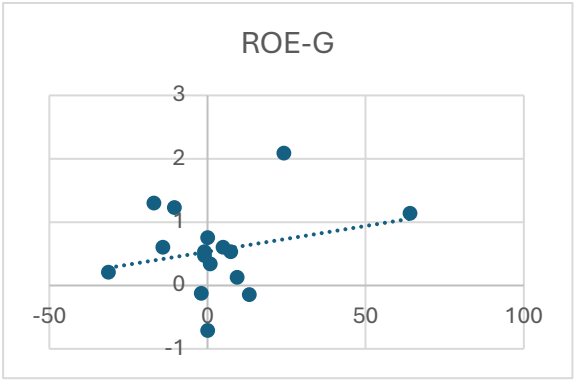


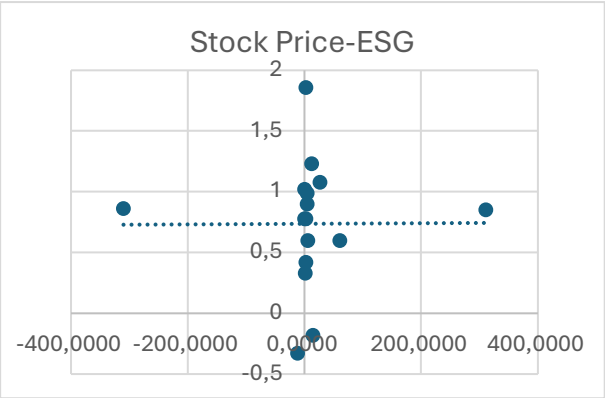











Stock Price-ESG
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0
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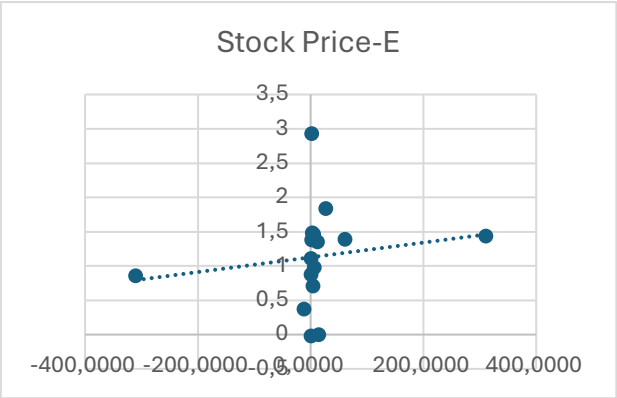
-200,0000
0,0000
200,0000
400,0000


Stock Price-E
3,5
3
2,5
2
1,5
1
0,5
0
-0,5
-400,0000
-200,0000
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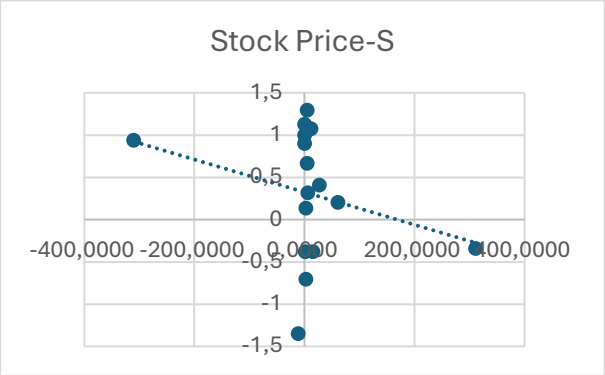
200,0000
400,0000


Stock Price-S
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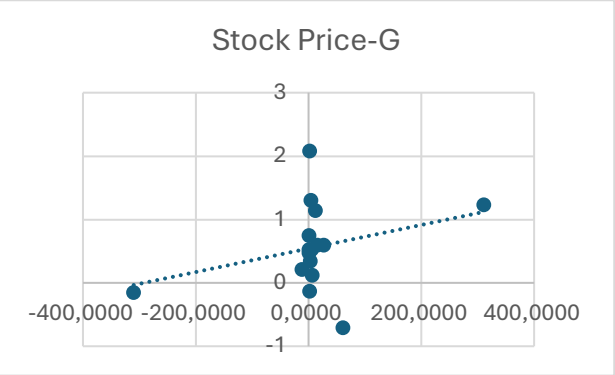
-0,5
-1
-1,5
-400,0000
-200,0000
0,0000
200,0000
400,0000


Stock Price-G
3
2
1
0
-1
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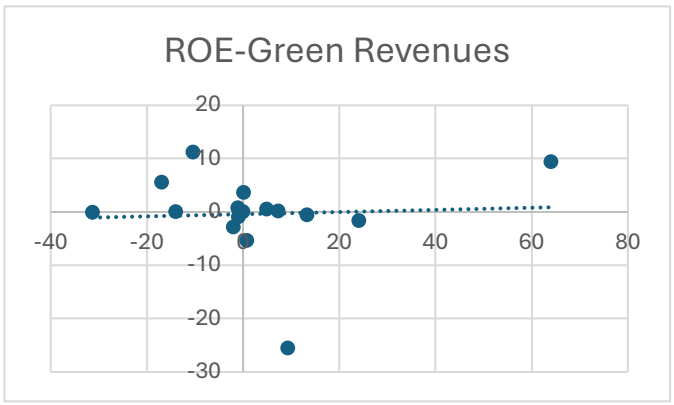
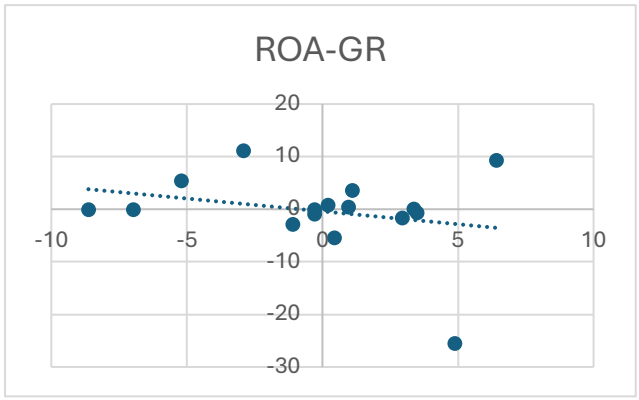
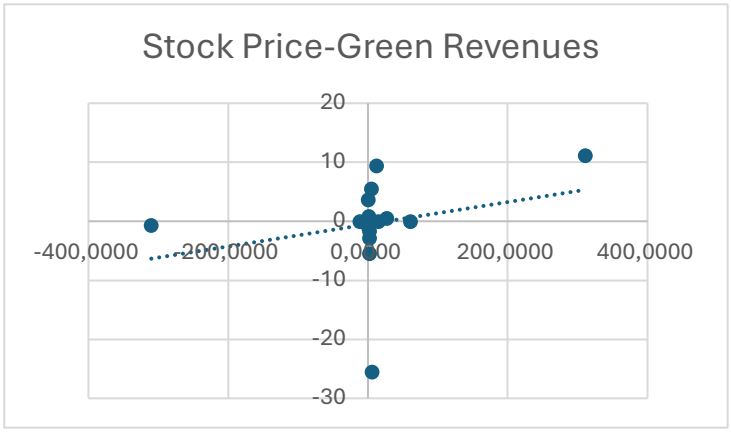
-200,0000
0,0000
200,0000
400,0000

VI. Correlation Analysis – Green Revenues

This section presents scatter plots as an aid to our correlation analysis, specifically using the Green Revenues sustainability metric.







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