Undergraduate Dissertation

Internationalization of Renewable Energy Companies

Internacionalización de Empresas de Energía Renovable

Author

Ana Val Marcén

Supervisor

Marisa Ramírez Alesón

Facultad de Economía y Empresa

Faculty of Economics and Business
Academic year 2023-2024

Autora: Ana Val Marcén
Directora: Marisa Ramírez Alesón
Título: Internacionalización de Empresas de Energía Renovable
Title: Internationalization of Renewable Energy Companies
Grado en ADE, Universidad de Zaragoza

ABSTRACT

As the increase into the global demand for renewable energy has encouraged companies to start exploring international markets, this study aims to provide insights about the term "internationalization" and the Spanish and European renewable energy markets in order to make an analysis of the most promising renewable energies to internationalize and where to do so, taking into account factors such as experiential learning (analyzed by the Uppsala model) and cultural distance (reason that has led this research to be mainly focused on European countries). Insights about environmental policies, consumption patterns and market trends are provided to compare the different renewable sources. After examining them, the focus is put into the internationalization of solar energy, analyzing, among others, its applications, costs evolution, electrical potential, and future prospects. From that section, Southern Europe appears to be the most promising region due to its high irradiation levels and supportive policies. To conclude, the environmental impact of solar PVs is analyzed, delivering notions to improve it.

RESUMEN

Dado que el aumento de la demanda mundial de energías renovables ha animado a las empresas a empezar a explorar mercados internacionales, este estudio tiene como objetivo facilitar información sobre el término "internacionalización" y los mercados español y europeo de energías renovables con el fin de poder hallar cuáles son las más prometedoras para internacionalizar y dónde hacerlo, teniendo en cuenta factores como el aprendizaje mediante la experiencia (analizado por el modelo Uppsala) y la distancia cultural (razón por la cual esta investigación se centra en los países europeos, principalmente). Para comparar las distintas fuentes renovables se aportan datos sobre tendencias de mercado, políticas medioambientales y pautas de consumo, entre otros. Tras examinarlos, el estudio se centra en la internacionalización de la energía solar, analizando, entre otros aspectos, sus aplicaciones, evolución de costes, potencial eléctrico y perspectivas de futuro. De ese apartado, el sur de Europa parece la región más prometedora debido a sus altos niveles de irradiación y a sus políticas de apoyo. Finalmente, se analiza el impacto medioambiental de la energía solar fotovoltaica, aportando ideas para mejorarlo.

Table of Contents

Table of Figures

1. Introduction

The transition towards renewable energy is a critical response to the current global challenge of climate change. This dissertation investigates the internationalization of renewable energy companies, mainly focusing on Spanish firms expanding into the European market, which is closer in distance and has common policies and regulations.

Understanding the internationalization process should be the starting point for companies seeking to navigate regulatory frameworks, cultural differences, and market dynamics. This research makes use of the Uppsala Model to analyze how companies, by gradually entering into foreign markets, can gain experience and reduce perceived risks.

The importance of this study lies in its potential to guide Spanish renewable energy companies in their internationalization efforts, contributing to global sustainability goals, whose importance is constantly increasing. Given the impact into shifting to renewable energy sources instead of using traditional non-renewable ones, the internationalization of companies providing these types of energies can be very beneficial and profitable, as it will be observed. Moreover, because of the impact renewable energy makes, policies and regulations (European Green Deal, Fit for 55…), as well as financial aids, are increasing through time, facilitating their spread throughout the globe.

By shedding light on the internationalization processes of Spanish renewable energy firms, this study not only contributes to academic knowledge but also provides practical guidance for industry stakeholders and renewable energy companies that may be interested in expanding their offer overseas. The insights gained from this research are intended to support the ongoing transition to a sustainable energy future, aligning with both national and international climate objectives.

The structure of this dissertation is mainly divided into 6 sections: a review of the theoretical concepts associated to internationalization and its characteristics, different types of internationalization strategies that can be followed, the renewable energy sector in Spain, the renewable energy sector in Europe, the internationalization of solar energy, and the environmental impact of solar PVs. To finalize, several conclusions from the research will be drawn.

2. Definition and Characteristics of Internationalization

The term "internationalization" can be defined, in general terms, as "the process of increasing involvement in international operations" (Welch & Luostarinen, 1998). As companies increase their level of internationalization, they tend to modify the methods they use to serve foreign markets, usually increasing the depth and diversity of operational methods used. Moreover, their supply to foreign markets usually grows, being deeper and more diversified (either by offering more product lines, or by completely changing products to produce new, better, ones), while also increasing the funds needed in order to support the additional activities they perform in other countries.

Nowadays, most companies are able to participate in internationalization processes (and, indeed, take part of them) quickly due to the high speed of internationalization, being able to achieve significant gains in a really short period of time, especially when taking as reference the situation in the past.

Internationalization usually gives companies numerous benefits, such as a competitive advantage with respect to their rivals, a stronger position in the market, a distribution of the risks they face, a higher availability of resources, the advantage of benefiting from economies of scale to reduce costs, the chance to meet customers' expectations more efficiently… Although it may also bring some difficulties along the way, such as the cost of establishing in new markets, disagreements regarding how to coordinate operations in foreign markets, labor availability, problems of communication with foreigners due to cultural differences… (Taşel, 2020)

Overseas, companies may have extra costs due to higher political and economic risks of the host country, and also as a consequence of the so-called "liability of foreignness" (that is, the additional costs that corporations face when doing business abroad due to spatial distance (such as transportation), firm-specific costs (as there is a lack of roots in the local environment, which leads to a very high unfamiliarity), host country environment costs, and home country environment costs (Cao & Alon, 2021).

The internationalization process is composed by several decisions regarding the location, entry mode, amount to invest, and the way in which foreign operations should be managed and controlled (Beugelsdijk, Kostova, Kunst, Spadafora, & Van Essen, 2017).

Usually, when companies internationalize, they tend to base their first decision on the location in which they are going to expand their activity in. That process can be based either on a rational process of decision-making (seeking the market efficiency, national resources, and knowledge: basing the decision on their growth opportunities or cost advantages), or on a more behavioral approach, emphasizing a gradual learning when expanding horizons for future internationalization.

One of the most popular and widely used theories that explain how gradual learning reduces internationalization risks is the so-called Uppsala Model, which will be one of the key theories used in this thesis for making an analysis of the process of internationalization of renewable energy companies.

The Uppsala Model suggests that firms start operating exclusively nationally, having no involvement in international markets, to then start exporting (usually through intermediaries), increasing their exports' frequency. As companies start engaging in more operations with international markets, gaining experience and confidence, they start establishing new relationships overseas (with subsidiaries or joint ventures, mainly), which leads to a higher experience and familiarity with those markets, being able to expand their operations in them, developing closer relations with local partners. Eventually, companies end up having a lower risk than when compared to the situation of not having any experience as a consequence of the operations in which they engage in overseas markets because of the experience acquired, which enables them to diversify their operations and expand to further markets, as they may be closer to the reached overseas markets than they were with the initial local one (Forsgren, 2002).

Some of the assumptions of the Uppsala model are: there exists a a lack of knowledge about foreign markets (which tends to be the major obstacle to international operations) that can be acquired through time; the main source of knowledge is the firm's own operations, so acquiring knowledge is a matter of being active in the new environment rather than merely collecting and analyzing information; the decisions and implementations concerning foreign investments are made incrementally, due to the market uncertainty, by using the "learning by doing" method, by which the more the firm knows about a market, the lower the perceived market risk and the higher the level of foreign investment in the market will be; firms postpone stepping into markets until the perceived risk associated with the new investment (strongly linked with the level of the market knowledge) is lower than the maximum tolerable risk; knowledge highly depends on individuals and is, therefore, very difficult to transfer, so the problems and opportunities of a market will be mainly discovered by those working in the market; experience creates more business opportunities, and it is the driving force of the internationalization process.

Nevertheless, although the main emphasis is put on experiential learning, there are other ways by which firms can acquire knowledge apart from it: through their business relationships, organizations can obtain the knowledge of other firms without experiencing exactly the same as them; moreover, imitative learning enables companies to observe other firms and imitate their behaviors; in addition, hiring people with the necessary knowledge, or acquiring other organizations with the acquired knowledge, are also useful manners to acquire more information apart from through experience (Forsgren, 2002).

In conclusion, the term "internationalization" represents a dynamic process whereby companies are able to expand their operations overseas. It involves a strategic decision-making process in which the location, investment and operational management of the new market must be discussed. While internationalization provides numerous benefits for companies, such as a competitive advantage and a higher availability of resources, it also faces some challenges because of the higher costs and cultural differences. Therefore, understanding the nuances of internationalization is crucial for companies that want to embark in the internationalization process.

In the subsequent sections, the internationalization process will be further analyzed, applying it to the case of renewable energy companies from Spain.

3. Internationalization Strategies

At this moment in time, with some capital and experienced staff, companies can expand their businesses almost “anywhere”, since the appearance of newer communication and transportation technologies in recent years has allowed companies to reduce their costs in a really large scale compared to how they used to be a few decades ago, enabling faster and better communications through the globe.

Nevertheless, as there is a wide variety of companies, each of them may choose different ways of internationalizing, usually depending on the framework of the firm, the entrepreneur, and the factors of the market in which they operate (Taşel, 2020).

The timing of internationalization (described as the time elapsed between the initial establishment of the company and the initiation of foreign operations) is crucial to analyze the internationalization process of different firms, which is many times related to the age of the firm. Moreover, the pace of internationalization (that is, the number of countries in which a firm enters in a certain period of time) is an important factor to take into account in the analysis.

Depending on the degree of internationalization, companies can be split into 3 different groups: early internationalized companies, mature internationalizers (currently benefiting from the globality of their business) and highly internationalized firms.

Firms in their early stages are usually young and small, and usually do not offer a very wide product range, as they generally enter markets shortly after their founding. They may face some uncertainties and risks due to their lack of resources (financial, human…), which will be reduced with experiential learning through time.

Figure 3.1. Strategic Commitment to Internationalize. Source: (Wood et al., 2011)

As it can be seen in Figure 3.1, Wood et al. (2011) based the distinction of internationalizers in 2 dimensions: the founder's strategic commitment to internationalize, and the time of internationalization. Therefore, 4 types of internationalizers can be distinguished: strategic early ones (their founders' initiatives are meant to be internationalized early, and they actually do so), serendipitous ones (their initiatives do not commit to early internationalization but, nevertheless, they end up internationalizing early, for example as a consequence of unexpected international demands), permanent late ones (where there is a commitment to internationalize early but, because of many factors (such as lack of resources, for example), they end up expanding their markets later), and long-term internationalizers (whose new initiatives do not have a strategic commitment to early internationalization, and in fact do internationalize late).

Something that companies should bear in mind when deciding when to internationalize are the benefits and drawbacks of doing so. For example, if companies internationalize early (which are usually companies lead by a manager who is more risk seeking), they may take advantage of the so-called "first mover advantage" (having a temporary monopoly, economies of scale, better customer relations…), but they will also face risks and uncertainties associated with the market, its products and the technologies used.

On the other hand, if companies decide to internationalize later (usually for companies whose manager is more risk averse), they will most likely have a lower cost when doing so, but their entrance may not be as successful for not having benefited from the first mover advantage (Taşel, 2020).

Therefore, companies that want to internationalize their operations should bear in mind the timing and strategy chosen for doing so, analyzing their availability of resources, the market in which they operate, their long-term goals and their willingness to take risks.

4. Renewable Energy Sector in Spain

As Olabi and Abdelkaarem (2022) stated, the rapid expansion of global population has led to a higher energy demand. The main energy sources are currently fossil fuels, which are not sustainable because of the high amount of greenhouse gases they emit in their combustion process (leading to weather changes, health problems, sea-level rises, changes in the ecosystem…). Therefore, many governments are currently using different methods to eliminate those negative effects by implementing different measures, such as improving the efficiency of technologies, developing new more efficient devices that cause lower environmental impacts, or transitioning into using renewable energy resources (usually defined as "the energy produced by natural resources naturally re-established within a few years" (Bortoluzzi, De Souza, & Furlan, 2021)).

Among the different renewable energies, the most common ones are (Osman, et al., 2022):

1. **Hydraulic Energy** (obtained by transforming the potential energy of water into kinetic energy, it is usually generated by the construction of dams on rivers, as the fall of the water from a high height onto the turbine generates the electricity, and it is the largest renewable energy source).
2. **Solar Energy** (also known as Solar Photovoltaic Energy, which is generated from sunlight, coming from solar panels, having one of the fastest expansions among renewable energies).
3. **Wind Energy** (it is based on the utilization of wind power as a generator of energy by means of a wind turbine, both for residential and industrial uses).
4. **Geothermal Energy** (it is derived from the earth's heat, or from the steam coming from hot rocks, mainly for industrial uses).
5. **Biomass** (which is a material formed by vegetable and animal substances in origin, being the energy obtained through combusting firewood, agricultural residues, animal excrements… in summary, through organic materials).

Nevertheless, even though renewable energy is currently one of the solutions proposed to substitute fossil fuels, there are some barriers to using them as an energy source, which can be classified into: economic and financial (as they require a large capital investment, the cost of energy is higher…), technical (since renewable energy has to be available and there must be a lot of expensive investments in new technology, infrastructure and skilled labor), social and environmental (by making people more aware of the situation, changing cultural and behavioral aspects, the problem of people accepting the change, and also problems related with the environment), regulatory and policy (as rules and regulations will be needed to be taken into account), and institutional and administrative (involvement of stakeholders, obtaining bureaucratic licenses…) (Olabi & Abdelkareem, 2022).

In Spain, the distribution of renewable energy sources in the first half of 2023 is represented as follows (Red Eléctrica, 2023):

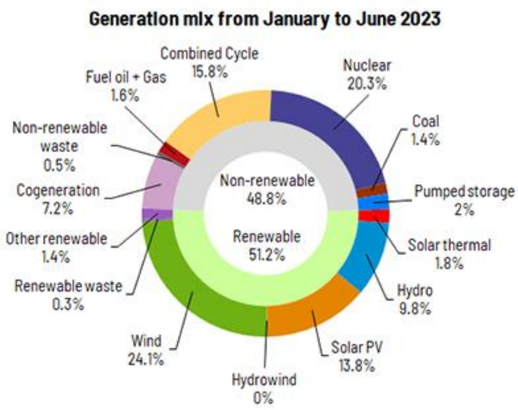

Figure 4.1 Renewable Energy Sources in Spain. Source: (Red Eléctrica, 2024)

As it can be observed in Figure 4.1 (Red Eléctrica, 2024), over half of the energy generated in Spain in the first half of 2023 was obtained from renewable sources. Among the renewable energies used, the most widely used was the one coming from the wind (wind energy), followed by solar PV (solar (photovoltaic) energy, increasing specially during summer months, reaching its peak in June of 2023, becoming the leading source of renewable generation in Spain during that month) and hydraulic energy (which is actually experiencing the highest increase in the country, showing a year-on-year variation of 57.6%).

Nevertheless, there is still a really high presence of non-renewable energies in the country, where combined cycle and nuclear energy stand out (15,8% and 20,3%, respectively, constituting over 1/3 of the total generation sources, if put together).

There were some slight changes in the situation at the end of the year, where the use of renewable energies within the installed power capacity structure increased up to a 61,3%, standing out among them wind energy (24,5%), followed by hydraulic energy (13,6%) and solar energy (20,3%). Among non-renewable energies, the combined cycle (which consists of using fuel for producing electricity from 2 different power generation cycles, converting the heat from a gas turbine into steam for a steam turbine, to have a better thermodynamical efficiency than conventional power plants (Ersayim & Özgener, 2015)) stood out, with a 20,9%.

Moreover, it is important to remark that the generation park with renewable energy sources in Spain reached at the end of 2023 an all-time high of 50,3% of the total energy generation, which is an important milestone for the country (Red Eléctrica, 2024).

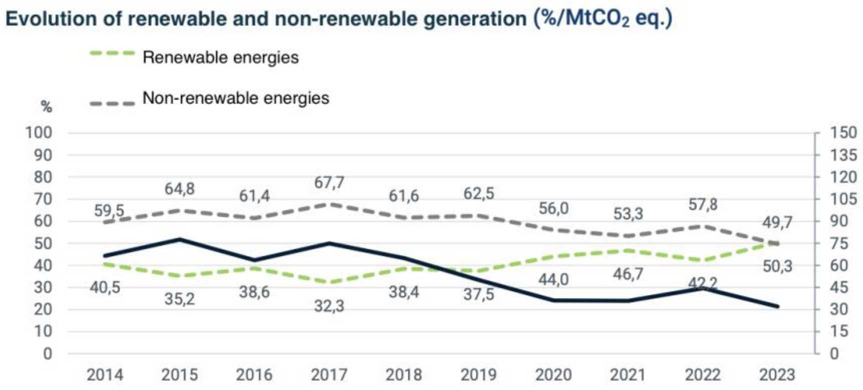

Figure 4.2. Evolution of Renewable and Non-renewable generation in Spain. Source: (Red Eléctrica, 2024)

As it can be observed in Figure 4.2 (Red Eléctrica, 2024), energy generation through the last 10 years slowly shifted from mainly coming from non-renewable sources to a majority of it coming from renewable ones in 2023. The renewable energies trend has been increasing through time, reaching a trough (in the last 10 years) in 2017, followed by a prolonged increase since then until today, reaching its peak in 2023 and having for the first time a greater presence than non-renewable generation.

This higher share of renewable generation in 2023 mainly happened due to a 41.1% increase in hydroelectric production, and a 33.8% increase in the solar photovoltaic one, when compared to the previous year. Both wind and solar photovoltaic energies have exceeded the maximums in production and participation in the national mix because of the weather conditions and the increase in renewable installed capacity in the national electricity system.

5. Renewable Energy Sector in Europe

As this research paper will focus on the internationalization of renewable energy companies in Europe (mainly focusing on EU countries), given that the continent has common policies and regulations regarding renewable energies, is a global leader in renewable energy adoption, and is composed by countries that are more similar in culture and are located closer in distance than the rest of the world, it will be important to look at different aspects of such region, which will be analyzed in the following sub-sections:

5.1 EU Targets and Policies

The world's climate has constantly been changing over time, having a significant shift in the last 65 years, and such impact is expected to remain as high in the coming years, being a really important problem not only for Spain or even Europe, but for the whole world. As a consequence of the current climate change, of which humans are mostly blamed for (high usage of fuels, burning of residues and fossil fuels, deforestation, transportation industries…), temperatures are constantly rising, precipitation patterns are changing, as well as atmospheric pressure, sea levels are rising, ice sheets are melting…

Given the importance of the matter, in December of 2015 the Conference of Paris (COP-21) to the United Nations Framework Convention on Climate Change (UNFCCC) took place, in which an agreement was created in order to fight climate change and reinforce the actions and expenditures needed to achieve a sustainable low-carbon future. The goal of this agreement was to unite all governments to impose the common goal of tackling climate change by also providing funds (and better technology and enhanced capacity budlings) for developing countries to be able to adapt to the effects and fight the consequences as developed countries do. The main target of the agreement was to limit the temperature rise to 1,5ºC over pre-industrial levels, boosting the worldwide response to climate change matters and preparing countries to fight it to minimize GHG emissions.

The pact was ratified by over 50 countries (each of them being required to submit their own contribution to reducing GHG emissions and adapting to climate change), accounting for at least 55% of global emissions, and by 2017 it was accepted by 125. In November of 2016, the COP22 took place in Marrakesh, being the first time the Conference was taking place after the Paris one, establishing a deadline for achieving the goal by 2018. Moreover, a long-term goal of keeping the rise in average global temperature below 2ºC above pre-industrial levels was set (Raihan, 2023).

Nonetheless, the Paris Agreement has not been the only step the EU has taken to align its policies and actions with its sustainability goals, as other policies, legislative proposals and actions have been taking place in the recent years, such as the European Green Deal (EGD), announced in December of 2019. The EGD is the European Union's roadmap to achieve climate neutrality in Europe by 2050, implying an important diminishing of emission reductions, while reducing social and regional inequalities in Europe to gain the support needed. It has been proposed as a mission for Europe to become the first carbon-neutral continent by 2050, while strengthening European cohesion through its mission and boosting the competitiveness of the European industry, having environmental, social, and economic impacts (Wolf, Teitge, Mielke, Schütze, & Jaeger, 2021).

Moreover, as part of the European Green Deal, on July 29 of 2021 the European Climate Law entered into force after being approved by the Parliament, being a legislative proposal for a Climate Law across Europe with the aim of establishing a framework for achieving the objective for the EU to become climate-neutral by 2050. After several discussions, the agreement set a 55% net European GHG emission target for 2030, and an EU-wide climate neutrality target for 2050 (net-zero GHG emissions) with the aim of achieving negative emissions thereafter. Additionally, the European Climate Law aims to provide a long-term direction for EU climate action while also enabling investors and businesses to have a better predictability, ensuring transparency and accountability (Erbach, 2021).

Besides, in order to achieve the 55% GHG target and the implementation of the EU's Green Deal, the EU Commission suggested the so-called "Fit for 55", initially consisting of 16 legislative and strategic proposals to reach it. It contains proposals to amend and expand the current European legislation on climate and energy, which is nowadays seen as an impediment for achieving the new targets. Therefore, the package suggests to tighten all existing legal climate and energy acts by amending their targets and scopes and revising their structures, including reforms in the existing EU emissions trading system, energy taxation and efficiency, and renewable energies, among others, while also suggesting the creation of a second EU emissions trading system for the building and transports sectors, of a Carbon Border Adjustment Mechanism, and of a Social Climate Fund (Schlacke, Wentzien, Thierjung, & Köster, 2022).

Apart from the European Green Deal and related policies, the EU has set a minimum renewable energy target of 42,5% renewable energy sources in the EU's overall energy mix by 2030, as the energy sector is responsible for more than 75% of the EU's greenhouse gas emissions. The target was initially established (2018) to reach a 32% by 2030, with a clause for a possible revision by 2023, which has actually taken place. It was initially increased up to 40% by 2021, to then being increased in 2022 with the publishment of the REPowerEU plan (which established some measures to reduce as fast as possible the EU's dependence on Russian fossil fuels as a consequence of the war with Ukraine, enabling a faster renewable energy transition; the plan was based on 3 pillars: saving energy, producing clean energy and diversifying the EU's energy supplies, as it was highly dependent on Russia up to that date). Lastly, the target was in 2023 increased to a minimum of 42,5% (although aiming for a 45%) by the revised Renewable Energy Directive, which implies an almost double increase into the existing share of renewable energies in the EU (European Commission, 2024).

5.2 Market and Trends

Even though the usage of renewable energies in the EU has been increasing through time, reaching a 23% in 2022, there is still a long path until the 2030's target of a 42,5% share is reached, which implies almost doubling the rates of renewable energies usage. In 2021 the share stood at 21,9%, and the increase between those 2 years was mainly driven by a severe growth of solar power usage, as it is currently one of the most rapidly growing renewable energies. Moreover, a reduction in the use of non-renewable energies as a consequence of their high prices also increased the growth rate.

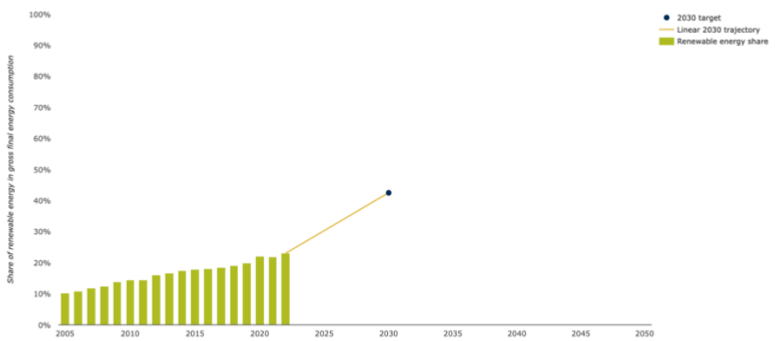

Figure 5.2.1 Progress Towards Renewable Energy Source Targets for EU-27. Source: (European Environment Agency, 2024)

Figure 5.2.1 (European Environment Agency, 2024) enables a comparison of the use of renewable energies in the EU through time, while also providing an insight of the trajectory that renewable energies share should follow in order to meet the 2030 target. As it can be observed, a maximum was reached in 2022, although the graph also shows that the growth rate of renewable energies usage has been slower since 2020 than it used to be up to that year.

When analyzing different sectors, the one that had the highest increase in renewables in 2022 was the power sector, in which 41,2% of the total electricity generated came from renewable sources, followed by the heating and cooling sector (24,9%), with the transportation sector occupying the third place (9,6%).

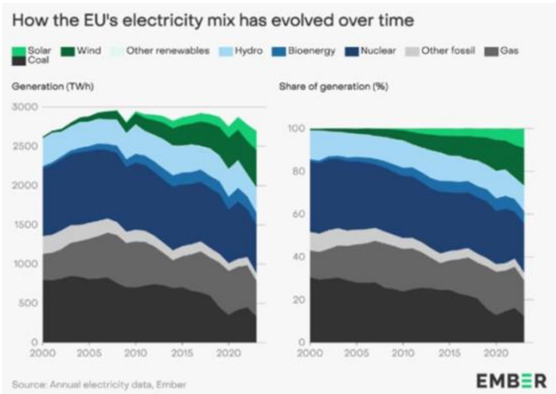

Figure 1.2.2 EU's Electricity Mix Evolution Through Time. Source: (Ember, 2024)

Figure 5.2.2 (Ember, 2024) allows a comparison of the generation and share evolution of different energy sources (both renewable and non-renewable) from 2000-2023. As it can be observed, in 2000 over half of the EU electricity (52%, precisely) came from non-renewable fossil fuels (coal, gas and other fossils), falling to roughly a 33% in 2023. Much of that fall was due to the fact that, since 2009, solar and wind power have been constantly increasing through time (whose evolutions can be observed in Figure 5.2.3 and Figure 5.2.4, respectively, disclosed by country; their numerical data can be found in Appendix 2), accompanied as well by a slight increase into bioenergy sources. In counterpart, generation from other sources, such as the above-mentioned fossil fuels, in addition to nuclear energy sources, have been losing their share within the total electricity generation.

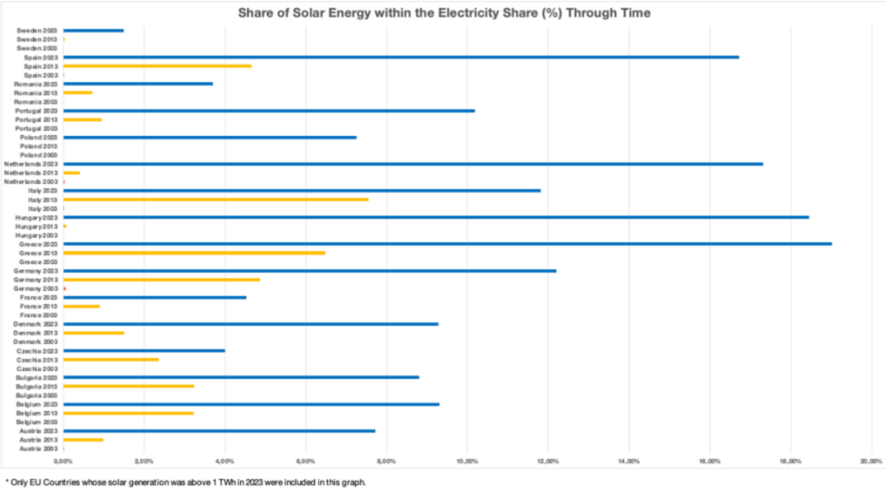

Figure 5.2.3 Evolution of Solar Energy Share in Europe. Source: Own elaboration, data from (Ember, 2024)

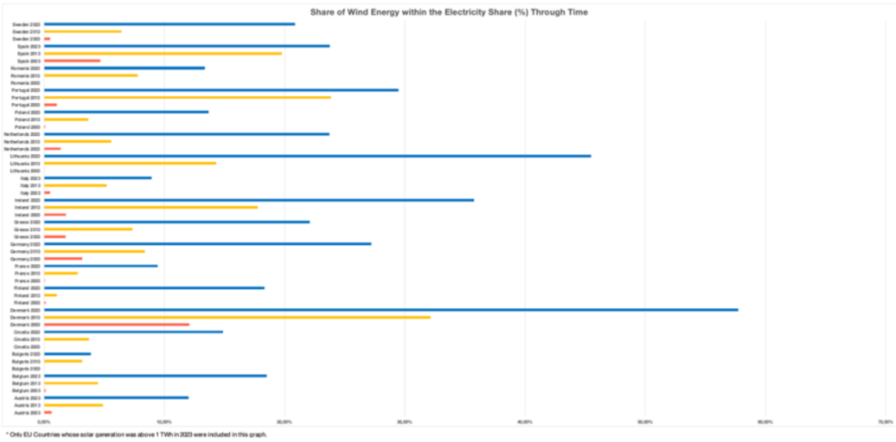

Figure 5.2.4 Evolution of Wind Energy Share in Europe. Source: Own elaboration, data from (Ember, 2024)

By Figure 5.2.3 and Figure 5.2.4 the evolution of wind and solar energy's shares can be observed. As it can be seen, solar energy is relatively "new", as it barely had any presence in 2003, reaching levels between 10-20% in 2023. On the other hand, wind's share has always been higher, having some presence in many countries already in 2003, and reaching levels of over 20% in many EU countries in 2023.

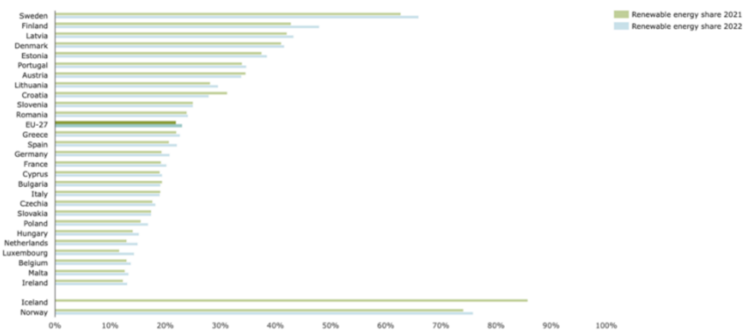

Figure 5.2.5 Share of Energy from Renewable Sources by Country. Source: (European Environment Agency, 2024)

Figure 5.2.5 (European Environment Agency, 2024) allows a comparison of the overall renewable energy situation across European countries. As it can be observed, Sweden, Finland and Latvia had the highest Renewable Energy Share among the EU in 2022, all of them having very strong hydropower industries and a wide use of biofuels. Regarding their renewable sources' composition, Sweden primarily relied on hydro, wind, biofuels and heat pumps, with a similar situation for Finland (hydro, wind and (solid) biofuels, in this case). In Latvia, most of the renewable energy came from hydro (Hughes, 2024).

On the other hand, Ireland, Malta and Belgium had the lowest shares in 2022, only having around only 13% of their energy used coming from renewable sources. Nevertheless, all 3 countries, as well as the rest of them, with the exception of Austria, Croatia, Bulgaria and Italy, have experienced an increase in the share from 2021 to 2022.

Over time, the countries that have experienced the highest growth in their Renewable Energies Shares since 2005 have been Sweden, Denmark and Estonia, all of them having a higher share than the average in the EU. On the contrary, Romania and Slovenia (both roughly above the average) have suffered the lowest increases in that same period.

If the whole European Economic Area is analyzed (therefore, also including some countries outside of the EU), Norway and Iceland have the highest RES shares, of above 70%; in Norway, most of their electricity is generated from hydropower, while in Iceland most of it comes from geothermal sources.

Maximum Electrical Capacity (MW) in the EU from 2000-2021

	2000	2006	2012	2018	2021
Total Capacity	613.221	693.041	854.766	930.623	991.045
Combustible Fuels	340.088	379.790	426.573	405.710	379.382
Hydro	134.729	139.516	144.943	150.364	151.668
Geothermal	604	697	783	861	877
Wind	12.297	45.612	97.145	157.212	188.371
Solar	175	3.224	71.041	104.058	164.185
Tide, Wave, Ocean	213	215	216	223	216
Nuclear	124.851	122.837	113.237	111.240	105.112
Other sources	263	1.149	827	955	1.234

Figure 5.2.6. Maximum Electrical Capacity in the EU Through Time. Source: (Eurostat, 2023)

Figure 5.2.6 (Eurostat, 2023) provides an analysis of the installed electrical capacity within the EU, showing an increase of over a 60% from 2000 to 2021. As it can be observed in the table, the structure suffered significant changes through time, as in 2000 the highest share was for combustible fuels (accounting for a 55,5% of them), followed by hydro (with a 22%), while in 2021, the share of installed capacity of combustible fuels has decreased up to only reaching a 38,3% of the total, ; on the other hand, wind has increased up to a 19% (and, when looking at 2000, it can be observed that its contribution was minimum) and solar photovoltaic, with a 16,3% (which was almost non-existent in 2000). Moreover, as it can be observed, in the case of geothermal and tide, wave and ocean, they have remained at minimum levels through time, barely having any increases.

Additionally, other important measures for the renewable energies sector in the EU are the imports and exports, whose overall picture can be observed in Figure 5.2.7 (Branding, 2024). Moreover their detailed trajectory in the last 10 years can be analyzed in figures 5.2.8 and 5.2.9 (Eurostat, 2023).

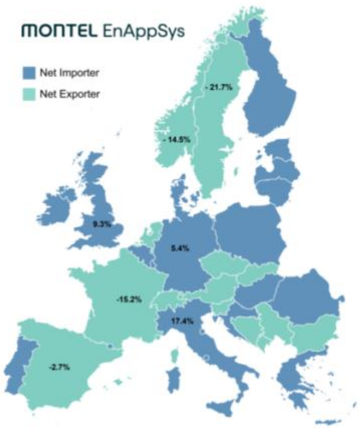

Figure 5.2.7 Renewable Energy Imports vs Exports in Europe Disclosed by Country. Source: (Branding, 2024)

As it can be observed, more European countries are importers than exporters in 2023 (shown as a percentage of the demand). Sweden, France and Norway have the strongest positions as exporters, followed by Spain; on the contrary, Italy, the UK and Germany have the highest net imports across Europe.

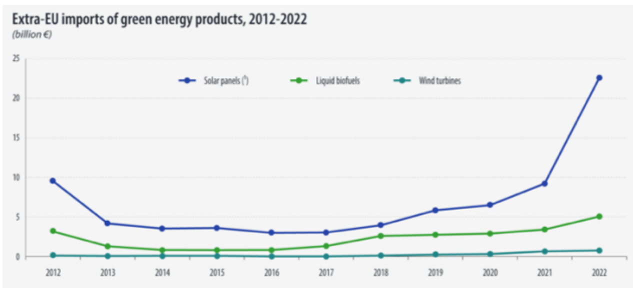

Figure 5.2.8 EU Imports of Renewable Energies 2012-2022. Source: (Eurostat, 2023)

As figure 5.2.8 (Eurostat, 2023) shows, solar panels have constantly been (from 2012-2022) the most demanded ones in terms of imports, with an exponential increase in the last years, with a value of 22,6B Euros in 2022. Knowing that the EU spent in 2022 28,4B Euros on imports of green energy products, solar panels constitute almost an 80% of them. A big increase into total imports can be observed from 2021 to 2022 (from 13,3B to 28,4B Euros), mainly incoming from the share of Solar Panels (which has had a 145% increase from 2021 to 2022), although additionally, the amount of liquid biofuels has doubled, and there has been a slight increase (of 02,B Euros) in wind turbines. If the situation is compared to 2012, imports of all three green energy products have increased, with an overall increase of around 15B Euros.

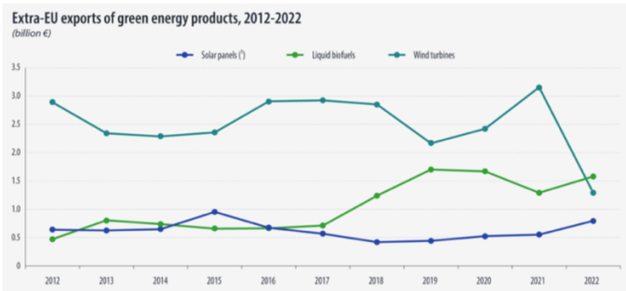

Figure 5.2.9 EU Exports of Renewable Energies 2012-2022. Source: (Eurostat, 2023)

On the other hand, figure 5.2.9 (Eurostat, 2023) provides some insights of the exports of green energy products from the EU where, as it can be observed, the trend is not as clear as it was with imports. In 2022, the total amount of green energy products exports was of 3,7B Euros, while in 2021 it was higher, amounting for a total of 5B Euros when adding solar panels, liquid biofuels, and wind turbines altogether (representing a -27% year-on-year variation). The decline into exports mainly comes from wind turbines, which amounted for a total of 1,3B Euros in 2022 (3,2B Euros in 2021 (59% decrease)). On the other hand, both solar panels and liquid biofuels exports have higher figures in 2022 than they did in 2021, being solar panels the least exported out of the three.

As it can be observed, exports have always been lower than imports for the EU.

5.3 Renewable Energy Leaders in Europe

In addition to analyzing the market as a whole, it is also important to provide some insights about the most important companies in the sector by taking into account factors such as their revenue, the location of their headquarters, the countries in which they have presence, their renewable energies portfolio and other potential facts that can be useful for analyzing their international presence and position in the market.

In order to make a selection of companies with significant influence in the renewable energy sector, the 20 companies with the highest revenue from the ORBIS and Statista databases that appeared under the term “renewable energy companies” were used. From there, companies whose main activity was not renewable energy (i.e., only a small part of their business was dedicated to this sector) were eliminated from the selection; on the other hand, companies that appeared in both databases were selected. Afterwards, in order to expand the selection, supplementary information was sought from various online sources to search for supplementary important companies in the sector. These online-sourced companies that appeared on the websites were only considered and added to the selection if they also appeared in any of the 2 databases.

- **Enel SPA:** it is a multinational company headquartered in Rome, Italy, that holds 70,1% of Endesa (whose headquarters are located in Spain), with European presence in Italy, Spain, Portugal, France, the Netherlands, the UK, Ireland, Germany, Poland, and Greece. It is involved in several segments of the energy industry, including energy generation, transmission, distribution, and supply. In terms of revenue, Enel’s EBITDA amounted for 22 billion Euros in 2023, half of it coming from Italy. Regarding its renewable energies offer, it is focused on solar, wind, hydro and geothermal energies, and its installed renewable capacity is of 63GW. The aim of the company is to achieve a complete decarbonization by 2040, gradually reducing the contribution from coal to zero, to enable their stakeholders to have access to renewable energies to live in a sustainable manner (Enel, 2024).
- **Uniper SE:** it is a leading international energy company whose headquarters’ location lies in Düsseldorf, Germany. The company has presence in various segments of the energy value chain: power generation, energy trading and energy storage, and they offer gas, hydro, hydrogen, wind and solar energies. It is active in more than 40 countries, having core markets in Germany, the Netherlands, Sweden and the UK. Its EBITDA in 2023 was of 7.164 million Euros. Among their goals are to become carbon-neutral by 2040 and an increase up to at least an 80% of renewable energies by 2030 (Uniper, 2024).
- **Iberdrola SA:** it is one of the most important multinational energy companies located in Spain (headquartered in Bilbao), specializing mainly in renewable energies, being a leader in electricity generation, transmission, distribution, and retailing. Among its renewable energies wind, solar, hydroelectric and biomass

power generation can be found. Iberdrola's international presence is supported by strategic acquisitions, partnerships, and investments aimed at expanding its renewable energy portfolio and accessing new markets, actively pursuing growth and innovation opportunities. Regarding its operations, the company had an EBITDA of 14.417 million Euros in 2023, coming from its operations in Spain, the UK, the USA, Brazil, and Mexico, mainly (Iberdrola, 2024).

- **Vestas A/S:** it is one of the global leaders in sustainable energy solutions, focusing on wind power generation. Its headquarters are located in Aarhus, Denmark, and it operates in over 80 countries, including many European ones (Denmark, Germany, Finland, Poland, France, Spain…), and its EBITDA in 2023 amounted for a total of over 1.028 million Euros. The company's focus on innovation and technology has enabled it to develop innovative wind turbine technology, enhancing efficiency, reliability, and performance. They are committed to carbon neutrality by 2030, and trying to decarbonize the whole wind energy supply, and they aim to create zero-waste wind turbines by 2040 (Vestas, 2024).
- **Ørsted A/S:** it is a global leader in renewable energy, mainly because of its focus on offshore wind power. Its headquarters are situated in Fredericia, Denmark, and it has European presence in Denmark, Spain, France, Germany, the UK, Ireland, the Netherlands, Poland, and Sweden. It used to be known as DONG Energy (Danish Oil and Natural Gas), but it underwent a strategic transformation to adapt to current renewable energy needs to become a renewable energy company, divesting its oil and gas assets and turning towards wind energy. The company's operations currently focus on the development, construction, and operation of wind farms (primarily), as well as biomass and solar energy products. Its EBITDA in 2023 was of 18.717 million DKK (around 2.509 million Euros), and it mainly came from the sale of the electricity generated, although the company is also involved in providing energy solutions and services to customers (Ørsted, 2024).
- **Engie:** it is a leading MNC energy company headquartered in Paris, France, with a substantial presence across the globe, focusing in hydroelectric, wind, hydrogen, biomass, and geothermal energies. In terms of financial results, the company had in 2023 an EBITDA of 15 billion Euros. It is actively involved in research and innovation to develop innovative energy solutions and enhance operational efficiency and is trying to reduce its GHG emissions in a 60% by 2030 (2017 as

base year). Also, it aims to obtain 80GW of installed capacity worldwide by 2030, 11GW of them in France by the same year (Engie, 2024).

- **Acciona SA:** it is a prominent Spanish multinational corporation whose headquarters are located in Madrid. It holds presence across the world and, when focusing on the energetic area (as the company offers a very diversified portfolio: energies, financial, Real Estate, transport…) it has presence in Spain, Portugal, Italy, Croatia, Hungary, Ukraine, Germany, and Poland within Europe. The company operates primarily in the renewable energy sector (wind, solar, hydroelectric and biomass energies mainly), focusing on sustainable infrastructure, on the generation of energy and on water management, and it had in 2023 an EBITDA of 1.981 million Euros. The company is committed to sustainability and reducing its carbon footprint, reflected in its investments in clean energy projects and innovative technologies (Acciona, 2024).

In addition to the above-mentioned data, a comparison of the economic and financial profitability (whose data has been obtained from the annual accounts of each company, disclosed in Annex 1) of the 7 companies will be made in Figure 5.3.1:

ROA				
	2023	2022	2021	2020
ACCIONA	1,96%	2,72%	2,06%	2,29%
ENEL	2,19%	1,33%	1,86%	2,22%
UNIPER	8,06%	-6,08%	0,71%	1,92%
IBERDROLA	3,61%	3,42%	3,09%	3,24%
VESTAS	0,35%	-7,82%	0,73%	4,25%
ORSTED	-7,18%	4,77%	4,03%	7,90%
ENGIE	1,49%	0,17%	1,67%	-0,58%

ROE				
	2023	2022	2021	2020
ACCIONA	9,06%	9,76%	7,27%	11,24%
ENEL	9,46%	6,94%	9,11%	8,55%
UNIPER	42,47%	-168,74%	13,35%	6,92%
IBERDROLA	8,98%	8,83%	7,82%	8,41%
VESTAS	2,56%	-51,37%	3,04%	16,39%
ORSTED	-25,94%	15,70%	12,79%	15,96%
ENGIE	8,13%	0,99%	8,95%	-2,64%

Figure 5.3.1 Economic and Financial Profitability of the Renewable Energy Leaders in Europe. Source: Own elaboration, data from 2022 and 2024 financial statements of the companies

Return On Assets (ROA) Analysis

- Acciona's ROA has been decreasing steadily from 2020-2023, always maintaining low levels at around 2%, which may imply that the company is not effectively using its assets to generate profits (due to inefficient operations, high costs, poor investment decisions, competitive pressures…).
- Enel had similar ROA levels than Acciona in 2020, suffering a decline in the next 2 subsequent years, but increasing it again in 2023, reaching a similar level than in 2020. Nonetheless, the return is not high either, so it should be improved.

- Uniper has shown extreme volatility, even reaching a negative ROA (as its operations did not generate enough revenue to cover its asset-related expenses) in 2022. Nevertheless, it peaked in 2023, with over an 8%, being the company in the best position currently, showing an effective use of the assets to generate profits.
- Iberdrola has obtained similar ROA levels through time, at around 3,3%, increasing through time since 2021.
- Vestas has suffered severe fluctuations, reaching negative ROA values, and in general low ones (with the exception of 2020, in which the value was the best).
- Ørsted had the best ROA value for 2020, showing a strong assets-returns relationship, with almost an 8%; nevertheless, it currently holds the worst position, with over a -7%, figure that should be revised in order to increase it to reach at least a positive figure again.
- Engie has had slight fluctuations as well, always with a low value (although never below 0%), suggesting a need for a better asset management and operational efficiency to enhance profitability.

Return On Equity (ROE) Analysis

- Acciona's values have fluctuated through time, usually being around a 10%, being lower in 2023 than in 2020, which reveals that the company currently generates less profit with the money shareholders invested than it used to.
- Enel's ROE has also been fluctuating, with similar levels than Acciona for 2023. Nonetheless, in this case, the company is currently generating more profits with shareholders' inversions than it used to 3 years ago.
- Uniper is an extremely volatile case, with a significant recovery in 2023 (currently holding the best ROE ratio among the compared companies) after a drastic drop in 2022, where the company's net income was lower, in fact negative, than its shareholders' equity.
- Iberdrola is the only company that has maintained a stable ROE ratio, usually of around an 8,5%, being among the highest for 2023.
- Vestas was again a case with very severe fluctuations (especially with the drop to negative numbers in 2022, where the company had a negative net income).
- Ørsted, as it happened with the ROA, currently holds the worst position in terms of ROE due to the fact that it is the only company with a negative value for 2023.

Nevertheless, with the exception of 2023, the company has been the one with the best figures for the rest of the years, in which they were constant.

- Engie has also had fluctuations through time, and it currently holds over a 8% ROE, which is one of the best values it has obtained in the last years.

5.4 Renewable Energy Consumption

As it has been stated, the transition to renewable energy uses is very important for the EU, not only because of the already mentioned environmental aspects, but also because it enables countries to have a greater energy independence (therefore, enabling countries to reduce their energy imports). Because of its high efforts, the EU has become the leader in imposing pro-environmental legislation, which has led to an increase into the share of renewable energies in energy consumption.

In general terms, the main focus on using renewable energies has been put into the transport sector and, more recently, also into the building industry, as it constitutes around 40% of the total energy consumed in the EU, generating around 36% of emissions related to energy production. This has led to a proposal made from the European Commission to increase the share of renewable energy in the building industry to at least a 49%. Another sector in which special attention has been put on regarding Renewable Energy Sources (RES) development is the agriculture sector due to its increasing energy demand, related to the fast development of mechanization. (Tutak, 2022).

It is also important to remark that there are many differences between urban and rural areas in terms of renewable energies usage. For rural areas, many factors impede the increase into RES, which include a low interest from residents to shift to renewable energies, a fear to discover that the RES technologies are hard to understand and implement, a lack of reliable information about their benefits, potentially high requirements for construction of necessary infrastructures… Most of them due to a lack of knowledge and a limited assistance from local authorities, and also because of a lack of strategies for renewable energies implementation.

In the case of urban areas, the main problem to implement renewable resources are the high investment costs: in Western Europe the cost of wind power plants was over 4 times higher than the cost of gas power plants, and the cost of large-scale photovoltaic power plants was almost 15 times higher than the cost of gas power plants. Additionally, especially for less wealthy countries, the high cost of hiring specialists adds another barrier to a growth into the RES share.

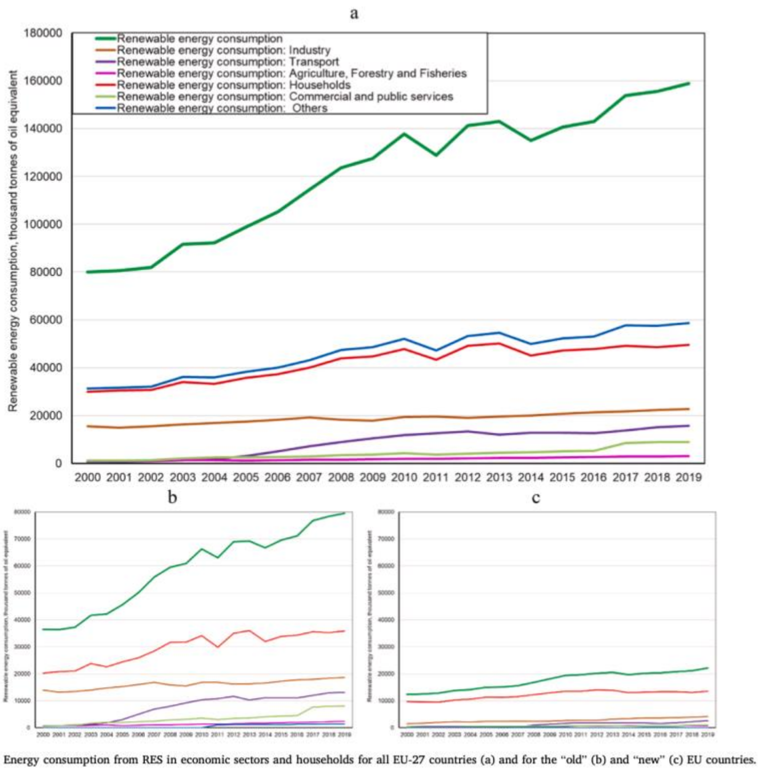

Figure 5.4.1 Energy Consumption from RES in the EU. Source: (Tutak, 2022)

Figure 5.4.1 (Tutak, 2022) enables a comparison of renewable energy consumption by a disclosure both by sector and by area. Figure 5.4.1 a shows the renewable energy consumption across all the EU, while Figure 5.4.1 b shows the situation for the "old" (or EU-14) countries (Austria, Belgium, Denmark, Finland, France, Germany, Greece, Ireland, Italy, Luxembourg, the Netherlands, Portugal, Spain and Sweden) and Figure 5.4.1 c shows the situation for the "new" (or EU-13) countries (Czech Republic, Poland, Romania, Slovakia, Slovenia, Bulgaria, Estonia, Latvia, Lithuania, Hungary, Croatia, Cyprus and Malta). The distinction between them mainly lies on their economic levels, influenced by the fact that for the EU-13 countries (except for Malta and Cyprus), they came from a long transition process from centrally managed to free market economies.

Results show that, in the EU as a whole, there has been an increase into renewable energy consumption from 2000-2019 (200% general increase), attributing the most dynamic growth to the transport sector (2200% increase), and the smallest one for the industry sector (around a 140% increase, lower than the average).

Moreover, for the EU-14 countries the increase amounted to almost a 220%, while for the EU-13 ones it constituted a 180% increase. Again, for both of them, the highest increase was experienced in the transport sector, being it higher for the EU-13 countries (4250% increase), mainly because of the result of the legislative actions imposed in this sector to increase the use of RES. After proving it to be effective, it has been suggested to implement such legislations in other sectors.

Summary of the coefficients of variation of renewable energy consumption in the EU countries between 2000 and 2019 in economic sectors and households.

	Industry sector	Transport sector	Commercial and public services	Households	Agriculture, forestry and fishing	Other sectors
UE-27	12%	62%	57%	17%	32%	20%
UE-14	10%	60%	64%	19%	39%	23%
UE-13	27%	80%	24%	13%	18%	13%
Belgium	29%	100%	99%	49%	81%	51%
Bulgaria	58%	123%	76%	14%	77%	21%
Czechia	28%	71%	43%	24%	88%	24%
Denmark	27%	110%	13%	24%	3%	23%
Germany	36%	48%	52%	24%	65%	28%
Estonia	43%	174%	30%	10%	39%	10%
Ireland	19%	97%	77%	50%	–	59%
Greece	22%	78%	160%	11%	38%	18%
Spain	13%	77%	93%	16%	58%	21%
France	10%	62%	35%	13%	66%	14%
Croatia	26%	150%	82%	6%	156%	7%
Italy	28%	77%	173%	40%	21%	44%
Cyprus	102%	88%	104%	66%	96%	71%
Latvia	55%	106%	18%	17%	45%	17%
Lithuania	23%	73%	10%	6%	25%	6%
Luxembourg	63%	93%	40%	26%	51%	27%
Hungary	47%	81%	33%	41%	36%	37%
Malta	183%	131%	183%	124%	235%	135%
Netherlands	31%	82%	44%	12%	103%	20%
Austria	21%	67%	38%	14%	13%	15%
Poland	38%	83%	21%	7%	8%	8%
Portugal	15%	77%	135%	15%	91%	20%
Romania	22%	94%	160%	18%	115%	18%
Slovenia	20%	100%	78%	9%	106%	9%
Slovakia	26%	72%	71%	208%	110%	178%
Finland	12%	108%	26%	19%	18%	19%
Sweden	8%	93%	47%	27%	52%	27%

Figure 5.4.2 Variation of Renewable Energy Consumption in the EU 2000-2019. Source: (Tutak, 2022)

Figure 5.4.2 (Tutak, 2022) enables a comparison of the variation of renewable energy consumption in the EU between 2000 and 2019 based on different sectors and disclosed by country. For clarification purposes, coefficients of variation below 25% were considered to have a low variability of energy consumption.

As it can be observed, the sector that has increased the most overall is the transport one (62% increase), followed by the commercial and public services sector (57% increase). When analyzing the transport sector, the countries with the highest variability are Bulgaria, Denmark, Estonia, Croatia, Latvia, Malta, and Finland, all of them with over a 100% increase each. Moreover, no country has a low variability (under a 25% increase), which shows the magnitude of the impact RES implementation has had in this sector. For the commercial and public services sector, Greece, Italy, Cyprus, Malta, Portugal and Romania have suffered over a 100% increase into renewable energy consumption.

Nevertheless, renewable energy consumption in this sector has only experienced a 13% increase in Denmark, an 18% in Latvia, a 10% in Lithuania and a 21% in Poland.

On the other hand, the sector with the lowest increase into renewable energies consumption is the industry one, followed by the households one. In these 2 sectors, there is a country, Malta, which has experienced over a 100% increase for both of them. It is also important to remark that Slovakia has experienced over a 200% increase into the renewable energy consumption in the households sector, and Cyprus has had over a 100% increase in the industry one.

5.5 EU Renewable Energy Financing Mechanism

To provide a better support to renewable energy projects and encourage a greater uptake of renewable energy, the European Commission established in September of 2020 the "EU Renewable Energy Financing Mechanism", whose main objective is to enable Member States to work together to achieve both their individual and collective renewable energy targets. The mechanism also aims to boost renewable projects in line with the European Green Deal, enabling a more cost-effective launch of renewables across the EU. As it was developed when Europe had barely started recovering from a crisis, the financing mechanism is intended to facilitate regions to start projects even if their local economy is under pressure.

The mechanism is based on the idea that the collective nature of the renewable energy target set for 2030 (42,5% of energy coming from renewable sources) should reflect the EU members' collective efforts. Therefore, it allows several countries to jointly support renewable projects by providing the funding and the territory, encouraging EU countries to voluntarily participate to share the benefits of the produced renewable energy.

The mechanism unites countries that voluntarily pay into the mechanism (contributing countries) with countries that agree to have new projects built on their soil (hosting countries) by having no direct negotiation between them, as the Commission provides a common agreement with the conditions and criteria under which the support to the projects will be granted. In such wise, contributing countries can finance their projects in a country other than theirs with lower costs than they would undergo without this mechanism, while also having access to renewable energy sources that their own country lacks. Additionally, they ensure a compliance with the national contribution towards the EU renewable energy target, contributing to a clean energy transition of the EU, while getting visibility for investing in local renewable energy projects outside of their country.

On the other hand, host countries will receive additional local investment in renewable energy projects irrespectively of the national budget, they will benefit from more local employment (more projects will be carried out in their country), keep part of the benefits from the sustainable project, reduce their GHG emissions, improve air quality, and get a renovation of the energy system of the country and a lower dependency of imports.

Project developers and energy producers will also be benefited, as they will be able to receive a grant funding and national political support to develop their sustainable projects.

Regarding the selection of projects, the financial contributions are allocated to new renewable projects through competitive tenders for grants, in which all EU countries that agreed to participate as host countries can take part of. The grants given can cover either the installation of a renewable production facility with a certain capacity (investment support) or the actual production of the renewable energy (operating support), and the grant amount will depend on each project, applicable across the electricity, heating and cooling and transport sectors.

6. Internationalization of Solar Energy

Due to the rapid growth of the solar energy market and its installed capacity, its fast reduction in costs, and its high availability and number of imports into the EU, among others, the research into the internationalization of renewable energy companies will be tailored to focus on the internationalization of solar energy from now on, as the EU can highly benefit from its internationalization processes, especially in the near future.

The Photovoltaic (PV) industry has started benefiting from globalization in the recent years, allowing it to have huge improvements in economies of scale, while also creating strong value chains (vertical integration), since manufacturers search for materials from a wide number of suppliers, leading to a reduction in the prices while keeping (or even improving) the quality of their offer. Additionally, the PV market is currently experiencing a fast growth, which is expected to increase in the near future, enabling solar energy firms to benefit from it (by means, among others, of government help through trading licenses, subsides, training a competitive workforce…), and the increase into competition has led to a higher motivation to continue investing in research and development, resulting in lower costs, and better quality. From 2010 to 2018 the cost of generating energy through solar PV plants decreased by 77%, while solar PV installed capacity increased (from 40.334 in 2010 to 709.674 in 2020) (Maka & Alabid, 2022).

6.1 Solar Energy Applications

Solar energy has 2 applications: Concentrated Solar Power (CSP) and Solar Photovoltaics (PVs). In CSP systems, solar rays are concentrated by using mirrors, which heat a fluid (that can be either used right away or stored to generate electricity outside of daylight hours) that will lead to the formation of steam, used to power a turbine to generate electricity. On the other hand, Solar PV devices, also known as solar cells, which are one of the fastest-growing renewable energy technologies, transform sunlight into electrical power. They can either be incorporated to supply electricity on a commercial level or installed in smaller clusters for individual usage (which is a great way to offer electricity to people living far from power-transmission lines, especially in developing countries with abundant solar energy resources). In the last decade, the cost of producing PV panels has plummeted, sometimes making them the least expensive energy source (Maka & Alabid, 2022).

6.2 Solar Energy Costs Evolution

Between 2010 and 2020 the cost of solar PV has fallen by around 15% each year, representing a technological learning rate of around a 20% per doubling of installed capacity. Moreover, its installed capacity has risen by around a 25% per year (if compared to wind, the other fastest-developing renewable energy, its capacity grew by a 12% per year, with a learning rate of 10% per doubling of capacity, being therefore much lower than solar). There are many reasons that explain such high learning rates, among which solar energy (solar PV)'s simplicity, modularity and mass-scale replicability can be found (Nijsse, et al., 2023).

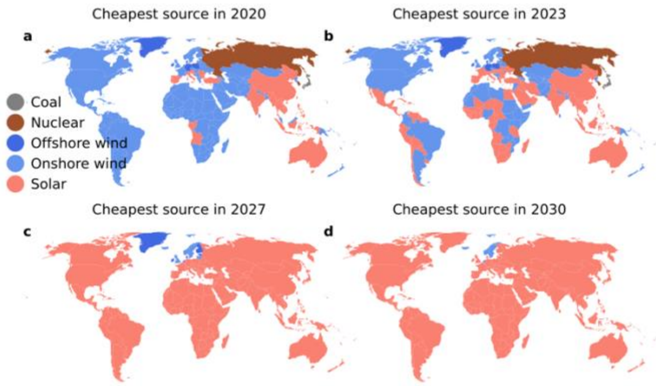

Figure 6.2.1 Technology with the Lowest Levelized Cost of Electricity by Year and Region. Source: (Nijsse, et al., 2023)

Figure 6.2.1 (Nijsse, et al., 2023) allows a comparison of the expected LCOE (Levelized Cost of Electricity) by offering a comparison of the costs of different energies across the different countries in the world through time. In 2020 wind energy had the lowest LCOE in most countries, as it can be observed in Figure 6.2.1 a; where that was not the case, solar PV, nuclear and coal energies where the predominant ones. Nevertheless, the costs are expected to shift through time, as the cost of solar energy is expected to be drastically reduced, being the lowest among almost every country by 2030 (with the exception of some Nordic parts), as Figure 6.2.1 d shows, as a decline into the cost per kW of PV panels worldwide is expected, leading to most regions having access to low-cost solar energy (when compared to its cost nowadays, and also to other sources of renewable energies), therefore allowing developing countries to become realistic markets for solar energy.

6.3 Barriers to Solar Energy

Nevertheless, there are some barriers to the use of solar energy, being the first one grid resilience, as geophysical constraints (such as periods of low solar irradiation) can be hard to overcome, as well as the lack of available storage (the usual optimal share of solar when 12h of battery storage is available lies between 10% and 70%). Secondly, the availability of finance is a major constraint for solar growth, as it highly depends on it, and an unequal distribution of finance will reflect different investment risks. The differences in the environments (macroeconomic conditions, business confidence, policy uncertainty, regulatory frameworks…) have an impact on risk perceptions, and therefore on the cost of capital for renewable projects (the higher the perceived risk, the higher the cost of capital). As a third barrier, supply chains can be found. Electrification and batteries of solar PV require large-scale raw materials (lithium, copper), and solar panels require niche materials (such as tellurium); as the renewable energies share is expected to increase in the near-future, they are expected to make up 40% of mineral demand for copper and rare earth elements, between 60% and 70% for nickel and cobalt, and 90% for lithium by 2040, which can lead to a scarcity of them. Yet, the risk associated with having low reserves can be mitigated with substitutions, recycling and circular economy practices. Lastly, the fourth barrier is the resistance from declining industries, as the transition to renewable energies depends both on the economic decisions made by entrepreneurs and on how desirable police makers consider them. Although solar energy aligns with many policy objectives, it also holds some disadvantages, as it leads to a fast economic and industrial change (risking the livelihood of workers of fossil fuels industries and the areas in which they are located, usually in communities close to mines) (Nijsse, et al., 2023).

6.4 Top 10 EU solar markets in 2023

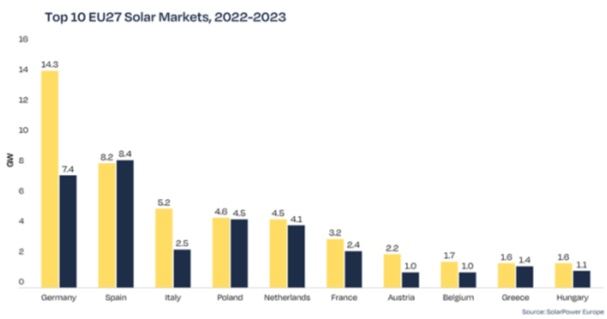

Figure 6.4.1: Top EU Solar Markets 2022-2023. Source: (SolarPower Europe, 2023)

Figure 6.4.1 (SolarPower Europe, 2023) enables a comparison of the top 10 solar markets within the EU, together with their evolution from 2022 (represented in yellow) to 2023 (in dark blue). As it can be observed, Germany has become the leader in 2023, overtaking Spain, and making the gap with other countries very large, having the highest year-on-year increase, followed by Italy's, whose solar GW installed capacity has almost doubled in one year. On the other hand, Spain has suffered a slight decrease from 2022-2023, being the only exception within the 10 countries, which mainly took place as a consequence of a decline into the residential segment, in addition to delays in subsidy payments (SolarPower Europe, 2023).

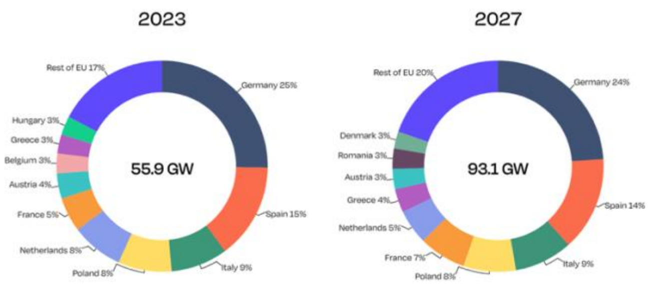

Figure 6.4.2 Shares of Top 10 Solar Markets 2023 vs 2027. Source: (SolarPower Europe, 2023)

Figure 6.4.2 (SolarPower Europe, 2023) allows a comparison of the current solar market shares of the EU-27 (as of 2023) with the prospected ones for 2027. As it can be observed, the total solar capacity in 2023 was of 55.9GW, being the leader Germany with ¼ of it, followed by Spain, Italy, Poland and the Netherlands (all of them having over a 5% share).

On the other hand, the expected situation for 2027 slightly changes, with an overall growth into installed capacity, adding a total of 93.1 GW for all EU-27 countries. Germany is expected to remain as the leader, although diminishing its share by a 1%, happening the same with Spain. Italy and Poland are expected to keep the same share. The Netherlands' share is expected to slightly decrease by a 2%, contrary to France's, switching positions. Greece's share is expected to grow by a 1%, contrary to Austria's, which is expected to decrease by the same amount. Moreover, it must be pointed out that both Belgium and Hungary are not expected to be within the top 10 countries anymore, being replaced with Romania and Denmark instead.

This data reveals that there is going to be a growth in solar capacity through time, reflecting an expansion of the solar energy sector. Germany and Spain are expected to remain leaders, although their shares are expected to start decreasing slightly, suggesting a more widely distributed solar power across other countries. The inclusion of Romania within the top 10 may suggest that emerging markets' solar capacity will start increasing in the near future.

6.5 Analysis of PV Electricity Potential

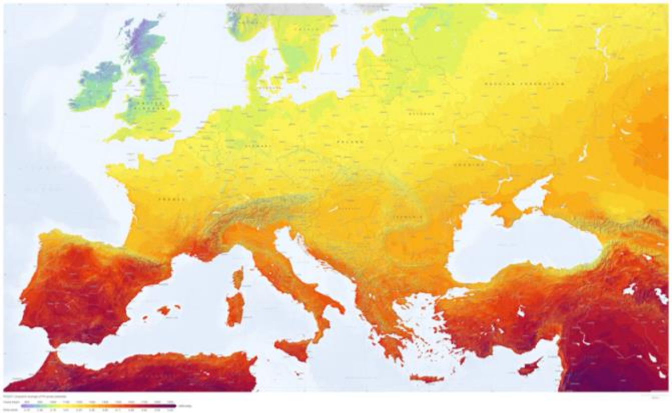

Figure 6.5.1 Photovoltaic Power Potential Across Europe. Source: (Solargis, 2021)

Figure 6.5.1 (Solargis, 2021) enables an overview of the photovoltaic (PV) power potential across European countries, indicating the average long-term solar power output (in kWh/kWp) that can be expected from a well-maintained and optimally tilted PV system in various regions. Before analyzing it, it must be noted that "the calculation takes into account solar radiation, air temperature, and terrain, to simulate the energy conversion and losses in the PV modules and other components of a PV power plant." (Solargis, 2021)

Based on that, a distinction between 4 different areas depending on the PV power potential can be made:

1. High Potential Areas:
   - Southern Europe (Spain, Portugal, Italy, Greece and the south of France, mainly).
   - South-Eastern Europe (Albania, Montenegro, Bosnia and Herzegovina, Croatia) and Turkey.
2. Moderate-High Potential Areas:
   - Eastern Europe (mainly countries located along the Black Sea (Bulgaria, Romania, and Ukraine, among others), as well as next to it (as Moldova)).

- Central Europe (countries in the southern part of central Europe, as Hungary, France, Austria, and Slovakia).

3. Moderate-Low Potential Areas:
   - Central Europe (Germany, Poland, Czech Republic, Belgium, and the Netherlands, inter alia).
4. Low Potential Areas:
   - The United Kingdom.
   - Nordic Countries.
   - North-Eastern Europe (Lithuania, Estonia, and Latvia).

6.6 Irradiation Levels Across the EU

Before analyzing the actual irradiation levels, a distinction between 2 types of irradiations has to be made (Pérez-Higueras, Rodrigo, Fernández, Almonacid, & Hontoria, 2012):

1. Global Horizontal Irradiation (GHI): it measures the total solar radiation received on a horizontal surface, including both direct sunlight and diffuse sky radiation. It is mainly used for assessing the potential for flat-plate PV systems (usually installed on rooftops or flat surfaces).
2. Direct Normal Irradiation (DNI): it measures the intensity of solar radiation that reaches the Earth's surface when the sun's rays are not scattered by the atmosphere. It is used for concentrating solar power (CSP) systems and other technologies that track the sun that require direct sunlight to operate efficiently.

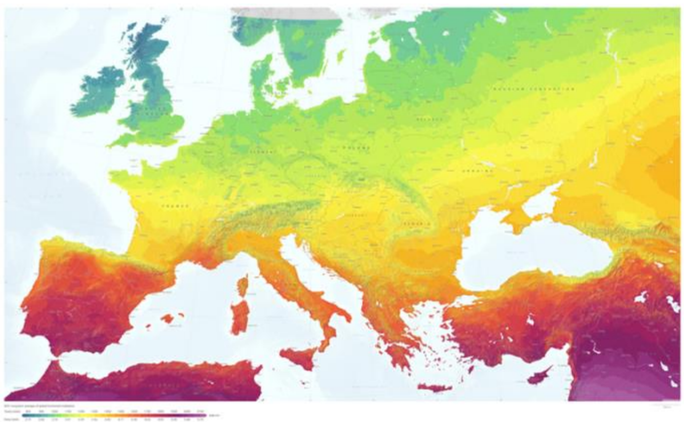

Figure 6.6.1 Global Horizontal Irradiation (GHI) in Europe. Source: (Solargis, 2021)

Figure 6.6.1 (Solargis, 2021) shows the long-term average of Global Horizontal Irradiation (GHI) across Europe. When analyzing the map, different areas can be distinguished:

1. Northern Europe (Nordic countries, the UK and Ireland, mainly) shows low GHI levels (colors ranging from blue to green); implying that such regions have less solar energy available, usually making them less appealing in terms of solar power generation in comparison with other parts of Europe.
2. Central Europe (Germany, Czech Republic, Belgium, Poland, Austria…) displays moderate GHI values (light green to yellow colors), which suggests that while solar energy is probably more feasible there, it is probably less efficient than in southern regions (which have the highest levels); nevertheless, solar power installations can still be beneficial, especially if they are combined with other renewable energy sources.
3. Southern Europe (Spain, Portugal, Italy, Greece, Croatia, Albania…) has the highest GHI values (shaded in dark orange, red and purple colors), implying that those countries have very high solar energy potential due to the high irradiation levels, making them highly suitable for solar power generation; thus, investments in solar infrastructure can yield significant energy returns.
4. Eastern Europe (Ukraine, Romania, Bulgaria, Moldova…) shows moderate to high GHI levels (yellow to purple colors), quite similar to the Central Europe ones.

As seen, Southern Europe stands out as the most promising area for solar energy investment in terms of GHI. Likewise, Central and Northern Europe, while less optimal, still offer viable opportunities for solar energy, particularly when integrated with other renewable energy sources.

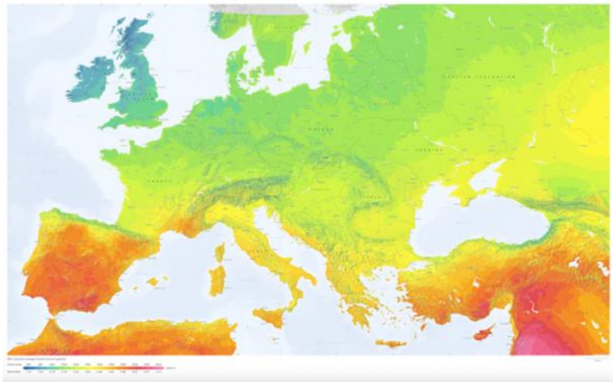

Figure 6.6.2 Direct Normal Irradiation (DNI) in Europe. Source: (Solargis, 2021)

This second map in Figure 6.6.2 (Solargis, 2021) shows the long-term average of Direct Normal Irradiation (DNI), providing insights into the potential for CSP and other solar energy systems requiring direct sunlight, distinguishing several zones:

1. Northern Europe (Nordic Countries, the UK, Ireland) has low DNI values (shaded in blue and green), it has less direct sunlight available, making them less suitable for CSP or other solar technologies that depend on direct irradiation.
2. Central Europe (Germany, Poland, the Czech Republic, Belgium, the Netherlands…) has moderate DNI values (depicted in light green, mainly), indicating moderate solar potential (PV systems may probably be more efficient than CSP here).
3. Southern Europe (Spain, Portugal, Italy, Greece, Turkey, Croatia…) displays high DNI values (orange colors), implying a high solar energy potential due to the high direct irradiation levels, making them highly suitable for CSP and PV systems.
4. Eastern Europe (Ukraine, Romania, Bulgaria…) has moderate to high DNI values (yellow shades), similar to Central Europe levels, having the areas closer to the Black Sea and southern borders the highest potential for solar energy.

The map shows that direct normal irradiation potential in Europe varies significantly based on the European region. Southern Europe, once again, stands out as the most promising area for solar energy investment, with very high DNI values.

6.7 Short-Term Future Prospects

Country	2023 Total capacity (GW)	By 2027 Total capacity Medium Scenario (GW)	2024-2027 New capacity (GW)	2024-2027 Compound annual growth rate (%)	Political support prospects
Germany	82.1	158.6	76.5	18%	☀
Spain	35.6	82.2	46.6	23%	☀
Italy	29.5	56.7	27.2	18%	☀
Poland	16.8	41.9	25.1	26%	☀
France	18.7	38.7	20.0	20%	☁
Netherlands	22.5	42.2	19.7	17%	☁
Greece	7.2	18.1	10.9	26%	☀
Austria	5.9	15.9	10.0	28%	☀
Romania	2.9	11.7	8.7	41%	☁
Sweden	4.1	11.8	7.7	30%	☀
Bulgaria	2.9	9.8	6.9	36%	☀
Belgium	9.5	16.1	6.7	14%	☀
Czech Republic	3.6	10.2	6.6	30%	☀
Denmark	4.9	11.5	6.5	24%	☁
Portugal	3.6	9.8	6.2	29%	☁

Figure 6.7.1 Top Solar PV Market's Prospects. Source: (SolarPower Europe, 2023)

Figure 23 (SolarPower Europe, 2023) enables an overview of the solar energy market in the EU in the next 5 years, from which the following aspects can be highlighted:

- The table indicates a considerable increase into solar capacity across all listed European countries from 2023 to 2027. The total capacity for several countries is expected to more than double, highlighting the rapid adoption of solar technology as a consequence of the ambitious climate and renewable energy targets the EU has set and of the technological advancements that had led to cost reductions.
- Countries with initially smaller capacities (such as the Czech Republic, Bulgaria, Portugal, Romania and even Greece) are projected to experience the highest compound annual growth rates (CAGR), suggesting that emerging markets are becoming key players in the European solar sector.
- Strong political support is expected in most countries (designated by the sun icons), crucial for the deployment and expansion of solar energy infrastructure. Supportive policies, subsidies, and regulatory frameworks are likely contributing factors. The only EU countries appearing on this table not showing strong political support are France, the Netherlands, Romania, Denmark and Portugal.
- Growth rates are very diverse, since while some countries exhibit slower growth rates (lower than 20%: Germany, Italy, the Netherlands and Belgium), others show exceptionally high growth rates (over 25%: Poland, Greece, Austria, Romania, Sweden, Bulgaria, the Czech Republic and Portugal), indicating different levels of maturity and investment in the solar sector.

In brief, Figure 6.7.2, created from all the data collected from this section, provides an overview of it, allowing a visual comparison of the EU Top 15 Solar PV Markets (as it can be observed, the 15 countries appearing in the table are the 15 countries appearing in Figure 6.7.1, given that it provides both a current and a future comparison of the top EU countries in terms of solar energy markets).

	Solar Energy as Cheapest Source (2020)	Solar Energy as Cheapest Source (2027)	Top 10 Highest Solar Market Share (2023)	Top 10 Highest Solar Market Share (2027)	Average Annual PV Electricity Potential >1300kWh/kWp	Average Annual GHI > 1500kWh/m²	Average Annual DNI > 1400kWh/m²	Top 10 Highest Total Solar Capacity (2023)	Top 10 Highest Total Solar Capacity (2027)	Strong Political Support
Austria	✓	✓	✓	✓				✓	✓	✓
Belgium		✓	✓					✓	✓	✓
Bulgaria	✓	✓			✓					✓
Czech Republic		✓								✓
Denmark				✓				✓		
France		✓	✓	✓				✓	✓	
Germany		✓	✓	✓				✓	✓	✓
Greece		✓	✓	✓	✓	✓	✓	✓	✓	✓
Italy	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓
Poland		✓	✓	✓				✓	✓	✓
Portugal	✓	✓			✓	✓	✓			
Romania	✓	✓		✓						
Spain	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓
Sweden									✓	✓
The Netherlands			✓	✓				✓	✓	

Figure 6.7.2 Conclusions from the Section. Source: Own Elaboration

As it can be observed, solar energy was in 2020 the cheapest energy source for less than 50% of the analyzed companies (only for Austria, Bulgaria, Italy, Portugal, Romania and Spain), situation that is expected to change drastically in the near future (as it will be the cheapest one in 2027 for Belgium, the Czech Republic, France, Germany, Greece, and Poland as well, being only Denmark, Sweden and the Netherlands the exceptions).

In terms of solar market share, Austria, France, Germany, Greece, Italy, Poland, Spain and the Netherlands are already within the Top 10 countries and still expected to remain in 2027. Belgium's position, even though it is currently in the top, is expected to worsen in the near-future, contrary to Denmark and Romania, countries that are expected to be among the Top 10 market share leaders by 2027.

Regarding GHI and DNI irradiation levels, Greece, Italy, Portugal and Spain have the highest levels, and also have the highest PV electricity potential, in addition to Bulgaria.

Moreover, concerning total solar capacity, Austria, Belgium, France, Germany, Greece, Italy, Poland, Spain and the Netherlands are and within the Top 10, remaining as such by 2027. Denmark, currently in the top, is expected to be substituted by Sweden by 2027.

Finally, regarding political support, Austria, Belgium, Bulgaria, the Czech Republic, Germany, Greece, Italy, Poland, Spain and Sweden show the highest levels.

7. Environmental Impact of Solar PVs

Before drawing conclusions, it is important to remember that it is not only important to seek for the best places to internationalize renewable energy companies (solar energy ones, especially, as they have been the focus of the previous section), but also to seek for good practices in order to reduce the present and future impacts on the environment, which can be perceived as minimal, or even zero, but are in fact larger than they seem.

Even though the operation of PV systems exhibits minimal pollution during their lifetime (which is why they are usually seen as clean and sustainable energy sources), the impact of the process that goes between their manufacturing until their disposal cannot be ignored. It is also important to denote that, even though their whole lifespan involves negative environmental impacts, they can be substantially mitigated by using optimized designs, developing new materials, minimize the use of hazardous materials, recycling as much as possible and carefully selecting where to place them (Tawalbeh, et al., 2021). In this subsection, 5 different environmental aspects will be taken into account:

7.1 Land Use

Solar power systems (both PV and CSP) have the highest energy land-use intensity if compared to other energy technologies, which may become a problem if many PV systems are installed, as the available land will be reduced through time. In order to combat their massive land use, Dual-Angle Solar Harvest systems (also known as DASH) could be implemented, consisting of arranging solar panels at 2 different tilt angles to optimize solar energy collection and land use (benefitting both by installing more solar panels and by having lower land costs, as less land will need to be purchased). By using two angles, the DASH method increases energy yield and reduces the number of panel rows needed, thus lowering land and labor costs, being particularly effective in areas with complex radiation fields (Kafka & Miller, 2020).

Moreover, further installation practices to raise land efficiency have emerged, such as installing the PV modules in parking lots, roofs, and landfills, or in already disturbed or degraded land (spent mines, contaminated sites…), lowering the impact compared to the usage of undisturbed land.

Additionally, floating PV (FPV) systems could be used, in which panels are laid on top of a structure floating in waterbody (as they are usually used in unused areas, the land use is highly minimized), bringing numerous benefits, as they are expected to generate more power than inland ones due to the higher efficiency coming from the continuous cooling caused by water evaporation.

7.2 Air Pollution

Even though PV systems have zero emissions of carbon dioxide, methane, sulfur and nitrogen oxides during operation, other phases (manufacturing, transportation, installation, disposal…) should also be considered; otherwise, their environmental impact will end up being harmful, even though their operation does not appear to be bad for it.

The manufacturing phase is responsible for most emissions, followed by construction and operation. In manufacturing, emissions are mainly generated because of the fabrication of steel and aluminum to build supports and frames, the production of glass, and the reduction of silica to silicon for silicon solar cells. To improve the environmental efficiency and lower the PV carbon footprint, best practices in design and deployment phases should be adopted to improve their performance and reduce the overall emissions. Their lifespan could be increased, as well as their system capacity and irradiance levels (by locating them in places such as deserts, which accumulate high levels).

7.3 Hazardous Materials Emissions

The manufacturing of PV solar cells involves different raw materials (silicon, cadmium, copper…), whose production involves mining and several extraction and purification processes in which several heavy metals emissions are generated. Moreover, many chemicals and solvents are used throughout the separation, extraction, production and cleaning processes of solar cells (hydrogen, nitric acid, ammonia…), which is bad not only for the environment but also for people's health.

Recycling PV waste and disposed PV modules is crucial to reduce their environmental impact, especially as most of the metals encountered in PV cell manufacturing are rare. Nonetheless, recycling processes require a lot of energy, are very complex and use massive quantities of chemicals, leading these latter ones to further negative environmental impacts, implying that further investigation of recycling and reusing of solar PV and design improvements should take place to facilitate the ease of reuse, improve the wastes collection system, and promote their recycling.

7.4 Water Usage

Water consumption is mainly critical in countries with severe water shortage (as a consequence of climate change, it would be no surprise to encounter these problems in many countries in the near future), so more sustainable and effective technologies for water consumption are desired. Even though the water consumption in PV systems during their operation phase is insignificant (as it has the lowest footprint in water usage compared to other renewables, shown in Figure 7.4.1), the problem comes for panels' cooling and cleaning.

Energy technology	Median of water consumption (L/MWh)
Biomass	85,100
Hydropower	4961
Oil	3220
Nuclear	2290
Coal	2220
CSP	1250
Geothermal	1022
Natural gas	596
PV	330
Wind	43

Figure 7.4.1 Median of Water Consumption for Different Energy-Generation Technologies. Source: (Tawalbeh et al., 2021)

Water used for cooling could be reduced by recirculating cooling water and using dry or hybrid cooling schemes with ventilation, or by installing the above-mentioned FPVs, and water used for cleaning could be reduced by new designs that can clean PV panels without using water. Again, further investigation is needed to improve designs' efficiency.

7.5 Noise and Visual Impacts

Noise is defined as an unwanted sound, being considered a type of pollution due to its impact on human health (it provokes tension and potential harmful effects on human health). Again, the main problem comes in the manufacturing phase of solar PV, where heavy machinery and vehicles are used, causing noise pollution for residents, travelers and wildlife. A novel design is the use of solar PV systems as noise barriers, being usually top mounted near highways, providing the dual combination of combating noise while providing electricity.

Visual pollution should also be taken into consideration, as it also has a negative impact due to the large scale of PV installations, since the degree of visual impact usually has an effect on public opinion towards solar energy installations. As most PV power plants are located in rural areas, their negative influence on the landscape is high; a potential solution to this problem could be to install the PV panels in rooftops and building facades (for which further investigation into newer designs and shapes to introduce esthetic designs without compromising the system functionality would be advantageous).

7.6 End of Their Life - Disposal

Although PV systems can last for decades and after around 30 years of operation they can sometimes be reused or refurbished to have a "second life" as power generators, all of them will eventually reach the end of their useful life. Once that happens, they are usually either decommissioned, disassembled, disposed, reused or recycled. Their recycling and reusing have environmental and economic advantages over their disposal in landfills or incinerators, as recycling can diminish the need for new materials (with their associated energy consumption and emissions), and reusing modules or parts of them for other purposes (building materials, art projects…) can also be advantageous. Moreover, both of them can create new jobs and industries in the circular economy, although finding them a large and sustainable market can be hard.

On the other hand, PV's disposal can occupy large land areas, reducing their availability for other purposes (which is a problem, as it was stated above), and landfilling can also cause soil contamination and leaching of toxic substances from the PV materials.

Therefore, finding sustainable solutions for end-of-life PV systems is crucial to minimize their environmental impact and maximizing economic benefits. Enhanced recycling programs and innovative reuse strategies can significantly reduce the need for new materials, energy consumption and emissions, and soil contamination risks (Bošnjaković, Santa, Crnac, & Bošnjaković, 2023).

8. Conclusions

The internationalization of renewable energy companies is a complex process influenced by regulatory frameworks, market conditions, and company strategies. Spanish renewable energy firms have successfully begun to expand into European markets by leveraging experiential learning and strategic partnerships.

The Paris Agreement, the European Green Deal and the Fit for 55 package provide a supportive environment and guidance for renewable energy adoption, setting clear targets and policies that drive market growth. However, internationalizing companies still face some challenges (cultural differences, regulatory compliance, competition…). The findings underscore the importance of continuous learning, adaptability, and collaboration in overcoming these barriers. Companies must carefully consider their market entry modes, investment strategies, and operational management to navigate the complexities of internationalization effectively.

It is relevant to mention some of the limitations implied in the writing of this dissertation. Given that renewable energies have started emerging in the near-past, it was not easy to find information about some numerical data (for example, about imports and exports), especially for countries which are currently beginning the transformation into renewable sources, neither studies using current data. Moreover, it was not easy to find which companies had the highest impact regarding renewable energies, as it is not easy to decide on what makes the difference between a company dedicated to renewable and non-renewable energy if it is in the process of transforming from one to the other.

From the analysis, it is evident that certain renewable energy sectors offer more favorable conditions for internationalization. Solar and wind energy sectors stand out due to their relatively lower entry barriers, higher scalability, and robust technological advancements. Solar energy, with its rapid technological advancements and declining costs, presents significant opportunities for international expansion, mainly in regions with high solar irradiance, such as Southern Europe (as it seems to be the most promising region for solar energy investments due to its high GHI and DNI values, making it very suitable for both CSP and also PV systems).

In conclusion, for Spanish renewable energy companies, focusing on the solar energy sector may provide the most strategic advantages for internationalization, as it aligns well with European renewable energy targets and also has the chance to benefit from technological innovation and supportive policy frameworks. Moreover, given the potential Spain has regarding solar energy, Spanish companies will probably already have some experience with the technologies and regulations used. By prioritizing these sectors, companies can better navigate the international market, leveraging their strengths and mitigating risks. As the renewable energy sector continues to grow, companies must remain agile and innovative to capitalize on emerging opportunities and contribute to global sustainability goals. Continuous adaptation to market conditions, regulatory changes, and technological advancements will be crucial for sustained success in international markets.

Bibliography

Acciona. (2022). *Cuentas Anuales e Informe de Gestión Consolidados Ejercicio 2021.* Acciona.

Acciona. (2024). *Consolidated Annual Accounts and Directors' Report for 2023.* Acciona.

Beugelsdijk, S., Kostova, T., Kunst, V. E., Spadafora, E., & Van Essen, M. (2017). Cultural Distance and Firm Internationalization: A Meta-Analytical Review and Theoretical Implications. *Journal of Management, 44*(1), 89-130.

Bortoluzzi, M. B., De Souza, C. C., & Furlan, M. (2021, June). Bibliometric analysis of renewable energy types using key performance indicators and multicriteria decision models. *Renewable & Sustainable Energy Reviews, 143*, 110958.

Bošnjaković, M., Santa, R., Crnac, Z., & Bošnjaković, T. (2023, August 2). Environmental Impact of PV Power Systems. *Sustainability, 15*(15), 11888.

Branding, E. (2024, February 5). *European power exports analysis: France returns to top spot*. Retrieved from Montel Group: https://montelgroup.com/updates-and-insights/european-power-exports-analysis-france-returns-to-top-spot on May 17th, 2024.

Cao, M., & Alon, I. (2021, May 1). Overcoming the liability of Foreignness – A new perspective on Chinese MNCs. *Journal of Business Research, 128*, 611-626.

Ember. (2024). *European Electricity Review 2024.* Ember.

Enel. (2022). *Integrated Annual Report 2021.* Enel.

Enel. (2024). *Full Year 2023: Consolidated Results.* Enel.

Enel. (2024). *Integrated Annual Report 2023.* Enel.

Engie. (2022). *2021 Management Report and Annual Consolidated Financial statements.* Engie.

Engie. (2024). *2023 Management Report and Annual Consolidated Financial statements.* Engie.

Erbach, G. (2021). *European Climate Law.* EPRS.

Ersayim, E., & Özgener, L. (2015, March). Performance analysis of combined cycle power plants: A case study. *Renewable & Sustainable Energy Reviews, 43*, 832-842.

European Commission. (2024). *Renewable Energy Targets*. Retrieved from Energy, Climate Change, Environment: https://energy.ec.europa.eu/topics/renewable-energy/renewable-energy-directive-targets-and-rules/renewable-energy-targets_en#:~:text=The%20revised%20Renewable%20Energy%20Directive%20EU%2F2023%2F2413%20raises%20the,renewable%20energy%20in%20the%20EU. On April 7th, 2024.

European Environment Agency. (2024, March 27). *Share of Energy Consumption from Renewable Sources in Europe*. Retrieved from European Environment Agency: https://www.eea.europa.eu/en/analysis/indicators/share-of-energy-consumption-from on April 8th, 2024.

Eurostat. (2023, August 23). *Electricity and Heat Statistics*. Retrieved from Eurostat Statistics Explained: https://ec.europa.eu/eurostat/statistics-explained/index.php?title=Electricity_and_heat_statistics on April 14th, 2024

Eurostat. (2023, November 9). *Imports of green energy products more than doubled in 2022*. Retrieved from Eurostat: https://ec.europa.eu/eurostat/web/products-eurostat-news/w/ddn-20231109-3 on April 14th, 2024.

Forsgren, M. (2002, June). The Concept of Learning in the Uppsala Internationalization Process Model: A Critical Review. *International Business Review, 11*(3), 257-277.

Gómez-Bolaños, E., Ellimäki, P., Hurtado-Torres, N. E., & Delgado-Márquez, B. L. (2022, April). Internationalization and environmental innovation in the energy sector: Exploring the differences between multinational enterprises from emerging and developed countries. *Energy Policy, 163*, 112867.

Hughes, R. A. (2024, January 10). Sweden, Portugal, Luxembourg: Which EU countries use the most - and least - renewable energy? *Euronews*.

Iberdrola. (2024). *Información Financiera Anual Iberdrola, S.A. y Sociedades Dependientes Ejercicio 2023.* Iberdrola.

Iberdrola. (2022). *Información Financiera Anual Iberdrola, S.A. y Sociedades Dependientes Ejercicio 2021.* Iberdrola.

Iberdrola. (2024). *Informe Integrado 2023.* Iberdrola.

Kafka, J., & Miller, M. A. (2020, August). The dual angle solar harvest (DASH) method: An alternative method for organizing large solar panel arrays that optimizes incident solar energy in conjunction with land use. *Renewable Energy, 155*, 531-546.

Kazi, A., Hussain, F., Rahim, N. A., Hardaker, G., Alghazzawi, D., Shaban, K., & Haruna, K. (2019, January). Towards Sustainable Energy: A Systematic review of renewable energy sources, technologies, and public opinions. *IEEE Access, 7*, 63837-63851.

Maka, A. O., & Alabid, J. (2022, June). Solar energy technology and its roles in sustainable development. *Clean Energy, 6*(3), 476-483.

Nijsse, F. J., Mercure, L.-F. J., Ameli, N., Larosa, F., Kothari, S., Rickman, J., . . . Pollitt, H. (2023, October 17). The momentum of the solar energy transition. *Nature Communications, 14*(1).

Olabi, A. G., & Abdelkareem, M. A. (2022, April). Renewable energy and climate change. *Renewable & Sustainable Energy Reviews, 158*, 112111.

Osman, A. I., Chen, L., Yang, M., Msigwa, G., Farghali, M., Fawzy, S., . . . Yap, P.-S. (2022, October 28). Cost, environmental impact, and resilience of renewable energy under a Changing Climate: A review. *Environmental Chemistry Letters, 21*(2), 741-764.

Pérez-Higueras, P. J., Rodrigo, P., Fernández, E. F., Almonacid, F., & Hontoria, L. (2012, October). A simplified method for estimating direct normal solar irradiation from global horizontal irradiation useful for CPV applications. *Renewable & sustainable energy reviews, 16*(8), 5529-5534.

Raihan, A. (2023, September 17). A review of the global climate change impacts, adaptation strategies, and mitigation options in the socio-economic and environmental sectors. *Journal of Environmental Science and Economics, 2*(3), 36-58.

Red Eléctrica. (2023, April 7). *Demand for electricity in Spain fell 5.7% in June*. Retrieved from Red Eléctrica: https://www.ree.es/en/press-office/press-release/news/press-release/2023/07/demand-electricity-spain-fell-5-7-percent-june on March 5th, 2024

Red Eléctrica. (2024). *Informe Resumen de Energías Renovables 2023.* Red Eléctrica.

Schlacke, S., Wentzien, H., Thierjung, E. M., & Köster, M. (2022, January). Implementing the EU Climate Law via the 'Fit for 55' package. *Oxford Open Energy*(1), 1-13.

SolarPower Europe. (2023). *EU Market Outlook for Solar Power 2023-2027.* SolarPower Europe.

SolarPower Europe. (2023). *EU Market Outlook for Solar Power 2023-2027.*

Solargis. (2021). *Solar resource maps of Europe*. Retrieved from Maps and GIS Data: https://solargis.com/maps-and-gis-data/download/europe on May 22nd, 2024.

Tawalbeh, M., Al-Othman, A., Kafiah, F., Abdelsalam, E., Almomani, F., & Alkasrawi, M. (2021, March). Environmental impacts of solar photovoltaic systems: A critical review of recent progress and future outlook. *Science of the total environment, 759*, 143528.

Taşel, F. (2020, December 31). The importance of timing of internationalization: a literature review. *Journal of Business, Economics and Finance, 7*(4), 202-209.

Tutak, M. (2022, April). Renewable energy consumption in economic sectors in the EU-27. The impact on economics, environment and conventional energy sources. A 20-year perspective. *Journal of Cleaner Production, 345*, 131076.

Uniper. (2022). *Annual Report 2021.* Uniper.

Uniper. (2024). *Annual Report 2023.* Uniper.

Vestas. (2022). *Annual Report 2021.* Vestas.

Vestas. (2024). *Annual Report 2023.* Vestas.

Welch, L. S., & Luostarinen, R. (1998, December). Internationalization: Evolution of a Concept. *Journal of General Management, 14*(2), 34-55.

Wolf, S., Teitge, J., Mielke, J., Schütze, F., & Jaeger, C. (2021, March). The European Green Deal — more than climate neutrality. *Intereconomics, 56*(2), 99-107.

Wood, E., Khavul, S., Pérez-Nordtvedt, L., Prakhya, S., Dabrowski, R., & Zheng, C. (2011, March 29). Strategic Commitment and Timing of Internationalization from Emerging Markets: Evidence from China, India, Mexico, and South Africa. *Journal of Small Business Management, 49*(2), 252-282.

Ørsted. (2024). *Annual Report 2023.* Ørsted.

Ørsted. (2022). *Annual report 2021.* Ørsted.

Ørsted. (2024). *Green Bond Impact Report 2023.* Ørsted.

Appendix

1. <u>Comparison of Renewable Energy Leaders: Assets, Equity and Net Income</u>

Own elaboration, information obtained from the 2021 and 2023 Financial Statements of:

	2023	2022	2021	2020
ACCIONA	(th)			
Assets	31.650,00	22.595,00	19.602,00	18.207,00
Equity	6.851,00	6.304,00	5.557,00	3.711,00
Net Income	621,00	615,00	404,00	417,00

(Acciona, 2024), (Acciona, 2022)

ENEL	mill			
Assets	195.224,00	219.874,00	206.940,00	163.453,00
Equity	45.109,00	42.080,00	42.342,00	42.357,00
Net Income	4.267,00	2.920,00	3.857,00	3.622,00

(Enel, 2024), (Enel, 2022)

UNIPER	mill			
Assets	54.961,00	121.802,00	128.397,00	40.222,00
Equity	10.436,00	4.386,00	6.788,00	11.188,00
Net Income	4.432,00	-7.401,00	906,00	774,00

(Uniper, 2024), (Uniper, 2022)

IBERDROLA	mill			
Assets	150.033,00	150.114,00	141.752,00	122.518,00
Equity	60.292,00	58.114,00	56.126,00	47.218,00
Net Income	5.415,00	5.131,00	4.387,00	3.970,00

(Iberdrola, 2024), (Iberdrola, 2022)

VESTAS	mill			
Assets	22.514,00	20.090,00	19.712,00	18.160,00
Equity	3.042,00	3.060,00	4.761,00	4.703,00
Net Income	78,00	-1.572,00	176,00	771,00

(Vestas, 2024), (Vestas, 2022)

ORSTED	mill			
Assets	281.136,00	314.142,00	270.385,00	196.719,00
Equity	77.791,00	95.532,00	85.137,00	97.329,00
Net Income	-20.182,00	14.996,00	10.887,00	15.537,00

(Ørsted, 2024), (Ørsted, 2022)

ENGIE	mill			
Assets	194.640,00	235.490,00	225.333,00	153.182,00
Equity	35.724,00	39.285,00	41.980,00	33.856,00
Net Income	2.903,00	390,00	3.758,00	-893,00

(Engie, 2024), (Engie, 2022)

2. <u>Evolution of Solar and Wind Energy Share in Europe (2003, 2013 and 2023)</u>

Area	Year	Electricity Share (%)
Austria	2003	0,02%
Austria	2013	0,98%
Austria	2023	7,71%
Belgium	2003	0,00%
Belgium	2013	3,22%
Belgium	2023	9,30%
Bulgaria	2003	0,00%
Bulgaria	2013	3,23%
Bulgaria	2023	8,80%
Czechia	2003	0,00%
Czechia	2013	2,36%
Czechia	2023	4,00%
Denmark	2003	0,00%
Denmark	2013	1,50%
Denmark	2023	9,28%
France	2003	0,00%
France	2013	0,90%
France	2023	4,52%
Germany	2003	0,05%
Germany	2013	4,86%
Germany	2023	12,20%
Greece	2003	0,00%
Greece	2013	6,48%
Greece	2023	19,02%
Hungary	2003	0,00%
Hungary	2013	0,07%
Hungary	2023	18,44%
Italy	2003	0,01%
Italy	2013	7,55%
Italy	2023	11,81%
Netherlands	2003	0,03%
Netherlands	2013	0,41%
Netherlands	2023	17,31%
Poland	2003	0,00%
Poland	2013	0,00%
Poland	2023	7,25%
Portugal	2003	0,00%
Portugal	2013	0,95%
Portugal	2023	10,18%
Romania	2003	0,00%
Romania	2013	0,72%
Romania	2023	3,70%
Spain	2003	0,01%
Spain	2013	4,65%
Spain	2023	16,71%
Sweden	2003	0,00%
Sweden	2013	0,03%
Sweden	2023	1,49%

Area	Year	Electricity Share (%)
Austria	2003	0,64%
Austria	2013	4,88%
Austria	2023	12,02%
Belgium	2003	0,11%
Belgium	2013	4,48%
Belgium	2023	18,53%
Bulgaria	2003	0%
Bulgaria	2013	3,18%
Bulgaria	2023	3,88%
Croatia	2003	0%
Croatia	2013	3,73%
Croatia	2023	14,88%
Denmark	2003	12,09%
Denmark	2013	32,13%
Denmark	2023	57,72%
Finland	2003	0,11%
Finland	2013	1,08%
Finland	2023	18,32%
France	2003	0,07%
France	2013	2,80%
France	2023	9,46%
Germany	2003	3,17%
Germany	2013	8,38%
Germany	2023	27,20%
Greece	2003	1,78%
Greece	2013	7,34%
Greece	2023	22,09%
Ireland	2003	1,81%
Ireland	2013	17,78%
Ireland	2023	35,76%
Italy	2003	0,51%
Italy	2013	5,21%
Italy	2023	8,95%
Lithuania	2003	0%
Lithuania	2013	14,32%
Lithuania	2023	45,50%
Netherlands	2003	1,38%
Netherlands	2013	5,60%
Netherlands	2023	23,72%
Poland	2003	0,08%
Poland	2013	3,66%
Poland	2023	13,67%
Portugal	2003	1,08%
Portugal	2013	23,85%
Portugal	2023	29,48%
Romania	2003	0%
Romania	2013	7,77%
Romania	2023	13,36%
Spain	2003	4,69%
Spain	2013	19,77%
Spain	2023	23,77%
Sweden	2003	0,50%
Sweden	2013	6,43%
Sweden	2023	20,87%

Source: own elaboration, data obtained from (Ember, 2024)