ISEG INSTITUTO SUPERIOR DE ECONOMIA E GESTÃO

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MASTER'S FINAL WORK

DISSERTATION

THE ENERGY SECURITY OF FIVE EU COUNTRIES BETWEEN 2000 AND 2020: FRANCE, GERMANY, HUNGARY, POLAND, AND PORTUGAL

PABLO LIMA

MAY – 2023

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ABSTRACT

ABSTRACT: Energy security has become a key issue for the EU, whose legislative production in the area is constantly growing. How are Member States responding to energy security challenges? This study examines the energy security evolution of five Member States between 2000 and 2020: France, Germany, Hungary, Poland and Portugal. The literature covered by the study describes a recent field that is characterized by its multidimensional aspect. The choice was made to study energy security through four dimensions (energy efficiency, affordability, availability, and environmental stewardship) which were the base of the eight indicators' index that was developed in this work. The latter, constructed using the z-score normalization method, revealed progress for the EU as a whole but different dynamics within the five countries studied.

The EU energy security trend is characterized by an improvement in the Energy Efficiency and Environmental Stewardship dimensions, but also by a deterioration in the Affordability dimension. As for the Availability dimension, the European average improved in one indicator but deteriorated in the other. On the other hand, the index showed a greater improvement in France and Portugal's energy security compared to the EU evolution. In contrast, the energy security of Hungary, Poland and Germany improved, but to a smaller extent than the EU average.

Additionally, the examination of performance in the selected indicators enabled us to identify points of weakness as well as European or national policies that have aimed to mitigate these weaknesses.

KEYWORDS: Energy security; Energy security indicators; Energy security indexes; European Union; Energy policy

TABLE OF CONTENTS

LIST OF FIGURES AND TABLES

1. Introduction

The exhaustion of resources, the essential role of transport in a globalized world, the environmental consequences of fossil fuel use, fluctuating relationship with the main energy producers - all these phenomena have made energy security a central theme on the global and European agenda.

In this thesis, we will attempt to define the concept of energy security, and then analyze its evolution within the EU. In addition to the overall EU evolution in terms of energy security, we will also study its evolution in five Member States: France, Germany, Hungary, Poland, and Portugal. The choice of these countries is motivated by their different characteristics in terms of geography (Hungary and Poland are on the EU's eastern border, while France and Portugal are on the EU's western side, with a significant Atlantic seaboard), demography, economic growth, history, etc. The study of these five countries will enable us to identify disparities within the EU in terms of energy security. The study will cover the period 2000-2020 and will be based on an index covering the main components of energy security. The latter will enable us to quantify the concept of energy security as it has been done in the literature of the area.

Very briefly, we could say that the concept of "energy security" aims to evaluate the degree of response (for a country or a group of countries) to the needs of energy use and their fluctuations, considering the conditions and consequences of this process. However, we will see that this statement hides a great complexity and several ambiguities. Indeed, researchers interested in the subject characterize the concept as multidimensional. The dimensions widely accepted in the literature are as follows: Availability, Affordability, Environmental Stewardship and Energy Efficiency (Sovacool and Brown, 2010, p. 85), which we will define in more detail in the next section. Each of these four dimensions can be subdivided : the origin of energy, the quality and quantity of energy infrastructures (Availability); greenhouse gas emissions and the share of renewable energies (Environment Stewardship); the prices of different types of energy (Affordability); the level of energy consumption of a population or an economy (Energy efficiency). All these components can serve as indicators to evaluate energy security and, taken together, they can give a level of performance for a country or region, enabling comparisons in space and time. This is what will be done in this thesis.

We will see to what extent the EU's overall performance in terms of energy security has improved in twenty years. This improvement is the result of progress in the Energy Efficiency and Environmental Stewardship dimensions, despite a deterioration in the Affordability dimension and a nuanced evolution in the Availability dimension. We also attempt to interpret the results of the five member states in relation to the EU score through the calculation of z-scores. These showed a greater improvement in France and Portugal's energy security compared to the EU evolution. In contrast, the energy security of Hungary, Poland and Germany improved, but to a smaller extent than the EU average.

The structure of the thesis is as follows. The next section makes a short review of the literature. Afterward, we explain the methodology used to construct the energy security index. Section 4 describes and interprets the results of the index, starting with the global trend of the five countries, followed by an analysis of each indicator. The last section concludes.

2. Short review of literature

2.1 Energy security as a recent field of study

In this section, we will look at how the concept of energy security is understood by various scientific studies. First, it should be recalled that the concept of energy security is a relatively new field of study and thus there is no consensus on the definition of the concept. In a synthesis article that I used to structure this chapter, B.W. Ang, Choong, and Ng (2015), summarize the general opinion that "there is no consensus on a widely accepted definition" (p. 1078). In fact, although data related to energy production and consumption have been collected since the 1950s (Sovacool and Brown, 2010, p. 79) for the Organization for Economic Cooperation and Development (OECD) countries, the subject has only begun to be widely studied in recent years. Even though the issue of energy prices has been regularly raised since the 1973 oil crisis, which led to a sharp increase in the oil barrel price, the integration of the issue of energy security into public policy and its association with the notion of climate change dates from the early 2000s (Lamy, 2006, p.133). The International Energy Agency (IEA) ministerial meeting on 2 and 3 May 2005 was the first to warn of the "unsustainability of current trends in energy consumption and Greenhouse gas (GhG)".

In addition, the lack of a universally accepted definition of the concept is also due to the fact that this field is highly dependent on the context of the research. Indeed, the challenges of energy security can be completely different depending on the country or region from which the topic is approached or depending on the period being studied. For example, the distribution of natural resources on the globe (Institute for 21st Century Energy, 2012, p.18) or technological developments contribute to the dependence on a context.

However, in light of its growing importance for policymakers and other actors, studies about energy security are multiplying and clarifying its definition. Thus, a first conclusion can be drawn from this overview, that energy security cannot be approached only through a single indicator, but rather includes different dimensions. This is illustrated by the metaphor proposed by the two economists Benjamin K. Sovacool and Marilyn A. Brown: "Trying to measure energy security by using contemporary methods in insulation- such as energy intensity or electricity consumption- is akin to trying to drive a car with only a fuel gauge or to seeing a doctor who only checks your cholesterol" (Sovacool and Brown, 2010, p.79).

2.2 Energy security as a multidimension concept

After these contextualizing considerations, we will now focus on the different dimensions that comprise our object of study. To do so, we will rely mainly on the work "Energy security: Definitions, dimensions and indexes" by Ang, Choong and Ng (2014) which proposes a review of one hundred and four works on energy security by classifying them by their method and the dimensions accepted to define energy security. In this way, we can identify and explain the most widely used dimensions to define energy security.

First, energy availability contributes positively to energy security. Indeed, the capacity to have continuous access to energy in sufficient quantities to meet national needs is the most important component in assessing a country's energy security. If we focus on imported energy rather than domestic production, energy availability depends on two main factors: geopolitical uncertainties and diversification (B.W. Ang, Choong, and Ng, 2015, p.82). But we will see later that other perspectives are accepted. Geopolitical contingencies include all political events that can affect supply from the country of origin to energy consumption in the country of destination. These include the outbreak of war, the political destabilization of a governing regime, and regional tensions, all of which can impede the flow of crude oil or natural gas. A prominent example in recent years is the annexation of Crimea by Russia in 2014, which has resulted in energy insecurity in the annexed region (Mazzucchi, 2017). Most of the energy consumed in the region was supplied by road from the rest of Ukraine, but these supply channels were cut off, creating blackouts in Crimea before Russia began building a pipeline from the Russian Kuban peninsula to the Crimean city of Kerch.

On the other hand, diversification can take several forms: it can concern the sources of supply (the more countries from which energy is imported, the less harmful disruptions to one of the supply routes will be). Diversification can also concern space (the spatial distribution of energy production and storage infrastructure in the national territory), the energy mix (the distribution of different types of energy produced and consumed), and finally the diversity of energy transport routes. In all these categories the principle is to minimize risks by considering various alternatives. As referred before, energy availability can also be viewed by the spectrum of national energy availability. In that case, the focus on national reserves of the three primary energy fuels (coal, natural gas, and oil) (Sovacool, Mukherjee, Drupady and D'Agostino, 2011, p. 5848) are preferred to external aspects as geopolitical contingencies. Finally, these considerations highlight the context-dependent characteristic of this field and confirm that the combination of both aspects seems useful to evaluate accurately the energy availability.

The second component regularly present in the definition of energy security concerns the quality of the infrastructure (B.W. Ang, Choong, and Ng, 2015, p. 1081). These may be dedicated to the production, transformation, distribution, and storage of energy. The challenge of this component is to assess the performance of the infrastructure, its reliability (the risk of industrial accidents can increase depending on the age of the infrastructure) and its robustness in the face of threats such as cyber-attacks against critical energy infrastructures. An example of such attacks is the one suffered by Saudi Aramco, the world's largest oil production company, in 2012 (Plėta, Tvaronavičienė, Della Casa and Agafonov, 2020, p. 709). This attack affected 30,000 computers within the facilities and demonstrated the company's security flaws as the perpetrators were described as "skilled amateurs".

Then, to determine the energy performance of a country, it will be necessary to look also at macro-economic factors linked to the global energy market and which will have an impact on the cost of energy, its affordability for the customers (Lee, Xing and Lee, 2022, p. 4). The first factor is the absolute price level of energy which is linked to availability or to decisions made by the major suppliers such as the Organization of the

Petroleum Exporting Countries (OPEC+)[1] for oil or Russia for natural gas.

Price volatility is another factor of energy affordability. It corresponds to "sudden and large price variations" (French Senate, 2011) and is directly linked to market uncertainty. This uncertainty is due to the possibility of geopolitical crises such as the war in Ukraine which has impacted the natural gas market, technological and scientific notions such as peak oil (i.e. the date when the maximum level of oil production is reached, after which it gradually falls due to the depletion of resources) or the 'energy pay-back ratio' (Smil, 2008, p. 14 and 354) (i.e. energy produced divided by the energy required for all the components of the power plant from fuel extraction to plant decommission). This last aspect becomes more and more concerning because of the increasing amount of energy needed to produce fossil fuels as resources become increasingly difficult to extract). Also, the price volatility can be affected by unilateral decisions taken by major energy producers such as private companies like Standard Oil (Veblen, 1917, p. 60) or the OPEC+ countries since the 1970s (Wigglesworth, 2023) (their objective is to push up prices by limiting production). Finally, exchange rates also have an impact on the cost of energy. Indeed, as most energy trade is conducted in US dollars, the devaluation of the national currency against the dollar for a country that imports energy will have a negative effect on the real price of energy for this country.

However, as mentioned earlier, we note that the measurement of energy security is strongly influenced by context, which makes comparisons difficult. Indeed, the macroeconomic factors described above would have little impact on a country whose energy consumption depends mainly on domestic production or domestic reserves. Thus, it would be inappropriate to burden its energy security level by including unfavorable macroeconomic factors in the calculation of its energy security when they are of little concern to them. We will see in another section how the notion of energy independence may respond to this problem.

[1] OPEC is an intergovernmental organisation of major oil exporting countries, founded in 1960, with 13 member countries. OPEC+ has 11 additional members countries including Russia.

Another widely accepted dimension of energy security studies is the social costs of energy (B.W. Ang, Choong, and Ng, 2015, p. 1082). Among these is the phenomenon of energy poverty, which describes the lack of access to energy for some households and can be the result of different factors such as access to the national electricity grid (Sovacool, Mukherjee, Drupady and D'Agostino, 2011, p. 5849). This phenomenon can reveal a flaw in a country's energy distribution and signifies a failure to respect the principle of continuous access to energy. Indeed, a country with a sufficient supply of energy may see its level of energy security deteriorate if the distribution of energy within its territory is not optimal. The second aspect of this social dimension is the possibility of protest movements against projects related to energy production. These movements can be analyzed as a cost of energy production. These protests may concern, for example, wind turbine construction projects. In France, where the development of wind energy is seen as an alternative to nuclear power, many construction projects are facing public protests because of the impact on the landscape (Garcia, 2020, p.137).

Moreover, the environmental dimension is nowadays described as one of the "most crucial components of energy sustainability" (Lee, Xing and Lee, 2022, p. 2) and is by consequence integrated in the calculation of energy security. Indeed, it is considered that a type of energy whose production, transport, storage, and consumption involve a high risk of accident will have a negative impact on the level of energy security. For example, oil spills created by sinking ships carrying crude oil have destructive consequences on the marine ecosystem. Also, the greenhouse gas emissions due to energy production and consumption are often included in the calculation of energy security, and so is the proportion of forest cover in the territory for its role of "carbon sequestration" (Sovacool, Mukherjee, Drupady and D'Agostino, 2011, p. 5849) As environmental preservation has become a major issue in global governance, this is reflected in the research work on energy security, where the environmental issue is increasingly present. In their classification of one hundred and four studies on energy security, the economists B.W. Ang, W.L. Choong n, T.S. Ng observe that only 10% of the studies published between 2001 and 2005 mention the environment, whereas this is the case for almost 50% of the studies published between 2010 and 2013 (B.W. Ang, Choong, and Ng, 2015, p. 1082).

Finally, two components that are also present in many definitions of energy security: political governance (Institute for 21st Century Energy, 2012, p. 18) and energy efficiency. The first component encompasses all decisions taken by national governments or by the European Union, as we will see later. These can be short-term responses to mitigate energy disruptions such as unexpected energy price rises, industrial accidents; or long-term energy planning policies such as diplomacy with an energy-supplying country or plans such as the "European Green Deal" launched in 2019 by the European Commission.[2] Energy efficiency differs from the previous components in that it addresses energy security from the demand view and not the supply view. Energy efficiency is defined as the amount of energy needed to produce one unit of output. Thus, by reducing this amount of input, the energy consumption and thus the dependence on the variables described above is reduced. Again, this is a question of energy independence, which we will discuss later.

At this point, we can consider some attempts to synthesize the components listed above into broader categories. Thus, energy security can be seen as a concept comprising an economic dimension (energy cost determination, availability, energy efficiency), a political dimension (governance, societal opposition, energy infrastructure development), and an environmental dimension (the probability of accidents harmful to nature) (Rodríguez-Fernández, Carvajal and Fernández de Tejada, 2022, p. 3).

However, this perspective is not unanimous among energy security research and another classification is the one proposed by researcher Benjamin Sovacool, who has worked as an energy advisor to the European Commission's Directorate-General for Research and Innovation. In the article co-authored with researcher Marylin Brown, energy security is presented through four pillars: Availability, Affordability, Energy and Economic efficiency, Environment stewardship (Sovacool and Brown, 2010, p.84). We note that all the components described above fit into one of these categories. Social effects

[2] Set of measures to put the EU on a green transition path, with the final objective of achieving climate neutrality by 2050.

for instance enter into the affordability calculation by taking into account possible gaps in access to energy for the poorest households, as well as the need to allocate a greater share of income to energy consumption for poor households than for rich households. Regarding environment stewardship, the authors adapt the Brundtland Report's definition (1987) of sustainable development to the issue of energy security. Energy supply would be sustainable if the following three principles are respected: "ensuring that the rates of exploitation of renewable resources do not exceed the rates of regeneration; ensuring that waste emissions do not exceed the relevant assimilative capacities of ecosystems; and ensuring that non-renewable resources are depleted only at a rate equal to the creation of renewable resources.

In summary, we have identified a multitude of components that allow us to calculate the level of energy security of a country and thus its ability to meet its energy needs in a continuous way and at an acceptable cost. We have also seen that some components become more important as global issues evolve, but we will now see that these components are not always compatible and may conflict with each other.

2.3 Conflicts in the concept

Some studies have highlighted the conflicting nature of the concept of energy security. B. Sovacool and M. Brown list different situations where one dimension of energy security conflicts with another (Sovacool and Brown, 2010, p. 86). The most obvious of these is the additional cost created by "low-carbon power and fuel technologies" considered as "clean" energy. This additional cost, because of the desire to reduce the environmental impact of energy production, therefore degrades Energy Affordability. Another example is the possible "take-back" effect that can be created by a drop in consumer energy prices, which leads to an increase in consumption and therefore has a negative effect on energy efficiency. Finally, this conflict between different dimensions of the concept has been theorized by members of the Information Center of the International Atomic Energy Agency (IAEA) which publishes information on the peaceful use of nuclear science (International Atomic Energy Agency, 2013, p.37). The "energy trilemma" is described as the balance between three objectives: energy security, economic competitiveness, and environmental sustainability, adding that the last objective should prevail over the other two in case of conflict. This concept illustrates the complex nature of this area, and we will see later how policymakers try to respond to this complexity.

While the elements described in this section were mainly concerned with the qualitative aspects of the definition of energy security, we will now see that many studies and reports, which serve as a basis for policy decisions in this area, extend their work to quantitative aspects by using energy security measurement indexes. Although there is not yet a "widely accepted procedure for constructing energy security indexes" (B.W. Ang, Choong, and Ng, 2015, p. 1091), in the following section we will look at some of these measurement indexes and the results they offer.

3. Energy Security Index

In an attempt to quantify energy security performance, economists have developed indexes that measure the level of performance of countries, or groups of countries, enabling these performances to be compared in space and time. These indexes can follow a variety of methodologies. First, we will try to explain the most widespread methodologies used in the construction of energy security indexes, as well as the advantages and drawbacks of each, using different examples. We will then reveal the methodology of the index constructed in this work. Finally, we will present a first general view of the results of this index.

3.1 Existent Indexes

In this first section, I will try to give an overview of existing energy security indexes. The starting point for my research was the work of Patrick Gasser from the ETH Zurich (2020), in the framework of the Future Resilient Systems program in collaboration with Singapore's National Research Foundation. The author develops a review of 63 energy security indexes designed to compare the performance of countries. The article classifies the different indexes according to, among other criteria, the scope or dimensions considered to define and quantify energy security, the geographical coverage, the number of countries analyzed, the time frame, the number of individual indicators considered, the normalization method, the weighting scheme of the indicators and the aggregation function.

The comparison of the number of individual indicators used in the 63 indexes studied shows us the heterogeneity of the Energy Security Indexes (Glasser, 2020, p. 11). Indeed, they may consider between 1 to 5 indicators (this is the case for 19 of the indexes studied) but may present up to more than 40 indicators (2 indexes). The author explains this heterogeneity by the differences in scope but also by the intrinsic differences of different countries, for example with regard to the natural resources of each country. Indeed, some of the indexes focus on only one country (21 of the 63 indexes studied), so the indicators are chosen according to the characteristics of the country in question. This is the case of the work of two economists (Kamsamrong and Sorapipatana, 2014) from King Mongkut's University of Technology (Thonburi, Thailand) on the case of Thailand in which the individual indicators are oriented towards the natural gas market since 70% of electricity production in Thailand comes from the combustion of natural gas.

At this level, we can note that the choice of indicators reflects the scope of the study and influences its results. We can cite two studies on the energy security of the European Union Member States, whose conclusions are different because of the dimensions considered by each of the articles. The work of researchers le Coq and Paltseva (2009) which focuses on the security of energy imports from outside the EU (the indicators considered are distance from the country of import, the political risk factors, diversification of suppliers, reliance on the studied energy in the national economy), identifies best-performing countries by type of energy in 2008: Denmark, Ireland and Slovenia for oil; Denmark, Ireland, The Netherlands, Sweden and the United Kingdom for gas; and Austria, Czech Republic, Greece and Hungary for coal. In contrast, the paper written by three researchers from three Serbian universities (Radovanović, Filipović and Pavlović, 2017) also includes environmental and social aspects in its study of the energy security of the EU Member States between 1990 and 2012 and concludes that the best performing countries in 2012 are the Netherlands, Austria, and Spain. The different results of two studies on the same countries in relatively similar periods show us the importance of the choice of indicators, as it decides the orientation of the study.

Moreover, Patrick Gasser argues that indexes can also be differentiated by their data normalization method. He thus proposes a quick review of the different methods (Gasser, 2020, p. 12). Firstly, he recalls the need to proceed with this normalization to be able to put data whose units are originally different on an identical scale. This enables the data to be compared and combined to form an index. The author presents the two most commonly used methods according to his study: the Min-Max method (most commonly used) and the data standardization method, also called the z-score method. The first method consists of "transforming the data linearly between 0 (the worst score) and 1 (the best score)". It should be added that this method is particularly useful for highlighting outperformers but has the limitation of causing difficulties in differentiating between nonoutperforming countries, as their scores end up being very close after applying the Min-Max method.

The standardization or z-score method consists of transforming the database into a normalized database with a mean of 0 and a standard deviation of 1. This method is only relevant when studying a large number of countries (B.W. Ang, Choong, and Ng, 2015, p. 1088) and has the advantage of better representing the differences between countries that are not located at the extremities of the distribution but rather at its center.

Subsequently, after looking at the main differentiating factors of energy security indexes in general, I tried to identify a limited number of them among the European Union countries in the 21st century. The aim here is to identify the index that will enable the objective of this work to be fulfilled: the comparison of the energy security of France, Germany, Hungary, Poland, and Portugal between 2000 and 2020. In addition, I have favored indexes integrating the four dimensions of energy security admitted in Chapter 1: Energy Efficiency, Affordability, Availability, and Environmental Stewardship (Sovacool and Brown, 2010).

One of the studies that I found relevant compares energy security in 1970 and 2010 (Brown, Wang, Sovacool, and D'Agostino, 2014) for the 22 countries that formed the OECD in 1970 by integrating the 4 dimensions mentioned above, divided into 10 individual indicators. The authors chose the long-term perspective and their objective was to provide policymakers with response tools to deal with situations such as "military conflicts, major embargoes, or the introduction of innovative, yet disruptive, energy technologies". Among the ten individual indicators chosen we can mention oil import dependence, natural gas import dependence, retail electricity prices, retail gasoline/petrol prices, energy per GDP intensity, electricity use per capita, and carbon dioxide emissions. We note that all four dimensions are present in this study. The authors then normalized the data using the z-score method and, after aggregating the indicators, the results are presented for the years 1970 and 2010. Finally, the results of the study are presented in the form of the evolution of the z-score of each country (in addition to the analysis that is done for each indicator individually). Thus, the countries that improved their energy security the most over the period are Canada, Belgium, Japan, the United States, the

United Kingdom, and Switzerland. Of the countries of interest to our study, only Portugal improved its score between 1970 and 2010. However, as Hungary and Poland only joined the OECD in 1996, the study does not include these two countries. The absence of these two countries made it impossible to use this index as a basis.

Another index that caught my interest was the one from the Institute of Economic Research of Bratislava (Obadi, and Korček, 2017). It studies the energy security of EU Member States (including the UK but omitting Malta and Cyprus) between 2005 and 2014. Again, the choice was made to consider all the dimensions of energy security (Energy Efficiency, Affordability, Availability, Environmental Stewardship) represented by 11 individual indicators. The data was normalized using the z-score method and the results are presented for the years 2005 and 2014. The latter consider Denmark, the United Kingdom, Austria, and France as the best performers in 2005, while in 2014 France is replaced by the Netherlands among the top 4 countries. This study differs from the previous one by using slightly different individual indicators such as the emission intensity of new cars, and the share of Renewable energy in transportation. However, this study does not cover the study period of my work which is from 2000 to 2020, hence I did not choose the results of this article as a basis for my comparison.

Finally, a last index that aroused my curiosity is the one mentioned above which considers the 28 EU Member States (including the UK) between 1990 and 2012 with a "Sustainable approach" (Radovanović, Filipović and Pavlović, 2017). The authors differentiate short-term energy security, which contains only affordability and availability aspects, and long-term energy security which includes social and environmental dimensions. This differentiation is supported by the International Energy Agency (International Energy Agency, 2014, p. 13), which defines short-term energy security as “the uninterrupted availability of energy sources at an affordable price” but adds to the concept the aspects of “sustainable environmental needs” and diversification of energy types and sources if the long-term perspective is chosen. The index constructed in this article considers 5 indicators: Energy Intensity (the amount of energy needed to create a given quantity of wealth), Carbon Intensity indicator (proportion of fossil fuels in the energy mix), Energy Dependency, Final Energy Consumption Per Capita, Share of

Renewable and Nuclear Energy. However, as the period considered in this article is not that of my work and the methodology for obtaining the results is difficult to identify, it was not possible to use this index.

Finally, after a deep study of the existing indexes, both in terms of their construction and the results they present, I considered the possibility of drawing inspiration from the research presented in this section to try to develop a new index to reach the objective of this work.

3.2 Construction of an Energy Security Index – Methodology

In order to meet the objective of my master thesis, the index constructed must be oriented toward the whole of the EU countries in order to analyze the performance of the five selected countries in the European context. Moreover, the study period chosen was from 2000 to 2020, providing results 5 in 5 years. Finally, this index must address energy security in its most comprehensive form, i.e. by integrating its four dimensions: Energy Efficiency, Affordability, Availability, and Environmental Stewardship. Thus, the choice of indicators should reflect these four dimensions.

We will therefore examine the process of constructing the index in three stages: the choice of indicators, the method of normalizing the indicators, and the weight allocated to each of the indicators and their aggregation.

3.2.1 Choice of indicators

In order to remain coherent with the review of literature carried out in this work, the choice was made to select indicators corresponding to the four dimensions of energy security presented in the first chapter. Thus, two indicators were chosen for each of the four dimensions.

Therefore, to quantify the Energy Efficiency dimension (A), we have chosen the

Energy Intensity indicator (1) which gives the amount of energy used for each thousand euros of GDP, and the Final Energy Consumption per capita (2). These two indicators give a clear idea of the type of energy use in a country (energy-intensive industries or not, household heating habits etc.).

Secondly, the Affordability dimension (B) is expressed in our index by the price of electricity for households (3) and industrial consumers (4). The choice of using the price of electricity instead of another type of energy is justified by its presence in all sectors of a country, whether it be for private households, industry, services, agriculture, or transport. In addition, the price of electricity reflects the cost of other energies used to produce it (gas, renewable energies, nuclear).

Thirdly, the Availability (C) of the countries' energy is calculated through the Energy imports dependency (5) which gives the proportion of gross available energy (that is comparable to the consumed energy) that comes from imports, given as a percentage and considering all types of energy combined. A percentage greater than 100% indicates an accumulation of stocks, while a negative percentage indicates a positive energy trade balance. The other indicator of this dimension is the Electricity production capacities per capita (6) which quantify the electricity generated in each Member State, divided by its population. The combined score of these two indicators enables an analysis of the leeway of the country studied. For example, a country with a low Availability score (high import dependency and low production capacity) coupled with an Energy inefficiency score will show a critical situation in terms of energy security.

Finally, the two indicators chosen to reflect Environmental Stewardship are the Greenhouse gas emissions per capita for the Energy sector (produced by fossil fuel combustion for instance) (7) and the Share of renewable energy in gross final energy consumption (8), given as a percentage. The energy sources considered in this indicator are those defined as renewable energy by the European Commission in its RED I and RED II directives, which set the EU's renewable energy targets. The energy sources included are hydro energy, wind energy, solar energy, and all electricity generation from gaseous and liquid biofuels, renewable municipal waste, geothermal, and tide, wave & ocean. These two indicators encompass many of the issues related to Environmental Stewardship such as the presence of high-carbon energy or the development of renewable energy for which the European Commission set a target in 2018: to reach 32% of renewable energy in energy consumption by 2030.

The data relative to the eight indicators were collected from the Eurostat database for the years 2000, 2005, 2010, 2015 and 2020 for all EU countries (including the UK). Eurostat is the statistical office of the European Union and has existed under this name since 1958. Its function is to produce open-access European statistics in partnership with the National Statistical Institutes. The office provides data in 9 themes such as Economy and Finance; Population and social conditions; International Trade, Agriculture, and fisheries; Environment and energy.

At this stage of the construction of the Index, it is important to note that some of the selected indicators do not present complete data. In particular, for electricity prices, data is not available for the year 2000 for nine countries: Austria; Bulgaria; Croatia; Estonia; Latvia; Lithuania; Poland; Romania; Slovakia. In addition, the Eurostat database does not provide data for the United Kingdom for the year 2020 (the country officially left the European Union on 31st January 2020 before leaving the EU Customs Union and the EU Single Market on 31st December of the same year). Also, as data were not available in 2020 for the Final Energy Consumption per capita, 2019 data were used. Finally, as data for the indicator Share of renewable energy in gross final energy consumption (8) was only available from 2004 onwards, the values for that year were used for the calculation of the year 2000.

Thus, the data have been grouped into 8 tables, one for each indicator showing results of the 28 Member States, and we will now see how these results have been normalized.

3.2.2 Indicators normalization

As explained in section 2.1, standardization of different indicators is a process that allows, in fine, to compare them even when they use different units of measurement. In other words, standardization removes the unit of measurement from the indicators to make them neutral. It was therefore necessary to identify which normalization method, the Min-Max or the z-score method, was most suitable for my study.

Thus, after a first quick analysis of the five countries that are the subject of this work, I found that their performances in different aspects of energy security were relatively close. Yet, as mentioned in the previous section, the limitation of the Min-max method is that it does not accurately represent the differences between the variables in the center of the distribution, giving them very close scores. This limitation led me to choose the standardization or z-score method. Moreover, we have seen that the z-score is relevant in the context of a study involving a large number of countries, which is the case with the 28 Member States that will be considered for this index.

Consequently, the choice was made to use the z-score method to construct this index. The z-score is a statistical tool that gives the distance of a variable from the mean of the population, this distance being given in number of standard deviations. For example, a variable with a z-score of 2 indicates that it is situated two standard deviations above the mean, and the z-score will be -2 if the variable is two standard deviations below the mean.

The formula for calculating a z-score is as follows:

$$\text{z-score(Variable)} = (\text{Variable} - \text{Mean}) / \text{Standard deviation}$$

The mean and standard deviation here concern the population of all 27+1 countries in the Eurostat database, and this independently for each year and each indicator concerned.

We then applied this formula to all the compiled data in order to be able to compare them. Moreover, we applied a multiplier of -1 to some indicators so that good performance is always reflected in positive values. The indicators affected by this change of sign are the following: Energy Intensity, Energy Consumption, Electricity prices for Households and Industrial consumers, Energy Imports Dependency, and Greenhouse gas emissions per capita for the Energy sector.

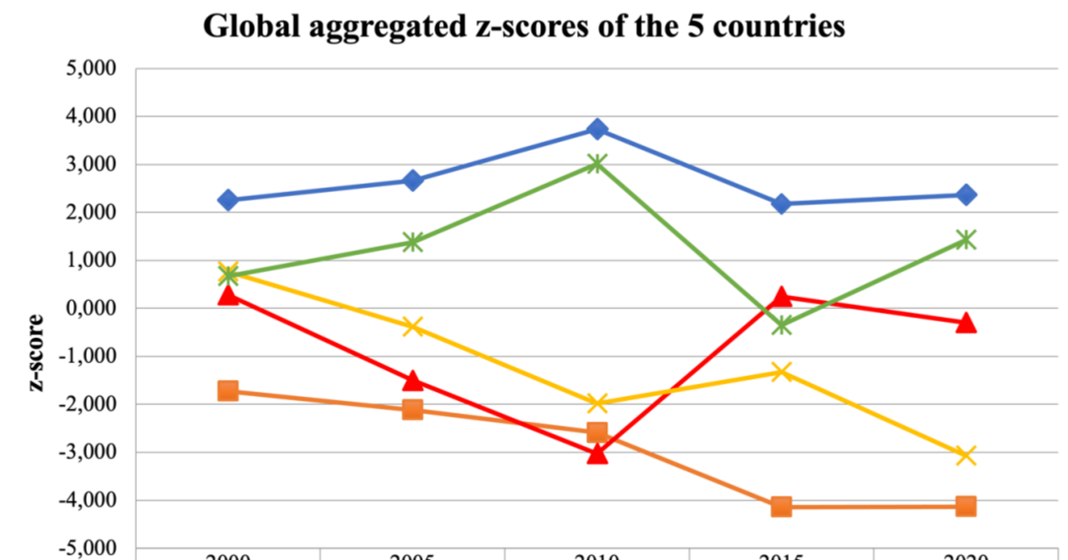
3.2.3 Aggregation of the weighted indicators

At this point, we have calculated for each concerned year the z-scores of the Member States for each of the eight indicators. In order to obtain an overall performance index, the z-scores of the eight indicators must be aggregated for each country. We saw earlier that it is possible to give a different weight to each indicator by applying a different coefficient to each. But for our Index, in the light of the readings discussed in Chapter 1, we have considered that each of the four dimensions is of equal importance and therefore an equivalent weight has been given to each of the eight indicators. Therefore, for each year, we added up the eight z-scores for each country to obtain a country performance index for each of the five years. A weight of 1 (not 1/8) was given to each indicator for a more comfortable reading of the differences between countries.

4. Energy Security Index results

4.1 Energy Security Index results : Global trends

Before providing in the next section a detailed analysis of the results country by country and indicator by indicator, we begin here with an overview of the information provided by the aggregated z-score.



	2000	2005	2010	2015	2020
France	2,251	2,663	3,731	2,176	2,361
Germany	-1,728	-2,115	-2,591	-4,141	-4,135
Hungary	0,279	-1,502	-3,032	0,245	-0,296
Poland	0,765	-0,383	-1,984	-1,326	-3,070
Portugal	0,670	1,376	3,011	-0,351	1,426

Figure 1. Global aggregated z-scores evolution

Indeed, *Figure 1* shows us the z-scores for each of the five countries for the five years studied. To obtain these aggregated z-scores, in each year we added up the z-score of each of the eight indicators (available in the annex) for each country individually. The results obtained thus correspond to the overall energy security performance of the five countries year by year.

The evolution of the z-scores allows us to identify an initial general trend. Indeed, three periods can be distinguished. Between 2000 and 2010, the z-score of France and

Portugal improved, while the one of Hungary, Poland and Germany declined. It should be noted here that the calculation of the z-score gives us the distance to the EU average, so the results of each country are analyzed in relation to this European average. Thus, the evolutions visible in *Figure 1* whose factors we will study in the next section, can be interpreted as an improvement in performance relative to the European average between 2000 and 2010 for France and Portugal. On the contrary, we can say that the energy security score of Hungary, Poland and Germany deteriorated compared to the EU as a whole between 2000 and 2010. It should be noted that these three countries were already those with the lowest z-scores among the five countries in 2000.

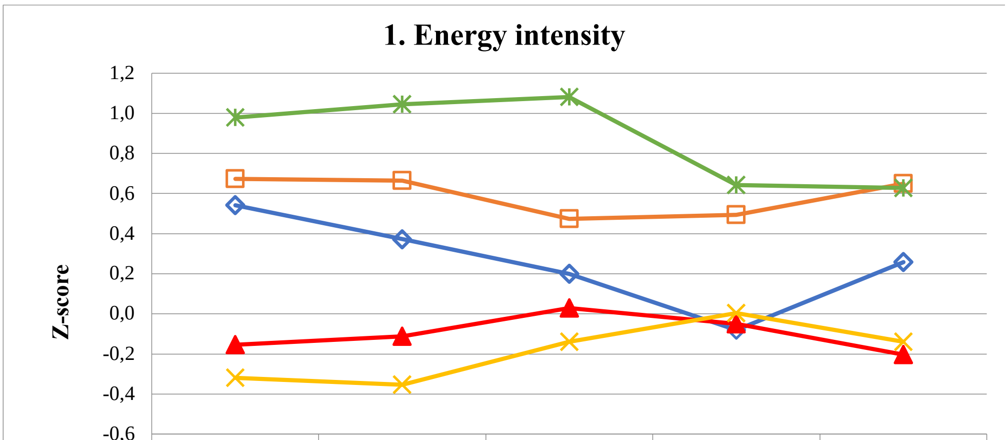
Subsequently, a second period emerges between 2010 and 2015 where three countries suffer a drop in their z-score: Portugal, France, and Germany to a lesser extent. On the contrary, the performance of Hungary and Poland improves compared to the EU average in the same period.

Finally, between 2015 and 2020, France and Portugal’s energy security scores return to growth, while Germany's stagnates and Hungary's and Poland's deteriorates again.

The general picture given in *Figure 1* is therefore the starting point for our analysis, which will then lead us to investigate the factors that explain such trends. To do this, we will examine the eight indicators in detail to identify the weaknesses and strengths of each country. In addition, we will study the energy policies of the countries studied as well as those of the EU to enhance our work.

4.2 Specific results : analysis by the indicators

4.2.1 Energy Efficiency



	2000	2005	2010	2015	2020
France	0,54	0,37	0,2	- 0,08	0,26
Germany	0,67	0,66	0,47	0,49	0,65
Hungary	- 0,15	- 0,11	0,03	- 0,05	-0,20
Poland	- 0,32	- 0,35	- 0,14	0,	-0,14
Portugal	0,98	1,04	1,08	0,64	0,63

Figure 2. Indicator 1 z-score evolution

The first indicator, belonging to the Energy Efficiency dimension, is the energy intensity. Before any analysis, it should be pointed out that it depends on two variables: the units of energy consumed (in kilograms of oil equivalent or KGOE) and the wealth produced in the country. Indeed, the indicator presents the quantity of energy necessary to produce 1000€ of GDP, in Purchasing Power Standards (i.e. the difference of general price level between the countries has been eliminated by dividing the initial results by the respective Purchasing Power Parities) (Insee, 2021). However, this indicator remains very useful to measure the energy needs of a country and to identify the structure of its economy, general standards of living and weather conditions (Eurostat, 2023).

Before analyzing the z-score of each of the five countries studied, we can observe with the help of *Table 1 of the annex* that the European average decreased between 2000 and 2020, which means that the energy intensity improves over the period. In other words, countries needed, on average, less energy in 2020 than in 2000 to produce €1000 of GDP in PPS.

This can be explained by a mutation of national economies with an increase in the share of service activities at the expense of industry and agriculture, which traditionally consume more energy. Another explanation for this positive evolution can be the technical progress in terms of energy saving through insulation, less energy consuming machines and vehicles...

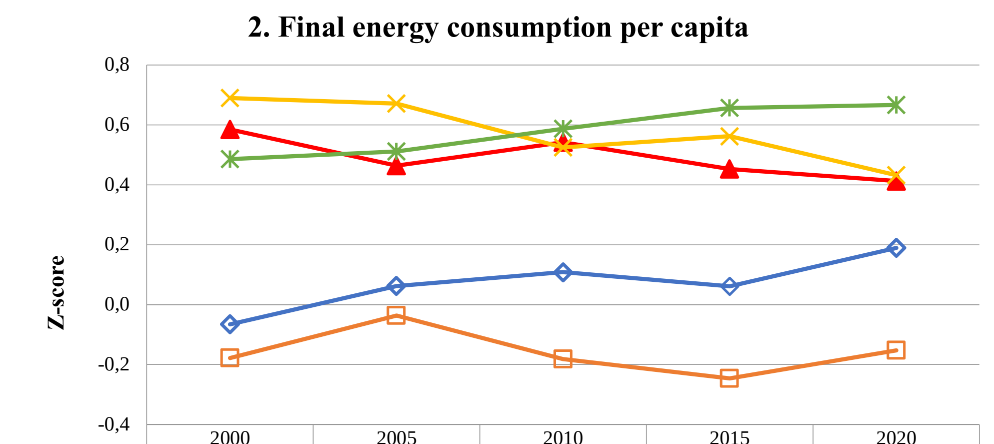
Furthermore, we note that the standard deviation shows a decreasing evolution, which indicates a reduction of the gaps between the best performing Member States and those with the highest energy intensity, in other words a catching up of the "bad performers" such as Estonia or Bulgaria, which had the worst scores in 2000 (440 and 429 KGOE per thousand euro in PPS against a European average of 238) and which have come closer to the European average in 2020 (155 and 139 respectively against a European average of 113).

With these preliminary considerations accomplished, we can observe the individual evolution of the five countries studied. Firstly, it should be noted that all five countries have improved their energy efficiency over the period 2000-2020 (*Table 1 of the annex*). Thus, the evolution of the z-score will tell us whether these five countries have improved their energy efficiency more or less than the EU average.

Firstly, for the year 2000 three countries are above the EU average (Portugal, Germany, and France) while Hungary and Poland have energy efficiency below the European average (z-score of -0.15 and -0.32 respectively).

Secondly, two different trends emerge in the period 2000-2010. Indeed, three countries experience an increase in their z-score: Portugal, Hungary (which catches up with the European average in 2010 with a z-score slightly above 0) and Poland. In contrast, the two largest European economies experienced a fall in their z-score over the same period (more pronounced for France than for Germany). Moreover, Portugal stands out in 2010 as it is one standard deviation above the European average. The global performance of Portugal over the period can be partly explained by the country's climatic conditions, which are conducive to lower energy use in everyday habits. Furthermore, the share of the industrial sector in the Portuguese economy (19.2%) (Word Bank, 2020), which usually consumes more energy than the agricultural or tertiary sector, is relatively low compared to the EU average (22.5%). Conversely, Poland, Germany and Hungary are among the most industrialized countries in the EU (respectively 28.3%, 26.6% and 24.4% of their GDP in 2020). However, the weight of the industrial sector in the final energy consumption of a country must be tempered by the following data. In France in 2021, the most energy-consuming sectors were the transport sector (28.2% of energy consumed), then the households (28%), with the industry sector only coming in third place (17.5%) (Service des données et études statistiques, 2022).

Afterwards, *Figure 2* reveals that Portugal's z-score fell between 2010 and 2015 (from 1.08 to 0.64) but stabilized to remain the best-performing of the five countries in 2020, alongside Germany, whose z-score increased between 2010 and 2020 (0.65). Finally, while France's z-score fell between 2010 and 2015 to reach a point of convergence with Poland and Hungary (z-score close to 0 for the three countries, i.e. an energy efficiency comparable to the European average), the country's z-score has risen again to reach 0.26 in 2020. The two Eastern European countries both experienced a decrease between 2015 and 2020 and obtained z-scores of -0.14 for Poland and -0.20 for Hungary. They are therefore the only countries below the European average among the five countries studied.



	2000	2005	2010	2015	2020
France	- 0,07	0,06	0,11	0,06	0,19
Germany	- 0,18	- 0,04	- 0,18	- 0,25	-0,15
Hungary	0,58	0,46	0,54	0,45	0,41
Poland	0,69	0,67	0,53	0,56	0,43
Portugal	0,49	0,51	0,59	0,66	0,67

Figure 3. Indicator 2 z-score evolution

The second indicator studied, the Final energy consumption per capita, is somewhat similar to the first since it quantifies the energy consumed by the “end-users” i.e. all the economic agents, but excludes the “energy consumption of the energy sector itself (the primary energy used to produce other energy, such as electricity) and losses occurring during transformation and distribution of energy” (Eurostat, 2022). However, in this indicator, the total amount of energy consumed in each of the five years studied has been divided by the population of the country in that year and not by the wealth produced. Thus, the indicator provides us with information on the level of consumption per capita and therefore on the degree of reasonableness, or sobriety in energy consumption.

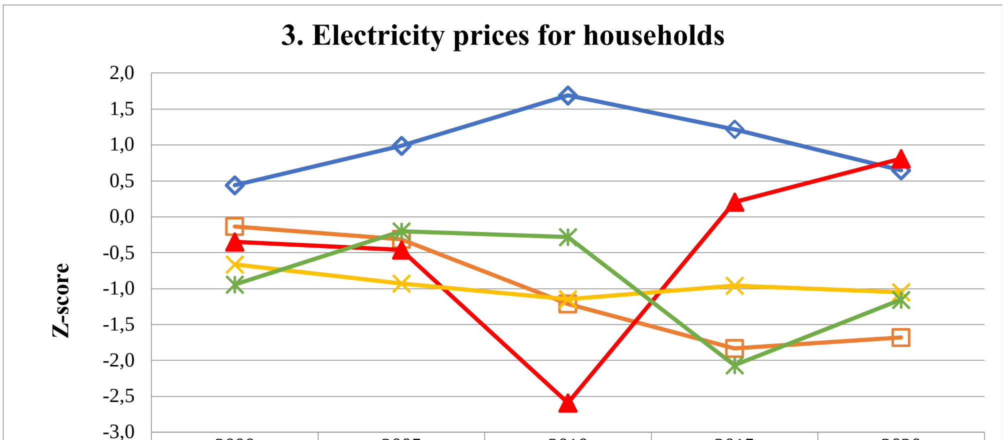
Therefore, looking at *Table 2 of the annex*, we see that per capita consumption in the EU has remained fairly constant between 2000 (2286.34 KGOE per person) and 2020 (2259.11 KGOE per person) with a slight increase in 2005 and 2010. Furthermore, the standard deviation has decreased over the whole period, reflecting an approximation of Member States' levels over twenty years.

When looking at the evolution of z-scores through *Figure 3*, two distinct groups can be clearly identified. On the one hand, Poland, Hungary, and Portugal have positive z-scores over the whole study period with slightly different evolutions. Portugal shows an increase from 0.49 in 2000 to a z-score of 0.69 in 2020. Poland and Hungary show a slight decrease but still have a positive z-score in 2020: 0.43 and 0.41 respectively.

On the other hand, the first two EU economies have negative z-scores in 2000, which means they are situated below the EU average, before experiencing relatively similar evolutions despite a slight improvement for France. Indeed, the latter obtains a z-score of 0.19 in 2020 whereas Germany has a per capita consumption above the European average with a z-score of -0.15 in 2020 (a coefficient of -1 is applied to the z-score of this indicator).

Analyzing the results together with those obtained for indicator 1, it can be concluded that Portugal's energy consumption is relatively efficient according to the wealth produced and sober according to its population, while the situation is more nuanced for the other four countries. Indeed, Germany scores well according to its GDP but not according to its population, and vice versa for Hungary and Poland. France scores similarly on both indicators, close to the EU average.

4.2.2 Affordability



	2000	2005	2010	2015	2020
France	0,44	0,99	1,69	1,22	0,65
Germany	- 0,13	- 0,31	- 1,21	- 1,83	-1,68
Hungary	- 0,35	- 0,46	- 2,59	0,21	0,81
Poland	- 0,66	- 0,93	- 1,15	- 0,96	-1,05
Portugal	- 0,94	- 0,2	- 0,28	- 2,07	-1,15

Figure 4. Indicator 3 z-score evolution

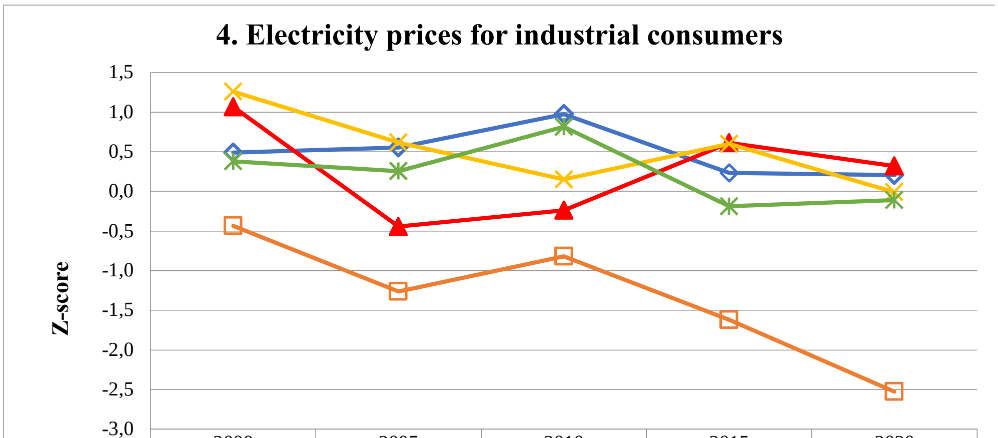
Subsequently, in the context of the Affordability dimension we will look at the evolution of electricity prices for households. These prices correspond to the consumer price of electricity for households, including all levies and taxes such as environmental taxes, value-added taxes, etc (Eurostat, 2022). The values are given in PPS per kilowatt hour (kWh) and take into account public support for prices such as price caps. The study of consumer prices is relevant because they include all costs in the energy production chain ("generation, aggregation, balancing energy, supplied energy costs, customer services, after-sales management and other supply costs") (Eurostat, 2022). As we have seen before, energy prices strongly affect the quality of life of households.

To start, *Table 3 of the annex* shows that the average price of electricity for households in the EU increased between 2000 and 2020 from 0.13 to 0.20 PPS per kWh. After a constant increase between 2000 and 2015, the price has stabilized over the last five years of the study. The standard deviation has remained constant throughout the study period. Moreover, the level of electricity prices for households has also increased in the five countries under study. We will now see, with the help of Figure 4, to what extent this increase has taken place in relation to the EU average.

First, *Figure 4* shows us the five countries close to each other in 2000 (France being slightly better placed and the only country with a positive z-score), then two distinct groups in 2020: France and Hungary with positive z-scores while the other three countries have prices at least one standard deviation above the European average (z-score lower or equal to -1).

To go further, we observe that France obtains a positive score over the whole period (peak in 2010 with a z-score of 1.69 then 0.65 in 2020). Hungary, on the other hand, saw a fall in its z-score until 2010 (-2.59) and then a significant increase until it overtook the French z-score in 2020 (0.81). This progression of the Hungarian z-score can be partly explained by public policies (International Energy Agency, 2022) which have fixed a ceiling price for household retail prices for electricity in order to "keep prices for households affordable and to avoid exposing households to price volatility".

The other three countries had negative z-scores (i.e. prices above the EU average) throughout the twenty years studied. Despite a growth in its z-score over the first ten years, Portugal's performance then fell between 2010 and 2015 (from -0.28 to -2.07) and finally reached almost the same level as Poland in 2020 (-1.05 for Poland and -1.15 for Portugal). Germany ends its evolution as the lowest-ranked country of the five with a z-score of -1.68.



	2000	2005	2010	2015	2020
France	0,49	0,55	0,97	0,23	0,20
Germany	- 0,44	- 1,26	- 0,82	- 1,62	-2,53
Hungary	1,07	- 0,44	- 0,24	0,61	0,32
Poland	1,26	0,62	0,15	0,6	-0,01
Portugal	0,38	0,26	0,81	- 0,19	-0,11

Figure 5. Indicator 4 z-score evolution

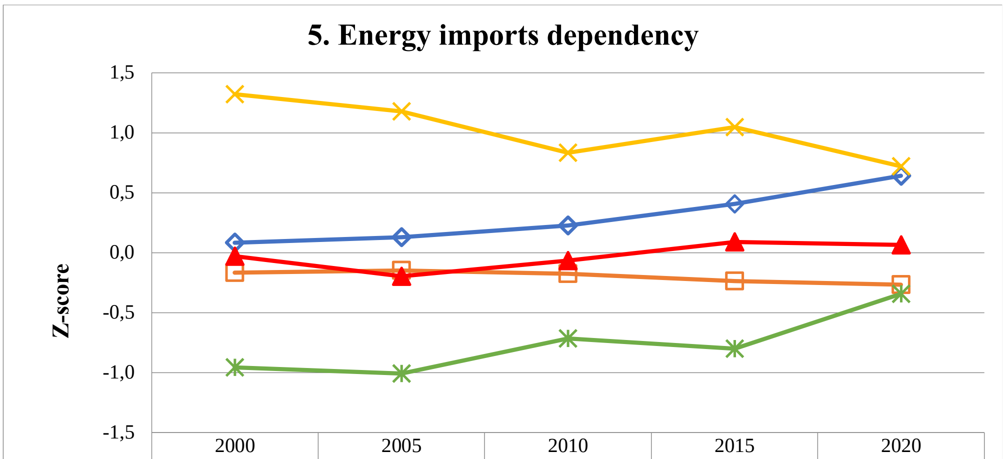
The second indicator of the Affordability dimension concerns electricity prices for industrial consumers. As for the previous indicator, the values include all levies and taxes but in this case the unit is the euro per kWh. The study of these prices is relevant because of the significant impact they have on the production costs of industrialists and therefore on the general price level of a country. First, we notice an increase of these prices in the European countries on average (*Table 4 of the annex*): in 2000 the kWh was sold to industrials at 0.07€, whereas the average price rose to 0.13€ per kWh in 2020. The standard deviation has remained constant over the period (0.02 in 2000 and 0.03 in 2020). Moreover, the price of electricity for industrial consumers has also increased for all five countries studied over the period.

Looking at *Figure 5*, a first observation can be made: the z-score of the five countries studied worsened over the period 2000-2020, which can be interpreted as a greater increase in prices for the five countries than for the EU average. However, while Hungary, France, Poland, and Portugal all have a positive z-score for 2000 and 2020 (or very close to 0 for Poland and Portugal in 2020), Germany has obtained negative z-scores throughout the period studied but has also deteriorated significantly (z-score of -0.44 in 2000 and -2.53 in 2020).

Thus, for the four best-performing countries, electricity prices for industry have always been below the EU average (or very close to it for Poland and Portugal) but have been moving closer to it over the years. In the case of Germany, the price has always been higher than the average of the Member States and has gradually moved away from it. For countries particularly exposed to fossil fuels, the observed deterioration of z-scores can be explained by the price of raw materials such as natural gas or coal which are used for electricity generation (in Poland almost 80% of electricity is generated from coal) (IEA, 2022). Also, for a country that relies on renewable energy more than the EU average, as it is the case for Portugal, the price of electricity generation through this type of energy (which is still more expensive than other energy sources) (IEA, 2022) can be an explanation of the z-score deterioration.

Furthermore, as prices are given in euros for this indicator, the values are not corrected from the price level of each country. As a result, Germany's performance must be nuanced by the fact that its price level index is the highest of the five countries studied in 2020 according to the OECD (OECD, 2023).

4.2.3 Availability



	2000	2005	2010	2015	2020
France	0,08	0,13	0,23	0,41	0,64
Germany	- 0,17	- 0,15	- 0,18	- 0,24	-0,27
Hungary	- 0,03	- 0,2	- 0,07	0,09	0,06
Poland	1,32	1,18	0,83	1,05	0,72
Portugal	- 0,96	- 1,01	- 0,72	- 0,8	-0,34

Figure 6. Indicator 5 z-score evolution

We now focus on the Availability dimension through the Energy imports dependency indicator and the electricity production capacities per capita. The first shows the share (in percentage) of total energy needs of a country met by imports from other countries (Eurostat, 2023).

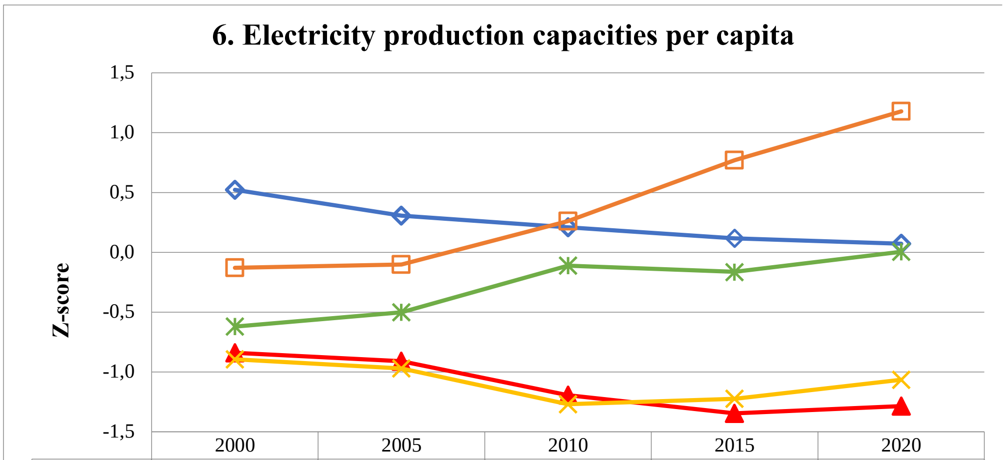
As mentioned earlier, dependence on imports exposes countries to volatile market prices and shortages for natural or geopolitical reasons. For this reason, the Energy Security Strategy was initiated in 2014 by the European Commission. The latter stresses the need to improve national energy production, notably by increasing local renewable energy production, improving energy efficiency, and providing missing infrastructure. However, *Table 5 of the annex* shows us very different results and developments among Member States due to different national policies. These differences in strategy are due to the sharing of competencies on energy between the EU and the Member States. Indeed, Article 4 of the Treaty on the Functioning of the EU recalls that the field of energy belongs to the system of shared competencies according to which "Member States may exercise their competence only to the extent that the EU has not exercised, or has decided not to exercise, its competence". However, the same Treaty clarifies the distribution of competencies in the field of energy by enshrining the right of Member States "to determine the conditions for exploiting their energy resources, their choice between different energy sources and the general structure of their energy supply" (Article 194, paragraph 2 of the Treaty on the Functioning of the EU).

Therefore, *Table 5 of the annex* reflects this disparity in national strategies: between 2000 and 2020 sixteen Member States succeeded in decreasing their dependence on energy imports, while twelve of them saw their dependence increase. Overall, the EU's energy dependency has increased from 53.96% to 57.99% and the standard deviation has decreased, indicating an approximation of national performances. We can also note that some Member States show a negative percentage (Denmark from 2000 to 2010 and the UK in 2000), which means that energy exports are more important than imports in these countries.

Now, if we analyze *Figure 6* we can differentiate three groups at the beginning of the period: Poland with a z-score of 1.32; an intermediate group composed of France (0.08), Hungary (-0.03) and Germany (-0.17); and Portugal located at -0.96. Then, over the twenty years studied, France almost caught up with Poland (0.64 and 0.72 in 2020), while Portugal reached the level of the intermediate group in 2020 (-0.34), where Hungary (0.06) and Germany (-0.27) had a constant evolution.

Thus, in percentage terms, Poland's dependence has deteriorated over the period (up 30 percentage points between 2000 and 2020) but its level is still 15 points below the European average. This negative trend can be explained by a transition that the country began in the 2010s aimed at reducing the use of coal (mostly extracted domestically) in favor of natural gas in particular (mostly imported from Russia). Hungary and Germany have seen their dependence increase in roughly the same proportions as that of the EU as a whole, while Portugal and France have gained in energy independence (-20 points and

-7 points respectively). Portugal, however, is still at a level of dependence above the EU average. The country's progress is explained, according to the IEA report (2021), by an increase in the share of renewable energy (produced domestically) in the Portuguese energy mix. The IEA report also states that the country aims to go below 65% energy dependency by 2030, and below 19% by 2050 according to its energy and climate policy.



	2000	2005	2010	2015	2020
France	0,52	0,31	0,21	0,12	0,07
Germany	-0,13	-0,10	0,26	0,77	1,18
Hungary	-0,84	-0,91	-1,19	-1,35	-1,29
Poland	-0,90	-0,97	-1,27	-1,23	-1,07
Portugal	-0,62	-0,50	-0,11	-0,17	0,00

Figure 7. Indicator 6 z-score evolution

Next, we will look at the sixth indicator of the index: Electricity production capacities per capita, which measures the amount of electricity produced in a country in Kilowatts, divided by its population (Eurostat, 2019). It should be remembered that electricity can be generated through various processes: by burning natural gas, coal, atomic fusion, or through various natural energy sources such as wind, the force of marine and river currents, the sun, the natural heat of the subsoil (geothermal energy), etc. As mentioned in the first chapter, the ability of a country to meet the energy needs of its population through domestic production is an important criteria for energy security.

Table 6 of the annex shows an increase in the average EU electricity production between 2000 (1.422 kW/capita) and 2020 (1.857 kW/capita). Meanwhile, the standard deviation has decreased slightly, reflecting an approximation of Member States' performance. In addition, we see that the amount produced per capita has developed positively in all five countries studied.

Hence, we will now analyze this evolution more closely with the help of *Figure 7*. The latter reflects the performance of Germany in particular, which has gone from a score close to 0 (i.e. close to the European average) to a z-score of 1.18 in 2020, which represents the best performance of the country among the eight indicators in 2020. As regards the other countries in the study, France experienced a slight deterioration in its z-score between 2000 (0.52) and 2020 (0.07), ending up very close to the EU average. Portugal has witnessed the opposite evolution with a z-score of -0.62 in 2000 and 0 in 2020. Finally, the two Eastern European countries have a very similar evolution: they are below the European average throughout the period and have both seen their z-score deteriorate (-1.07 for Poland and -1.29 for Hungary in 2020).

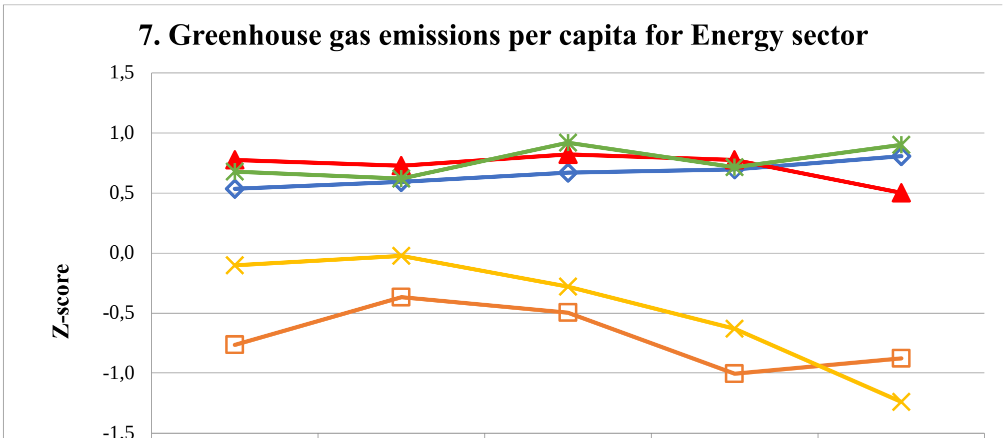
To these graphical analyses we can add that the levels of electrification are not identical in the five countries studied. That is, electricity is used to a greater or lesser extent in the economy and household habits differ from country to country. A telling example is the heating of homes, which may be predominantly gas or electric. Indeed, Hungary has a lower level of electrification than the other Member States studied. Therefore, according to the IEA report on the country, one of the objectives of the Hungarian government's energy policy was to increase the level of electrification of the country. Thus, a relatively low production of electricity per person can be compensated by other energies such as gas, which is not represented in this indicator.

Furthermore, it is interesting to compare Germany's high score for electricity production per capita with the Final energy consumption per capita (Indicator 2) where Germany was the worst performer of the five countries studied. Indeed, we can see that this relatively high electricity production compared to other Member States is in fact a response to relatively high consumption.

4.2.4 Environment Stewardship

The last dimension analyzed is the Environment Stewardship. First of all, it should be remembered that the field of environmental protection is a shared competence. This implies that, as in the field of energy, the States are only competent when the Union has not exercised its competence.

In this area, the EU has been producing a fairly substantial legislation since the first "energy and climate package", impulsed in December 2008 by the European Council, which provided the first objectives in the fight against global warming, known as the 3x20: a 20% reduction in greenhouse gas (GHG) emissions compared to 1990 levels, an increase in the share of renewable energies in the EU's energy consumption of 20% and a 20% improvement in the European Union's energy efficiency by 2020. Since then, several European texts have increased the targets but postponed the date set for achieving the objectives (Pauliat, Senimon and Bonnotte, 2021, p. 56). We can mention the revision of the same energy and climate package in 2014 which sets higher targets (40% reduction of GHG emissions instead of 20%) but for 2030, or the recent "Fit for 55" package, proposed in 2021 and progressively adopted since, which includes thirteen legislative proposals to achieve the 55% emissions reduction target before 2030 and integrates the 2050 carbon neutrality target. We will therefore look at the actual evolution of GHG emissions from the energy sector and the share of renewable energy in final consumption in the Member States, and more specifically in the five countries covered by the study.



	2000	2005	2010	2015	2020
France	0,54	0,59	0,67	0,69	0,80
Germany	-0,76	-0,37	-0,50	-1,00	-0,88
Hungary	0,77	0,73	0,82	0,78	0,50
Poland	-0,10	-0,02	-0,28	-0,63	-1,24
Portugal	0,68	0,62	0,92	0,71	0,90

Figure 8. Indicator 7 z-score evolution

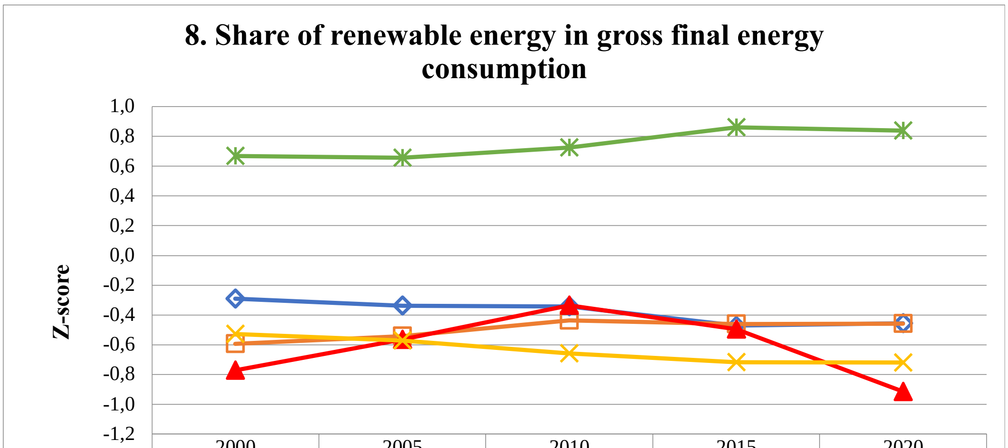
To begin, we will focus on greenhouse gas (GHG) emissions from the energy sector (i.e. from energy production), the amount being given in tones of emissions per capita (Eurostat, 2023). Thus, *Table 7 of the annex* shows that the average level of GHG emissions per capita from the energy sector has dropped by about 30% in the EU over the period 2000-2020, and that a catching up of the best-performing countries by the worst performing ones has occurred over the same period (reduction of the standard deviation). Furthermore, the five countries studied in this work have all experienced a diminution in their level of emissions. We will now see in what proportions.

Looking at *Figure 8*, we can easily differentiate between two distinct groups: Portugal, France and Hungary are all fairly close to each other and have positive z-scores over the whole period, and the opposite for Germany and Poland. The top group shows a flat evolution, between 0.5 and 1 over the twenty years, which indicates that their evolution has been in similar proportions to the European average.

The second group experienced a significant fall in z-score between 2005 and 2020: -0.02 to -1.24 for Poland and -0.37 to -0.88 for Germany. The evolution of the z-score of these two countries indicates that the decrease in emission level achieved was much less than that experienced by the EU as a whole and that they are both at an emission level above the EU average in 2020.

To try to explain the differences in z-score between the two groups, we can rely on the energy mix. Indeed, the share of fossil energies (GHG emitters) is more important in Germany and Poland due to the share of coal in particular. Conversely, Portugal stands out for the significant share of renewable energies in its energy mix, as we will see from the last indicator. In France, nuclear energy accounts for around 40% of the energy supply and, despite the risks that this type of energy entails, it was granted a "green label" by the EU institutions in 2022 (as was natural gas under certain conditions), a decision justified by the low level of emissions produced by nuclear power stations.

Finally, the case of Hungary raises a limitation of this indicator, which is the externalization of GHG emissions. Indeed, as this indicator quantifies emissions from energy production on the national territory, it omits emissions produced abroad by energy imported but consumed locally. Indeed, while gas and oil have a significant weight in Hungary's final energy consumption, the country produces very little of them since in 2020 Hungary's import dependency for fossil fuels stood at 87% (of which 64% of oil and 95% of gas from Russia).



	2000	2005	2010	2015	2020
France	- 0,29	- 0,34	- 0,34	- 0,47	-0,46
Germany	- 0,59	- 0,54	- 0,44	- 0,46	-0,46
Hungary	- 0,77	- 0,57	- 0,34	- 0,5	-0,91
Poland	- 0,53	- 0,57	- 0,66	- 0,72	-0,72
Portugal	0,67	0,65	0,72	0,86	0,84

Figure 9. Indicator 8 z-score evolution

We will now analyze the results of the last indicator: the share of renewable energy in final energy consumption, given in percentage (Eurostat, 2023). Firstly, *Table 8 of the annex* reveals that the share of renewable energy in the EU has doubled from 12.32% in 2000 to 24.36% in 2020. In addition, the standard deviation has increased slightly. This difference can be explained by the faster progress of some countries in this field. Indeed, there are significant differences between Member States: the best-performing country in 2020 is Sweden with 60% renewable energy in its final consumption, while Malta is at the bottom of the scale with 10.7% renewable energy in the same year. Finally, the share of renewable energy in final consumption has increased for all five countries in the study.

To deepen the analysis, *Figure 9* shows a significant gap between Portugal, whose z-score oscillates between 0.67 and 0.84 over the studied period, and the other four countries which obtain z-scores between -0.30 and -1. This z-score places Portugal among the best-performing countries in the EU, with a greater improvement than the EU as a whole. Renewable energies represent 34% of the final energy consumption in the country in 2020, the 5th best result among the 28 Member States.

On the contrary, the four other countries are situated below the European average (negative z-scores) but their progress has been comparable to the one of the EU as a whole (constant z-score over the period) except in the case of Hungary which initially progressed more significantly than the EU (2000-2010) before slowing down over the last ten years.

5. Conclusion

The rising challenges related to energy motivated this study focusing on the EU, and more specifically on five Member States which illustrate the disparities of the continent in terms of population, climate, political orientations, economic structure, and history. To illustrate these disparities, we first defined and then used a synthetic z-score measure.

The results observed in the tables in the annex show an overall improvement for the EU over twenty years in five of the eight indicators: Energy Efficiency, Final Energy consumption per capita, Electricity production capacities per capita, GHG emissions per capita for the energy sector, and the share of renewable energy in the final energy consumption. On the contrary, the EU performance worsened over the twenty years for the Energy imports dependency, the electricity prices for both households and industrials.

In addition, the index results show a greater improvement in the level of energy security for France and Portugal between 2000 and 2020 than for the EU. By contrast, Germany, Poland and Hungary all saw their energy security levels improve less than the EU average.

Looking specifically at the Energy Efficiency dimension, as mentioned above, the EU has made progress over the twenty years studied. In addition, the z-scores show that the five member states studied have made greater progress than the European average. Indeed, the latter show positive z-scores over the period, or negative z-scores in one of the dimension's two indicators but compensated by greater positive z-scores in the other indicator.

Next, we noted that the EU experienced an increase in electricity prices for households and for industrials, indicating a deterioration in performance in the Affordability dimension. As for the five countries in the study, they all experienced an increase in electricity prices over the period. This increase was lower than the European average for France and Hungary, but higher for the other three countries.

Also, we have seen that the EU's evolution in the Availability dimension is contrasted, since its dependence on energy imports increased by five percentage points over the period, but the electricity production per capita increased. The analysis of the evolution of the five countries in relation to the EU is also nuanced. France and Portugal both reduced their dependence on imports over the period (Portugal's level, however, is higher than the European average, unlike France's), while the other three countries saw their dependence increase over the period (only Poland, however, maintained a dependence below the European average over the entire period). In terms of electricity production capacity, Germany has seen a greater increase than the EU average, as has Portugal (which remains below the European average in absolute terms), while France is above the European average but has seen less growth than the EU. Finally, Hungary and Poland are below the European average, and have seen less progress than the EU.

Finally, we noted a clear improvement in European performance in terms of Environment Stewardship. Portugal outperformed in terms of emissions and share of renewable energies and is growing faster than the average. France's overall performance remains better than the European average and grows faster (despite a below-average performance in terms of renewable energies). Conversely, Poland, Germany and Hungary are below the European average in the Environment Stewardship dimension and are progressing slower than the EU average.

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ANNEXES

Dimension A : Energy Efficiency

1. Energy intensity

Time frequency	Annual
Energy balance	Energy intensity of GDP in purchasing power standards (PPS)
Unit of measure	Kilograms of oil equivalent (KGOE) per thousand euro in purchasing power standards (PPS)

Country	2000	Z-score 2000	2005	Z-score 2005	2010	Z-score 2010	2015	Z-score 2015	2020	Z-score 2020	Z-score evolution
Austria	149,60	1,13	145,84	0,99	131,09	0,7	108,89	0,67	96,72	0,53	
Belgium	273,80	-0,44	235,06	-0,77	207,87	-0,99	158,91	-0,82	140,18	-0,85	
Bulgaria	429,07	-2,41	312,87	-2,31	215,19	-1,15	197,76	-1,98	155,98	-1,35	
Croatia	213,72	0,32	180,48	0,31	145,45	0,39	120,64	0,32	105,73	0,24	
Cyprus	213,03	0,33	168,87	0,54	140,01	0,51	130,67	0,02	105,70	0,25	
Czechia	298,55	-0,76	246,47	-1,	205,72	-0,94	163,63	-0,96	134,37	-0,67	
Denmark	163,57	0,95	135,88	1,19	116,43	1,03	89,99	1,23	71,04	1,35	
Estonia	440,29	-2,55	304,19	-2,14	281,85	-2,62	186,17	-1,64	139,49	-0,83	
Finland	290,38	-0,65	256,77	-1,2	234,03	-1,56	196,88	-1,95	171,04	-1,83	
France	195,99	0,54	177,28	0,37	153,96	0,2	133,95	-0,08	105,33	0,26	
Germany	185,55	0,67	162,53	0,66	141,47	0,47	114,64	0,49	93,02	0,65	
Greece	179,82	0,75	147,44	0,96	132,20	0,68	124,28	0,21	110,85	0,08	
Hungary	250,96	-0,15	201,75	-0,11	161,62	0,03	132,91	-0,05	119,81	-0,20	
Ireland	152,13	1,1	112,98	1,65	101,95	1,34	61,69	2,07	45,33	2,17	
Italy	137,59	1,28	134,02	1,23	114,02	1,08	97,85	0,99	85,76	0,88	
Latvia	244,93	-0,08	190,10	0,12	173,65	-0,24	130,54	0,02	111,14	0,07	
Lithuania	303,09	-0,81	231,12	-0,69	153,29	0,21	120,57	0,32	106,37	0,22	
Luxembourg	183,05	0,71	183,27	0,25	133,97	0,64	94,60	1,09	80,08	1,06	
Malta	246,66	-0,1	216,11	-0,4	265,02	-2,25	191,48	-1,79	194,45	-2,58	
Netherlands	216,86	0,28	197,53	-0,03	176,59	-0,3	145,63	-0,43	122,71	-0,30	
Poland	263,90	-0,32	213,92	-0,35	169,30	-0,14	131,15	0,	117,80	-0,14	
Portugal	161,43	0,98	143,34	1,04	113,89	1,08	109,71	0,64	93,68	0,63	
Romania	337,15	-1,24	230,78	-0,69	131,70	0,69	103,62	0,82	76,70	1,17	
Slovakia	348,20	-1,38	255,43	-1,18	170,89	-0,17	138,80	-0,22	139,75	-0,84	
Slovenia	220,62	0,23	194,10	0,04	168,59	-0,12	139,89	-0,26	114,70	-0,04	
Spain	178,79	0,76	154,42	0,82	124,06	0,86	111,85	0,58	100,26	0,42	
Sweden	224,79	0,18	210,68	-0,29	174,92	-0,26	141,28	-0,3	124,33	-0,35	
United Kingdom	182,16	0,72	146,93	0,97	124,67	0,84	97,16	1,02			
Mean	238,77		196,08		162,98		131,26		113,42		
Standard deviation	79,03		50,5		45,41		33,59		31,41		

Table 1. Energy Intensity

Dimension A : Energy Efficiency

2. Final energy consumption per capita

Time frequency	Annual
Energy balance	Final consumption - energy use
Unit of measure	Kilograms of oil equivalent (KGOE) per capita

Country	2000	Z-score 2000	2005	Z-score 2005	2010	Z-score 2010	2015	Z-score 2015	2020	Z-score 2020	Z-score evolution
Austria	2 711,70	-0,33	3 111,5	-0,45	3 093,5	-0,56	2 915,4	-0,72	2 940,	-0,68	
Belgium	3 269,90	-0,76	3 219,5	-0,53	3 193,1	-0,64	2 920,8	-0,73	2 819,8	-0,56	
Bulgaria	1 073,1	0,94	1 263,2	0,84	1 183,9	0,94	1 317,2	0,84	1 398,7	0,85	
Croatia	1 380,5	0,7	1 659,8	0,56	1 664,7	0,56	1 554,1	0,61	1 661,9	0,59	
Cyprus	1 949,1	0,26	2 034,	0,3	1 934,2	0,35	1 672,1	0,49	1 824,60	0,43	
Czechia	2 348,2	-0,05	2 430,8	0,02	2 298,1	0,07	2 185,6	-0,01	2 268,1	-0,01	
Denmark	2 615,8	-0,26	2 708,4	-0,17	2 666,	-0,22	2 362,1	-0,18	2 332,4	-0,07	
Estonia	1 733,9	0,43	2 092,1	0,26	2 166,1	0,17	2 090,6	0,08	2 126,7	0,13	
Finland	4 487,6	-1,71	4 559,8	-1,47	4 644,6	-1,77	4 194,3	-1,97	4 462,3	-2,19	
France	2 371,3	-0,07	2 376,3	0,06	2 245,7	0,11	2 114,9	0,06	2 068,5	0,19	
Germany	2 515,7	-0,18	2 516,3	-0,04	2 615,	-0,18	2 428,3	-0,25	2 412,2	-0,15	
Greece	1 649,2	0,5	1 835,2	0,44	1 654,60	0,57	1 460,8	0,7	1 439,4	0,81	
Hungary	1 535,4	0,58	1 803,6	0,46	1 692,7	0,54	1 714,9	0,45	1 843,3	0,41	
Ireland	2 635,2	-0,27	2 761,3	-0,21	2 431,5	-0,04	2 201,8	-0,02	2 265,8	-0,01	
Italy	2 101,7	0,14	2 261,8	0,14	2 072,3	0,24	1 849,1	0,32	1 902,8	0,35	
Latvia	1 381,	0,7	1 784,90	0,48	1 943,1	0,35	1 878,1	0,29	2 066,9	0,19	
Lithuania	1 078,1	0,94	1 413,6	0,74	1 571,	0,64	1 666,4	0,5	1 952,8	0,30	
Luxembourg	7 213,2	-3,83	8 559,4	-4,27	7 518,5	-4,03	6 077,30	-3,82	6 006,8	-3,72	
Malta	812,5	1,15	927,7	1,08	964,2	1,11	1 015,3	1,14	1 062,5	1,19	
Netherlands	2 961,4	-0,52	2 994,9	-0,37	3 040,2	-0,52	2 566,	-0,38	2 561,9	-0,30	
Poland	1 400,40	0,69	1 507,1	0,67	1 714,50	0,53	1 602,9	0,56	1 824,20	0,43	
Portugal	1 661,1	0,49	1 735,1	0,51	1 635,8	0,59	1 506,1	0,66	1 588,3	0,67	
Romania	991,6	1,01	1 112,9	0,95	1 093,90	1,01	1 096,3	1,06	1 231,30	1,02	
Slovakia	1 845,30	0,34	1 936,	0,37	1 921,1	0,36	1 646,10	0,52	1 877,4	0,38	
Slovenia	2 280,3	0,	2 546,70	-0,06	2 458,8	-0,06	2 283,4	-0,1	2 312,20	-0,05	
Spain	1 868,7	0,32	2 110,9	0,25	1 826,3	0,44	1 636,3	0,53	1 721,	0,53	
Sweden	3 784,5	-1,16	3 492,2	-0,72	3 436,3	-0,83	3 175,5	-0,98	3 024,3	-0,76	
United Kingdom	2 361,1	-0,06	2 263,6	0,14	2 056,3	0,26	1 829,9	0,34			
Mean	2 286,34		2 464,95		2 383,43		2 177,2		2 259,11		
Standard deviation	1 286,05		1 426,82		1 274,06		1 022,12		1 007,49		

Table 2. Final energy consumption per capita

Dimension B : Affordability

3. Electricity prices for households

Consumption Households - Dc (Annual consumption: 3 500 kWh of which night 1 300)
Unit of measure Kilowatt-hour
Currency Purchasing Power Standard

Country	2000	Z-score 2000	2005	Z-score 2005	2010	Z-score 2010	2015	Z-score 2015	2020	Z-score 2020	Z-score evolution
Austria	0,12	0,32	0,1369	0,42	0,1784	0,05	0,1818	0,6	0,1857	0,38	
Belgium	0,14	-0,14	0,144	0,26	0,1767	0,09	0,1916	0,37	0,2474	-1,04	
Bulgaria			0,1797	-0,54	0,1834	-0,08	0,1998	0,17	0,1875	0,34	
Croatia			0,1399	0,35	0,163	0,44	0,2076	-0,02	0,2012	0,02	
Cyprus	0,1792	-1,17	0,2152	-1,33	0,2094	-0,75	0,2226	-0,38	0,24	-0,91	
Czechia	0,1272	0,1	0,1566	-0,02	0,2106	-0,78	0,2203	-0,32	0,2601	-1,33	
Denmark	0,1531	-0,53	0,1692	-0,31	0,1956	-0,39	0,2357	-0,69	0,2134	-0,26	
Estonia			0,116	0,88	0,1431	0,95	0,1744	0,78	0,1521	1,15	
Finland	0,0784	1,29	0,0915	1,43	0,111	1,78	0,1248	1,97	0,1405	1,42	
France	0,1133	0,44	0,1112	0,99	0,1143	1,69	0,1564	1,22	0,174	0,65	
Germany	0,1367	-0,13	0,1696	-0,31	0,2276	-1,21	0,2832	-1,83	0,2752	-1,68	
Greece	0,076	1,35	0,0831	1,62	0,13	1,33	0,2131	-0,15	0,2029	-0,01	
Hungary	0,1454	-0,35	0,1762	-0,46	0,2812	-2,59	0,1983	0,21	0,167	0,81	
Ireland	0,0825	1,19	0,1204	0,78	0,1633	0,43	0,218	-0,27	0,2009	0,03	
Italy	0,2178	-2,12	0,1917	-0,81	0,1922	-0,31	0,2441	-0,89	0,2236	-0,49	
Latvia			0,17	-0,26	0,1604	0,51	0,2384	-0,76	0,192	0,24	
Lithuania			0,1453	0,23	0,1954	-0,39	0,2039	0,07	0,2125	-0,24	
Luxembourg	0,0997	0,77	0,1355	0,45	0,1428	0,96	0,15	1,41	0,1575	1,03	
Malta	0,2117	-1,97	0,2623	-2,38	0,2255	-1,16	0,1567	1,21	0,1496	1,21	
Netherlands	0,137	-0,14	0,1859	-0,68	0,1587	0,55	0,1831	0,57	0,122	1,85	
Poland	0,1584	-0,66	0,1972	-0,93	0,23	-1,15	0,2469	-0,96	0,25	-1,05	
Portugal	0,1698	-0,94	0,1645	-0,2	0,1913	-0,28	0,293	-2,07	0,2524	-1,15	
Romania			0,1793	-0,53	0,21	-0,64	0,2536	-1,12	0,28	-1,77	
Slovakia			0,2533	-2,18	0,2274	-1,21	0,23	-0,46	0,2141	-0,27	
Slovenia	0,1337	-0,06	0,14	0,26	0,1667	0,35	0,1988	0,2	0,17	0,68	
Spain	0,1293	0,05	0,1209	0,77	0,1839	-0,09	0,2581	-1,23	0,2402	-0,87	
Sweden	0,0839	1,16	0,1152	0,9	0,1527	0,71	0,1475	1,43	0,1473	1,26	
United Kingdom	0,0952	0,88	0,0831	1,62	0,1332	1,21	0,1687	0,92	0,1892	0,30	
Mean	0,13		0,16		0,18		0,21		0,2		
Standard deviation	0,04		0,04		0,04		0,04		0,04		

Table 3. Electricity prices for households

Dimension B : Affordability

4. Electricity prices for industrial consumers

Consumption Band IC : 500 MWh < Consumption < 2 000 MWh
Unit of measure Kilowatt-hour
Currency Euro

Country	2000	Z-score 2000	2005	Z-score 2005	2010	Z-score 2010	2015	Z-score 2015	2020	Z-score 2020	Z-score evolution
Austria			0,0992	-0,98	0,1352	-0,34	0,1247	0,2	0,1429	-0,29	
Belgium	0,09	-1,03	0,0938	-0,71	0,1274	-0,1	0,1301	0,06	0,1408	-0,22	
Bulgaria			0,0516	1,45	0,0782	1,43	0,0831	1,23	0,0979	1,06	
Croatia			0,0676	0,63	0,1155	0,27	0,115	0,44	0,1179	0,46	
Cyprus	0,0949	-1,44	0,0927	-0,65	0,1727	-1,51	0,1648	-0,8	0,17	-1,11	
Czechia	0,0569	1,08	0,0713	0,44	0,1239	0,01	0,0934	0,97	0,1023	0,93	
Denmark	0,0911	-1,19	0,1086	-1,46	0,227	-3,19	0,2589	-3,14	0,2252	-2,74	
Estonia			0,0557	1,24	0,0833	1,28	0,1066	0,65	0,0988	1,03	
Finland	0,0513	1,46	0,0699	0,51	0,0846	1,24	0,0877	1,11	0,0862	1,41	
France	0,0659	0,49	0,0691	0,55	0,093	0,97	0,1232	0,23	0,1265	0,20	
Germany	0,0798	-0,44	0,1047	-1,26	0,1507	-0,82	0,1979	-1,62	0,218	-2,53	
Greece	0,0616	0,77	0,0697	0,52	0,10	0,64	0,146	-0,33	0,1139	0,58	
Hungary	0,0572	1,07	0,0886	-0,44	0,132	-0,24	0,108	0,61	0,1226	0,32	
Ireland	0,0744	-0,08	0,1056	-1,31	0,1263	-0,06	0,1601	-0,68	0,1498	-0,49	
Italy	0,1038	-2,03	0,1202	-2,06	0,1596	-1,1	0,1873	-1,36	0,1738	-1,21	
Latvia			0,05	1,62	0,1076	0,52	0,1425	-0,25	0,1246	0,26	
Lithuania			0,0588	1,08	0,1205	0,12	0,1198	0,32	0,1142	0,57	
Luxembourg	0,0752	-0,13	0,0902	-0,52	0,1078	0,51	0,10	0,8	0,1009	0,97	
Malta	0,0675	0,38	0,0741	0,3	0,1809	-1,76	0,1679	-0,88	0,141	-0,23	
Netherlands	0,0817	-0,56	0,107	-1,38	0,1205	0,12	0,1091	0,58	0,1291	0,13	
Poland	0,0543	1,26	0,0678	0,62	0,12	0,15	0,1085	0,6	0,13	-0,01	
Portugal	0,0675	0,38	0,0749	0,26	0,0982	0,81	0,1402	-0,19	0,1371	-0,11	
Romania			0,0915	-0,59	0,10	0,7	0,1029	0,74	0,13	0,20	
Slovakia			0,0837	-0,19	0,1397	-0,48	0,14	-0,06	0,1585	-0,75	
Slovenia	0,0718	0,1	0,07	0,34	0,1192	0,16	0,1009	0,79	0,12	0,39	
Spain	0,0775	-0,28	0,0836	-0,19	0,1354	-0,34	0,142	-0,23	0,1302	0,09	
Sweden	0,0468	1,76	0,0468	1,69	0,1005	0,74	0,0778	1,36	0,0972	1,08	
United Kingdom	0,078	-0,32	0,0696	0,53	0,1162	0,25	0,1788	-1,15	0,1968	-1,89	
Mean	0,07		0,08		0,12		0,13		0,13		
Standard deviation	0,02		0,02		0,03		0,04		0,03		

Table 4. Electricity prices for industrial consumers

Dimension C : Availability

5. Energy imports dependency

Time frequency	Annual
Standard international energy product classification (SIEC)	Total
Unit of measure	Percentage

Country	2000	Z-score 2000	2005	Z-score 2005	2010	Z-score 2010	2015	Z-score 2015	2020	Z-score 2020	Z-score evolution
Austria	65,54	-0,35	71,761	-0,49	62,779	-0,28	60,371	-0,17	58,415	-0,02	
Belgium	78,16	-0,74	79,912	-0,74	78,553	-0,84	84,145	-1,11	78,043	-0,95	
Bulgaria	46,409	0,23	47,343	0,26	40,146	0,53	36,446	0,78	37,884	0,95	
Croatia	48,45	0,17	52,564	0,1	46,693	0,3	48,786	0,29	53,564	0,21	
Cyprus	98,632	-1,37	100,703	-1,38	100,636	-1,62	97,319	-1,64	93,18	-1,66	
Czechia	22,704	0,96	27,846	0,87	25,379	1,05	32,089	0,96	38,763	0,91	
Denmark	-35,918	2,75	-50,618	3,29	-16,235	2,53	13,077	1,71	45,065	0,61	
Estonia	33,984	0,61	26,879	0,9	14,68	1,43	11,181	1,79	10,525	2,24	
Finland	55,475	-0,05	54,459	0,04	48,859	0,22	47,946	0,33	43,191	0,70	
France	51,275	0,08	51,698	0,13	48,668	0,23	45,929	0,41	44,402	0,64	
Germany	59,441	-0,17	60,74	-0,15	59,992	-0,18	62,132	-0,24	63,676	-0,27	
Greece	69,055	-0,46	68,203	-0,38	68,58	-0,48	71,047	-0,59	81,415	-1,11	
Hungary	54,978	-0,03	62,254	-0,2	56,93	-0,07	53,875	0,09	56,618	0,06	
Ireland	85,433	-0,96	89,655	-1,04	87,484	-1,15	88,777	-1,3	71,153	-0,62	
Italy	86,523	-1,	83,348	-0,85	82,571	-0,98	77,03	-0,83	73,454	-0,73	
Latvia	61,01	-0,22	63,84	-0,25	45,545	0,34	51,179	0,2	45,481	0,59	
Lithuania	57,776	-0,12	55,332	0,02	79,045	-0,85	75,452	-0,77	74,909	-0,80	
Luxembourg	99,598	-1,39	97,376	-1,28	97,069	-1,49	95,96	-1,58	92,331	-1,62	
Malta	100,246	-1,41	99,967	-1,36	99,036	-1,56	97,296	-1,64	97,555	-1,87	
Netherlands	38,267	0,48	37,784	0,56	28,279	0,95	48,998	0,28	68,021	-0,47	
Poland	10,72	1,32	17,748	1,18	31,57	0,83	29,848	1,05	42,76	0,72	
Portugal	85,286	-0,96	88,561	-1,01	75,22	-0,72	76,293	-0,8	65,282	-0,34	
Romania	21,884	0,98	27,474	0,88	21,39	1,19	16,687	1,57	28,19	1,41	
Slovakia	65,07	-0,34	65,99	-0,31	64,448	-0,33	60,10	-0,16	56,329	0,08	
Slovenia	51,852	0,06	50,83	0,16	49,277	0,2	49,304	0,27	45,68	0,58	
Spain	76,797	-0,7	81,534	-0,79	77,003	-0,78	72,741	-0,66	67,892	-0,47	
Sweden	39,316	0,45	38,075	0,55	37,99	0,6	30,061	1,04	31,98	1,23	
United Kingdom	-17,128	2,17	13,363	1,31	29,008	0,92	37,638	0,74			
Mean	53,96		55,88		55,02		56,13		57,99		
Standard deviation	32,72		32,39		28,17		25,15		21,16		

Table 5. Energy imports dependency

Dimension C : Availability

6. Electricity production capacities per capita

Standard international energy product classification (SIEC)	Total
Operator/Trader	Main activity producers
Unit of measure	Kilowatt

Country	2000	Z-score 2000	2005	Z-score 2005	2010	Z-score 2010	2015	Z-score 2015	2020	Z-score 2020	Z-score evolution
Austria	2,021	0,80	2,115	0,76	2,279	0,86	2,621	1,11	2,705	1,22	
Belgium	1,489	0,09	1,494	-0,05	1,537	-0,23	1,486	-0,45	1,597	-0,37	
Bulgaria	1,287	-0,18	1,560	0,04	1,344	-0,51	1,496	-0,44	1,559	-0,43	
Croatia	0,460	-1,28	0,849	-0,90	0,905	-1,16	1,091	-1,00	1,108	-1,08	
Cyprus	1,431	0,01	1,526	-0,01	1,864	0,25	1,993	0,25	1,999	0,20	
Czechia	1,260	-0,22	1,482	-0,07	1,740	0,07	1,897	0,11	1,836	-0,03	
Denmark	2,209	1,05	2,291	0,99	2,312	0,91	2,227	0,57	2,316	0,66	
Estonia	1,979	0,74	1,860	0,43	2,047	0,52	2,149	0,46	2,042	0,27	
Finland	2,667	1,66	2,673	1,49	2,491	1,17	2,640	1,14	2,675	1,18	
France	1,815	0,52	1,767	0,31	1,835	0,21	1,899	0,12	1,906	0,07	
Germany	1,325	-0,13	1,454	-0,10	1,871	0,26	2,371	0,77	2,676	1,18	
Greece	0,992	-0,57	1,190	-0,45	1,330	-0,53	1,693	-0,17	1,887	0,04	
Hungary	0,791	-0,84	0,837	-0,91	0,883	-1,19	0,838	-1,35	0,962	-1,29	
Ireland	1,213	-0,28	1,449	-0,11	1,722	0,04	1,992	0,25	2,167	0,45	
Italy	1,327	-0,13	1,394	-0,18	1,697	0,01	1,837	0,03	1,865	0,01	
Latvia	0,865	-0,74	0,948	-0,77	1,195	-0,73	1,454	-0,50	1,523	-0,48	
Lithuania	1,609	0,25	1,339	-0,25	1,065	-0,92	1,134	-0,94	1,148	-1,02	
Luxembourg	2,752	1,77	3,485	2,56	3,226	2,26	3,275	2,02	2,517	0,95	
Malta	0,000	-1,89	0,000	-2,01	1,379	-0,46	1,342	-0,65	1,147	-1,02	
Netherlands	1,143	-0,37	1,138	-0,52	1,288	-0,60	1,586	-0,31	1,529	-0,47	
Poland	0,749	-0,90	0,791	-0,97	0,830	-1,27	0,926	-1,23	1,115	-1,07	
Portugal	0,955	-0,62	1,149	-0,50	1,618	-0,11	1,694	-0,17	1,860	0,00	
Romania	0,749	-0,90	0,857	-0,89	0,943	-1,10	1,032	-1,08	0,933	-1,33	
Slovakia	1,381	-0,05	1,432	-0,13	1,346	-0,51	1,228	-0,81	1,201	-0,94	
Slovenia	1,221	-0,27	1,407	-0,17	1,470	-0,33	1,436	-0,52	1,622	-0,34	
Spain	1,206	-0,29	1,609	0,10	2,034	0,50	2,157	0,47	2,150	0,42	
Sweden	3,692	3,02	3,599	2,71	3,783	3,08	4,071	3,12	4,094	3,22	
United Kingdom	1,225	-0,26	1,230	-0,40	1,373	-0,47	1,217	-0,82			
Mean	1,422		1,533		1,693		1,814		1,857		
Standard deviation	0,751		0,763		0,679		0,725		0,696		

Table 6. Electricity production capacities per capita

Dimension D : Environmental Stewardship

7. Greenhouse gas emissions per capita for Energy sector

Unit of measure	Tonnes
Air pollutants and greenhouse gases	Greenhouse gases (CO_2, N_2O in CO_2 equivalent, CH_4 in CO_2 equivalent, HFC in CO_2 equivalent, PFC in CO_2 equivalent, SF_6 in CO_2 equivalent, NF_3 in CO_2 equ
Source sectors for greenhouse gas emissions	Energy

Country	2000	Z-score 2000	2005	Z-score 2005	2010	Z-score 2010	2015	Z-score 2015	2020	Z-score 2020	Z-score evolution
Austria	6,90	0,35	8,15	0,11	7,11	0,24	6,18	0,17	5,61	-0,03	
Belgium	10,37	-0,70	10,12	-0,38	9,18	-0,33	7,74	-0,39	6,68	-0,56	
Bulgaria	5,00	0,93	5,96	0,65	6,23	0,48	6,36	0,11	5,04	0,25	
Croatia	4,05	1,22	5,00	0,89	4,58	0,93	3,93	0,98	3,82	0,86	
Cyprus	9,24	-0,36	9,76	-0,29	9,24	-0,34	7,24	-0,21	7,23	-0,83	
Czechia	11,89	-1,16	11,85	-0,81	10,75	-0,76	9,38	-0,98	7,91	-1,17	
Denmark	10,05	-0,60	9,39	-0,20	8,88	-0,25	6,11	0,19	4,66	0,44	
Estonia	10,78	-0,82	12,32	-0,92	14,18	-1,70	12,00	-1,93	7,12	-0,78	
Finland	10,39	-0,70	10,26	-0,41	11,26	-0,90	7,42	-0,28	6,21	-0,33	
France	6,31	0,54	6,22	0,59	5,53	0,67	4,72	0,69	3,93	0,80	
Germany	10,58	-0,76	10,08	-0,37	9,79	-0,50	9,44	-1,00	7,32	-0,88	
Greece	8,98	-0,28	9,78	-0,29	8,38	-0,11	6,56	0,03	4,82	0,36	
Hungary	5,52	0,77	5,68	0,73	4,98	0,82	4,49	0,78	4,54	0,50	
Ireland	11,25	-0,97	11,12	-0,63	8,89	-0,25	7,88	-0,44	6,68	-0,56	
Italy	8,07	0,00	8,43	0,04	7,25	0,20	5,90	0,27	5,01	0,27	
Latvia	3,11	1,51	3,62	1,24	4,01	1,08	3,61	1,09	3,55	0,99	
Lithuania	3,11	1,51	3,91	1,16	4,17	1,04	3,85	1,01	4,23	0,66	
Luxembourg	18,66	-3,22	25,04	-4,08	21,38	-3,67	15,84	-3,31	12,22	-3,32	
Malta	6,48	0,48	6,60	0,50	6,28	0,47	3,79	1,03	3,11	1,21	
Netherlands	10,53	-0,75	10,60	-0,50	10,79	-0,77	9,54	-1,04	7,74	-1,09	
Poland	8,41	-0,10	8,69	-0,02	9,00	-0,28	8,40	-0,63	8,04	-1,24	
Portugal	5,85	0,68	6,10	0,62	4,62	0,92	4,66	0,71	3,74	0,90	
Romania	4,27	1,16	4,61	0,99	4,21	1,03	3,94	0,98	3,77	0,89	
Slovakia	6,67	0,43	6,74	0,46	5,94	0,56	5,04	0,58	4,51	0,52	
Slovenia	7,46	0,19	8,29	0,08	8,02	-0,01	6,51	0,05	5,98	-0,22	
Spain	7,17	0,27	7,98	0,15	5,73	0,61	5,49	0,42	4,21	0,67	
Sweden	5,56	0,76	5,35	0,81	5,08	0,79	3,94	0,97	3,08	1,23	
United Kingdom	9,33	-0,38	9,06	-0,11	7,90	0,02	6,18	0,17	4,62	0,46	
Mean	8,07		8,60		7,98		6,65		5,55		
Standard deviation	3,29		4,03		3,65		2,78		2,01		

Table 7. GHG emissions per capita for Energy sector

Dimension D : Environmental Stewardship

8. Share of renewable energy in gross final energy consumption

Time frequency	Annual
Energy balance	Renewable energy sources
Unit of measure	Percentage

Country	2000	Z-score 2000	2005	Z-score 2005	2010	Z-score 2010	2015	Z-score 2015	2020	Z-score 2020	Z-score evolution
Austria	22,553	0,99	24,353	1,12	31,205	1,38	33,497	1,11	36,545	1,06	
Belgium	1,916	-1,01	2,325	-1,01	6,004	-0,96	8,06	-1,04	13,	-0,99	
Bulgaria	9,231	-0,3	9,173	-0,35	13,927	-0,23	18,261	-0,18	23,319	-0,09	
Croatia	23,404	1,08	23,691	1,06	25,103	0,81	28,969	0,73	31,023	0,58	
Cyprus	3,071	-0,9	3,131	-0,93	6,161	-0,95	9,903	-0,89	16,879	-0,65	
Czechia	6,773	-0,54	7,113	-0,55	10,513	-0,54	15,07	-0,45	17,303	-0,61	
Denmark	14,839	0,24	15,955	0,31	21,888	0,51	30,469	0,86	31,681	0,64	
Estonia	18,42	0,59	17,478	0,46	24,575	0,76	28,987	0,73	30,069	0,50	
Finland	29,232	1,64	28,814	1,56	32,166	1,47	39,23	1,6	43,939	1,71	
France	9,319	-0,29	9,272	-0,34	12,671	-0,34	14,803	-0,47	19,109	-0,46	
Germany	6,207	-0,59	7,167	-0,54	11,667	-0,44	14,901	-0,46	19,09	-0,46	
Greece	7,161	-0,5	7,277	-0,53	10,077	-0,58	15,69	-0,39	21,749	-0,23	
Hungary	4,364	-0,77	6,931	-0,57	12,742	-0,34	14,495	-0,5	13,85	-0,91	
Ireland	2,378	-0,97	2,822	-0,96	5,755	-0,99	9,083	-0,95	16,16	-0,71	
Italy	6,316	-0,58	7,549	-0,51	13,023	-0,31	17,525	-0,24	20,359	-0,35	
Latvia	32,794	1,99	32,264	1,89	30,375	1,3	37,538	1,46	42,132	1,55	
Lithuania	17,221	0,48	16,768	0,39	19,639	0,31	25,748	0,46	26,773	0,21	
Luxembourg	0,899	-1,11	1,402	-1,1	2,851	-1,26	4,987	-1,3	11,699	-1,10	
Malta	0,102	-1,19	0,123	-1,23	0,979	-1,43	5,119	-1,29	10,714	-1,19	
Netherlands	2,03	-1,	2,478	-1,	3,917	-1,16	5,714	-1,24	13,999	-0,90	
Poland	6,882	-0,53	6,867	-0,57	9,281	-0,66	11,881	-0,72	16,102	-0,72	
Portugal	19,205	0,67	19,523	0,65	24,15	0,72	30,514	0,86	33,982	0,84	
Romania	16,811	0,44	17,571	0,47	22,834	0,6	24,785	0,38	24,478	0,01	
Slovakia	6,391	-0,58	6,36	-0,62	9,099	-0,67	12,882	-0,63	17,345	-0,61	
Slovenia	18,397	0,59	19,809	0,68	21,081	0,44	22,879	0,21	25,	0,06	
Spain	8,345	-0,39	8,444	-0,42	13,782	-0,24	16,221	-0,35	21,22	-0,27	
Sweden	38,427	2,53	39,982	2,64	46,099	2,77	52,22	2,7	60,124	3,11	
United Kingdom											
Mean	12,32		12,76		16,35		20,35		24,36		
Standard deviation	10,3		10,32		10,76		11,8		11,48		

Table 8. Share of renewable energy in gross final energy consumption

Z-SCORES for 2000

Indicator	Energy intensity	Final energy consumption/cap	Electricity prices for households	Electricity prices for industrials	Energy imports dependency	Electricity production capacities/cap	GHG emissions/cap	Share of renewable energy	TOTAL
Austria	1,13	-0,33	0,32		-0,35	0,80	0,35	0,99	2,91
Belgium	-0,44	-0,76	-0,14	-1,03	-0,74	0,09	-0,70	-1,01	-4,73
Bulgaria	-2,41	0,94			0,23	-0,18	0,93	-0,30	-0,78
Croatia	0,32	0,70			0,17	-1,28	1,22	1,08	2,21
Cyprus	0,33	0,26	-1,17	-1,44	-1,37	0,01	-0,36	-0,90	-4,63
Czechia	-0,76	-0,05	0,10	1,08	0,96	-0,22	-1,16	-0,54	-0,58
Denmark	0,95	-0,26	-0,53	-1,19	2,75	1,05	-0,60	0,24	2,41
Estonia	-2,55	0,43			0,61	0,74	-0,82	0,59	-1,00
Finland	-0,65	-1,71	1,29	1,46	-0,05	1,66	-0,70	1,64	2,93
France	0,54	-0,07	0,44	0,49	0,08	0,52	0,54	-0,29	**2,25**
Germany	0,67	-0,18	-0,13	-0,44	-0,17	-0,13	-0,76	-0,59	**-1,73**
Greece	0,75	0,50	1,35	0,77	-0,46	-0,57	-0,28	-0,50	1,55
Hungary	-0,15	0,58	-0,35	1,07	-0,03	-0,84	0,77	-0,77	**0,28**
Ireland	1,10	-0,27	1,19	-0,08	-0,96	-0,28	-0,97	-0,97	-1,23
Italy	1,28	0,14	-2,12	-2,03	-1,00	-0,13	0,00	-0,58	-4,43
Latvia	-0,08	0,70			-0,22	-0,74	1,51	1,99	3,17
Lithuania	-0,81	0,94			-0,12	0,25	1,51	0,48	2,24
Luxembourg	0,71	-3,83	0,77	-0,13	-1,39	1,77	-3,22	-1,11	-6,44
Malta	-0,10	1,15	-1,97	0,38	-1,41	-1,89	0,48	-1,19	-4,55
Netherlands	0,28	-0,52	-0,14	-0,56	0,48	-0,37	-0,75	-1,00	-2,59
Poland	-0,32	0,69	-0,66	1,26	1,32	-0,90	-0,10	-0,53	**0,77**
Portugal	0,98	0,49	-0,94	0,38	-0,96	-0,62	0,68	0,67	**0,67**
Romania	-1,24	1,01			0,98	-0,90	1,16	0,44	1,44
Slovakia	-1,38	0,34			-0,34	-0,05	0,43	-0,58	-1,58
Slovenia	0,23	0,00	-0,06	0,10	0,06	-0,27	0,19	0,59	0,84
Spain	0,76	0,32	0,05	-0,28	-0,70	-0,29	0,27	-0,39	-0,25
Sweden	0,18	-1,16	1,16	1,76	0,45	3,02	0,76	2,53	8,69
United Kingdom	0,72	-0,06	0,88	-0,32	2,17	-0,26	-0,38		2,75

Table 9. 2000 z-score detail per country

Z-SCORES for 2005

Indicator	Energy intensity	Final energy consumption/cap	Electricity prices for households	Electricity prices for industrials	Energy imports dependency	Electricity production capacities/cap	GHG emissions/cap	Share of renewable energy	TOTAL
Austria	0,99	-0,45	0,42	-0,98	-0,49	0,76	0,11	1,12	1,48
Belgium	-0,77	-0,53	0,26	-0,71	-0,74	-0,05	-0,38	-1,01	-3,94
Bulgaria	-2,31	0,84	-0,54	1,45	0,26	0,04	0,65	-0,35	0,04
Croatia	0,31	0,56	0,35	0,63	0,10	-0,90	0,89	1,06	3,01
Cyprus	0,54	0,30	-1,33	-0,65	-1,38	-0,01	-0,29	-0,93	-3,76
Czechia	-1,00	0,02	-0,02	0,44	0,87	-0,07	-0,81	-0,55	-1,11
Denmark	1,19	-0,17	-0,31	-1,46	3,29	0,99	-0,20	0,31	3,65
Estonia	-2,14	0,26	0,88	1,24	0,90	0,43	-0,92	0,46	1,09
Finland	-1,20	-1,47	1,43	0,51	0,04	1,49	-0,41	1,56	1,95
France	0,37	0,06	0,99	0,55	0,13	0,31	0,59	-0,34	**2,66**
Germany	0,66	-0,04	-0,31	-1,26	-0,15	-0,10	-0,37	-0,54	**-2,12**
Greece	0,96	0,44	1,62	0,52	-0,38	-0,45	-0,29	-0,53	1,89
Hungary	-0,11	0,46	-0,46	-0,44	-0,20	-0,91	0,73	-0,57	**-1,50**
Ireland	1,65	-0,21	0,78	-1,31	-1,04	-0,11	-0,63	-0,96	-1,83
Italy	1,23	0,14	-0,81	-2,06	-0,85	-0,18	0,04	-0,51	-2,99
Latvia	0,12	0,48	-0,26	1,62	-0,25	-0,77	1,24	1,89	4,07
Lithuania	-0,69	0,74	0,23	1,08	0,02	-0,25	1,16	0,39	2,66
Luxembourg	0,25	-4,27	0,45	-0,52	-1,28	2,56	-4,08	-1,10	-8,00
Malta	-0,40	1,08	-2,38	0,30	-1,36	-2,01	0,50	-1,23	-5,50
Netherlands	-0,03	-0,37	-0,68	-1,38	0,56	-0,52	-0,50	-1,00	-3,91
Poland	-0,35	0,67	-0,93	0,62	1,18	-0,97	-0,02	-0,57	**-0,38**
Portugal	1,04	0,51	-0,20	0,26	-1,01	-0,50	0,62	0,65	**1,38**
Romania	-0,69	0,95	-0,53	-0,59	0,88	-0,89	0,99	0,47	0,59
Slovakia	-1,18	0,37	-2,18	-0,19	-0,31	-0,13	0,46	-0,62	-3,78
Slovenia	0,04	-0,06	0,26	0,34	0,16	-0,17	0,08	0,68	1,33
Spain	0,82	0,25	0,77	-0,19	-0,79	0,10	0,15	-0,42	0,70
Sweden	-0,29	-0,72	0,90	1,69	0,55	2,71	0,81	2,64	8,28
United Kingdom	0,97	0,14	1,62	0,53	1,31	-0,40	-0,11		4,06

Table 10. 2005 z-score detail per country

Z-SCORES for 2010

Indicator	Energy intensity	Final energy consumption/cap	Electricity prices for households	Electricity prices for industrials	Energy imports dependency	Electricity production capacities/cap	GHG emissions/cap	Share of renewable energy	TOTAL
Austria	0,70	-0,56	0,05	-0,34	-0,28	0,86	0,24	1,38	2,06
Belgium	-0,99	-0,64	0,09	-0,10	-0,84	-0,23	-0,33	-0,96	-3,99
Bulgaria	-1,15	0,94	-0,08	1,43	0,53	-0,51	0,48	-0,23	1,41
Croatia	0,39	0,56	0,44	0,27	0,30	-1,16	0,93	0,81	2,54
Cyprus	0,51	0,35	-0,75	-1,51	-1,62	0,25	-0,34	-0,95	-4,05
Czechia	-0,94	0,07	-0,78	0,01	1,05	0,07	-0,76	-0,54	-1,82
Denmark	1,03	-0,22	-0,39	-3,19	2,53	0,91	-0,25	0,51	0,92
Estonia	-2,62	0,17	0,95	1,28	1,43	0,52	-1,70	0,76	0,80
Finland	-1,56	-1,77	1,78	1,24	0,22	1,17	-0,90	1,47	1,64
France	0,20	0,11	1,69	0,97	0,23	0,21	0,67	-0,34	**3,73**
Germany	0,47	-0,18	-1,21	-0,82	-0,18	0,26	-0,50	-0,44	**-2,59**
Greece	0,68	0,57	1,33	0,64	-0,48	-0,53	-0,11	-0,58	1,51
Hungary	0,03	0,54	-2,59	-0,24	-0,07	-1,19	0,82	-0,34	**-3,03**
Ireland	1,34	-0,04	0,43	-0,06	-1,15	0,04	-0,25	-0,99	-0,67
Italy	1,08	0,24	-0,31	-1,10	-0,98	0,01	0,20	-0,31	-1,16
Latvia	-0,24	0,35	0,51	0,52	0,34	-0,73	1,08	1,30	3,13
Lithuania	0,21	0,64	-0,39	0,12	-0,85	-0,92	1,04	0,31	0,15
Luxembourg	0,64	-4,03	0,96	0,51	-1,49	2,26	-3,67	-1,26	-6,08
Malta	-2,25	1,11	-1,16	-1,76	-1,56	-0,46	0,47	-1,43	-7,04
Netherlands	-0,30	-0,52	0,55	0,12	0,95	-0,60	-0,77	-1,16	-1,72
Poland	-0,14	0,53	-1,15	0,15	0,83	-1,27	-0,28	-0,66	**-1,98**
Portugal	1,08	0,59	-0,28	0,81	-0,72	-0,11	0,92	0,72	**3,01**
Romania	0,69	1,01	-0,64	0,70	1,19	-1,10	1,03	0,60	3,48
Slovakia	-0,17	0,36	-1,21	-0,48	-0,33	-0,51	0,56	-0,67	-2,46
Slovenia	-0,12	-0,06	0,35	0,16	0,20	-0,33	-0,01	0,44	0,63
Spain	0,86	0,44	-0,09	-0,34	-0,78	0,50	0,61	-0,24	0,95
Sweden	-0,26	-0,83	0,71	0,74	0,60	3,08	0,79	2,77	7,60
United Kingdom	0,84	0,26	1,21	0,25	0,92	-0,47	0,02		3,03

Table 11. 2010 z-score detail per country

Z-SCORES for 2015

Indicator	Energy intensity	Final energy consumption/cap	Electricity prices for households	Electricity prices for industrials	Energy imports dependency	Electricity production capacities/cap	GHG emissions/cap	Share of renewable energy	TOTAL
Austria	0,67	-0,72	0,60	0,20	-0,17	1,11	0,17	1,11	2,97
Belgium	-0,82	-0,73	0,37	0,06	-1,11	-0,45	-0,39	-1,04	-4,12
Bulgaria	-1,98	0,84	0,17	1,23	0,78	-0,44	0,11	-0,18	0,53
Croatia	0,32	0,61	-0,02	0,44	0,29	-1,00	0,98	0,73	2,35
Cyprus	0,02	0,49	-0,38	-0,80	-1,64	0,25	-0,21	-0,89	-3,15
Czechia	-0,96	-0,01	-0,32	0,97	0,96	0,11	-0,98	-0,45	-0,68
Denmark	1,23	-0,18	-0,69	-3,14	1,71	0,57	0,19	0,86	0,55
Estonia	-1,64	0,08	0,78	0,65	1,79	0,46	-1,93	0,73	0,93
Finland	-1,95	-1,97	1,97	1,11	0,33	1,14	-0,28	1,60	1,95
France	-0,08	0,06	1,22	0,23	0,41	0,12	0,69	-0,47	**2,18**
Germany	0,49	-0,25	-1,83	-1,62	-0,24	0,77	-1,00	-0,46	**-4,14**
Greece	0,21	0,70	-0,15	-0,33	-0,59	-0,17	0,03	-0,39	-0,69
Hungary	-0,05	0,45	0,21	0,61	0,09	-1,35	0,78	-0,50	**0,24**
Ireland	2,07	-0,02	-0,27	-0,68	-1,30	0,25	-0,44	-0,95	-1,35
Italy	0,99	0,32	-0,89	-1,36	-0,83	0,03	0,27	-0,24	-1,70
Latvia	0,02	0,29	-0,76	-0,25	0,20	-0,50	1,09	1,46	1,56
Lithuania	0,32	0,50	0,07	0,32	-0,77	-0,94	1,01	0,46	0,97
Luxembourg	1,09	-3,82	1,41	0,80	-1,58	2,02	-3,31	-1,30	-4,69
Malta	-1,79	1,14	1,21	-0,88	-1,64	-0,65	1,03	-1,29	-2,87
Netherlands	-0,43	-0,38	0,57	0,58	0,28	-0,31	-1,04	-1,24	-1,96
Poland	0,00	0,56	-0,96	0,60	1,05	-1,23	-0,63	-0,72	**-1,33**
Portugal	0,64	0,66	-2,07	-0,19	-0,80	-0,17	0,71	0,86	**-0,35**
Romania	0,82	1,06	-1,12	0,74	1,57	-1,08	0,98	0,38	3,34
Slovakia	-0,22	0,52	-0,46	-0,06	-0,16	-0,81	0,58	-0,63	-1,25
Slovenia	-0,26	-0,10	0,20	0,79	0,27	-0,52	0,05	0,21	0,64
Spain	0,58	0,53	-1,23	-0,23	-0,66	0,47	0,42	-0,35	-0,48
Sweden	-0,30	-0,98	1,43	1,36	1,04	3,12	0,97	2,70	9,34
United Kingdom	1,02	0,34	0,92	-1,15	0,74	-0,82	0,17		1,21

Table 12. 2015 z-score detail per country

Z-SCORES for 2020

Indicator	Energy intensity	Final energy consumption/cap	Electricity prices for households	Electricity prices for industrials	Energy imports dependency	Electricity production capacities/cap	GHG emissions/cap	Share of renewable energy	TOTAL
Austria	0,53	-0,68	0,38	-0,29	-0,02	1,22	-0,03	1,06	2,18
Belgium	-0,85	-0,56	-1,04	-0,22	-0,95	-0,37	-0,56	-0,99	-5,54
Bulgaria	-1,35	0,85	0,34	1,06	0,95	-0,43	0,25	-0,09	1,58
Croatia	0,24	0,59	0,02	0,46	0,21	-1,08	0,86	0,58	1,89
Cyprus	0,25	0,43	-0,91	-1,11	-1,66	0,20	-0,83	-0,65	-4,29
Czechia	-0,67	-0,01	-1,33	0,93	0,91	-0,03	-1,17	-0,61	-1,99
Denmark	1,35	-0,07	-0,26	-2,74	0,61	0,66	0,44	0,64	0,63
Estonia	-0,83	0,13	1,15	1,03	2,24	0,27	-0,78	0,50	3,71
Finland	-1,83	-2,19	1,42	1,41	0,70	1,18	-0,33	1,71	2,06
France	0,26	0,19	0,65	0,20	0,64	0,07	0,80	-0,46	**2,36**
Germany	0,65	-0,15	-1,68	-2,53	-0,27	1,18	-0,88	-0,46	**-4,14**
Greece	0,08	0,81	-0,01	0,58	-1,11	0,04	0,36	-0,23	0,53
Hungary	-0,20	0,41	0,81	0,32	0,06	-1,29	0,50	-0,91	**-0,30**
Ireland	2,17	-0,01	0,03	-0,49	-0,62	0,45	-0,56	-0,71	0,25
Italy	0,88	0,35	-0,49	-1,21	-0,73	0,01	0,27	-0,35	-1,26
Latvia	0,07	0,19	0,24	0,26	0,59	-0,48	0,99	1,55	3,41
Lithuania	0,22	0,30	-0,24	0,57	-0,80	-1,02	0,66	0,21	-0,09
Luxembourg	1,06	-3,72	1,03	0,97	-1,62	0,95	-3,32	-1,10	-5,75
Malta	-2,58	1,19	1,21	-0,23	-1,87	-1,02	1,21	-1,19	-3,28
Netherlands	-0,30	-0,30	1,85	0,13	-0,47	-0,47	-1,09	-0,90	-1,56
Poland	-0,14	0,43	-1,05	-0,01	0,72	-1,07	-1,24	-0,72	**-3,07**
Portugal	0,63	0,67	-1,15	-0,11	-0,34	0,00	0,90	0,84	**1,43**
Romania	1,17	1,02	-1,77	0,20	1,41	-1,33	0,89	0,01	1,60
Slovakia	-0,84	0,38	-0,27	-0,75	0,08	-0,94	0,52	-0,61	-2,44
Slovenia	-0,04	-0,05	0,68	0,39	0,58	-0,34	-0,22	0,06	1,06
Spain	0,42	0,53	-0,87	0,09	-0,47	0,42	0,67	-0,27	0,52
Sweden	-0,35	-0,76	1,26	1,08	1,23	3,22	1,23	3,11	10,03
United Kingdom			0,30	-1,89			0,46		-1,13

Table 13. 2020 z-score detail per country

Z-SCORES EVOLUTION

Country	2000	2005	2010	2015	2020
Austria	2,91	1,48	2,06	2,97	2,18
Belgium	-4,73	-3,94	-3,99	-4,12	-5,54
Bulgaria	-0,78	0,04	1,41	0,53	1,58
Croatia	2,21	3,01	2,54	2,35	1,89
Cyprus	-4,63	-3,76	-4,05	-3,15	-4,29
Czechia	-0,58	-1,11	-1,82	-0,68	-1,99
Denmark	2,41	3,65	0,92	0,55	0,63
Estonia	-1,00	1,09	0,80	0,93	3,71
Finland	2,93	1,95	1,64	1,95	2,06
France	2,25	2,66	3,73	2,18	2,36
Germany	-1,73	-2,12	-2,59	-4,14	-4,14
Greece	1,55	1,89	1,51	-0,69	0,53
Hungary	0,28	-1,50	-3,03	0,24	-0,30
Ireland	-1,23	-1,83	-0,67	-1,35	0,25
Italy	-4,43	-2,99	-1,16	-1,70	-1,26
Latvia	3,17	4,07	3,13	1,56	3,41
Lithuania	2,24	2,66	0,15	0,97	-0,09
Luxembourg	-6,44	-8,00	-6,08	-4,69	-5,75
Malta	-4,55	-5,50	-7,04	-2,87	-3,28
Netherlands	-2,59	-3,91	-1,72	-1,96	-1,56
Poland	0,77	-0,38	-1,98	-1,33	-3,07
Portugal	0,67	1,38	3,01	-0,35	1,43
Romania	1,44	0,59	3,48	3,34	1,60
Slovakia	-1,58	-3,78	-2,46	-1,25	-2,44
Slovenia	0,84	1,33	0,63	0,64	1,06
Spain	-0,25	0,70	0,95	-0,48	0,52
Sweden	8,69	8,28	7,60	9,34	10,03
United Kingdom	2,75	4,06	3,03	1,21	-1,13

Table 14. Aggregated z-scores evolution