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Contextualization of the Climate Change. Analysis of the Kaya Identity in Spain.

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Abstract

The objective of this work has been to analyse the factors that determine climate change in Spain in order to identify where policies and actions should been focused to combat this phenomenon.

To achieve this objective, a complete framework has first been developed in which the causes, consequences, impacts and policies have been studied to know the importance and current situation of climate change in Spain.

Next, this work presents a study of the drivers of climate change based on the Kaya identity, which establishes that CO_2 emissions can be decomposed into the product of four variables: population, GDP per capita, energy intensity and carbonization index. This analysis concludes the factors that have contributed the most to containment and even decrease of the amount of CO_2 are the energy intensity and the decarbonisation thanks to the introduction of renewable energies.

Key Words: Climate change, Kaya identity, Spain, CO_2 emissions.

Word Count: 14030

Resumen

El objetivo de este trabajo ha sido analizar los factores que determinan el cambio climático en España para poder identificar donde se deben focalizar las políticas y acciones de lucha contra este fenómeno.

Para alcanzar este objetivo, primero se ha desarrollado un completo marco de referencia en el que se analizan las causas, consecuencias, impactos y políticas para conocer la importancia y la situación actual del cambio climático en España.

A continuación, este trabajo presenta un estudio de los factores conductores del cambio climático en base a la identidad de Kaya que establece que las emisiones de CO_2 pueden descomponerse en el producto de cuatro variables: población, PIB per cápita, intensidad energética e índice de carbonización. Este análisis concluye que los factores que más han contribuido a la contención e incluso a la disminución de la cantidad de CO_2 son la intensidad energética y la descarbonización gracias a la introducción de energías renovables.

Palabras claves: Cambio Climático, Identidad de Kaya, España, Emisiones de CO_2

Número de palabras: 14030

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1. Introduction

The Holocene has been one of the most stable periods in the history of our planet, for 10,000 years, the average temperature has not oscillated up or down by more than one degree Celsius. The rich and prosperous living world around us has been key to this stability. Those conditions made it possible for humans to be the most widespread and dominant animal species on earth. There was nothing left to restrict or stop us except ourselves.

The excessive emission of certain gases, known as greenhouse gases (GHG), caused by our economic and society model has altered the composition of the global atmosphere, causing the current climate change. In fact, human activities are already responsible for an increase in global temperatures of approximately 1ºC above the pre-industrial level, which indicates that, at the current rate, the increase of 1.5ºC will be reached between 2030 and 2052 (IPCC, 2018).

In this context, Spain, due to its geographical location and socioeconomic characteristics, is among the economies with the greatest exposure to the impact of climate change in Europe. Climate changes will mainly affect the energy sector, water resources, agriculture and livestock, and tourism. However, the net impact will depend, largely, on the ability of the public and private sectors to accelerate the transition to a low-carbon economy.

The objectives pursued in this project are three: to create a base reference framework for climate change in Spain; to use the Kaya identity to study and analyse historical CO_2 emissions during the period 1995 - 2018 and the main factors that contribute to them in Spain; and to discover what national policies and actions are best suited to combat climate change. To fulfil these purposes, this work has been structured in three clearly differentiated parts.

The first part begins by defining climate change and why it represents a market failure. Next, it is explained the main characteristics of the GHG evolution and it is studied in depth the main global consequences and impacts of the climate change in Spain. Finally, it is made a compilation of the main international agreements, national policies and current financing instruments.

In the second part, the four variables of the kaya identity are individually analysed within the Spanish framework in order to define them and understand their individual characteristics and historical and estimated future evolution.

In light of what was discovered in the previous part, in the third part, the application of data analysis is carried out. The purpose is to give an integrated look at the four variables studied and the historical evolution of the Spanish economy and identify which variables have had a greater or lesser influence on the origin and evolution of climate change to better understand the dynamics and magnitude of the current situation in Spain. Finally, the main conclusions drawn from the analysis are presented.

2. Climate Change Framework

2.1. Definition of climate change

We talk about climate when we refer to conditions that are common in a given place, however, the climate changes. Indeed, the climate has faced important changes throughout Earth's history, due to natural causes. For example, the last glacier period. (Miteco, 2021)

Climate change is caused by changes in the variability of climate properties that persist for a long period. These changes can be due to natural internal processes (modulations of solar cycles, volcanic eruptions) or external forces (persistent anthropogenic changes in the composition of the atmosphere or in land use).

On the other hand, note that the Framework Convention on Climate Change (UNFCCC, 1992), in its Article 1, defines climate change as: “a change of climate which is attributed directly or indirectly to human activity that alters the composition of the global atmosphere and which is in addition to natural climate variability observed over comparable time periods”.

The UNFCCC makes a distinction between climate change attributable to human activities altering the atmospheric composition and climate variability attributable to natural causes (IPCC, 2018)

The current change in climate is very different from previous ones, essentially for two reasons:

1. Its causes, scientists agree that the cause of the current climate change is the emission of so-called “greenhouse gases” as a result of human activity. These gases increase the capacity of the earth’s atmosphere to retain heat, leading to the phenomenon of global warming.
2. Its speed, the current climate change is happening very quickly, which makes it very difficult, both for nature and for human societies, to adapt to new conditions (Miteco, 2021).

2.1.1. Climate change as a market failure

The analysis of change, from an economic point of view, introduces the question of market failures.

The atmosphere is a common good so in the absence of property the capacity of the atmosphere tends to be overused. At the same time, if the economic system of a country emits greenhouse gases, it is polluting and generating negative externalities to others.

In addition, the climate changes polices have two main characteristics to be a public good:

- Not rivalry: One person's enjoyment of the climate does not diminish the capacity of others to enjoy it too. For example, if a country assumes the costs of reducing greenhouse gases, it is not only benefiting itself, but also benefiting the whole, as it is a global problem.
- Not excludable: Those who do not pay for it can not be excluded from enjoying its benefits. You cannot prevent other countries from taking advantage of another country taking action against climate change

Climate change represents a global market failure. Economic activity (industry, energy, transport and land-use) involves the emission of greenhouse gases (GHGs). As GHGs accumulate in the atmosphere, temperatures increase, and the climatic changes that result impose costs on society. Those who produce greenhouse-gas emissions are bringing about climate change, thereby imposing costs on the world and on future generations, but they do not face directly, neither via markets nor in other ways, the full consequences of the costs of their actions.

Markets do not automatically provide the right type and quantity of public goods and in this case, they do not reflect the consequences of different consumption and investment choices for the climate. Thus, human-induced climate change is at its most basic level an externality.

Climate change has special features that pose particular challenges for the economy externalities theory.

a. Causes and consequences are global. The incremental impact of a tonne of GHG on climate change is independent of where in the world it is emitted
b. The impacts of climate change are persistent and develop over time
c. The potential size, type and timing of impacts and the costs of combating climates are uncertainties
d. The impacts are likely to have significant effect on the global economy if action is not taken to prevent climate change (Jacobs, 2006).

Regarding the first characteristic, we have to take into account although the impact is global; it is not equal in all countries.

It is now widely demonstrated that the developed countries (more likely to consume more, have larger homes, travel more or have larger vehicles) pollute more and have a larger carbon footprint than the developing ones, but are the polluting countries the most affected by the consequences of climate change? The answer is negative; the country's most vulnerable to global warming are also those, which have contributed the least to it (Clément Fournier, 2020).

Figure 1: Impact of climate change on national economy (1991-2010).

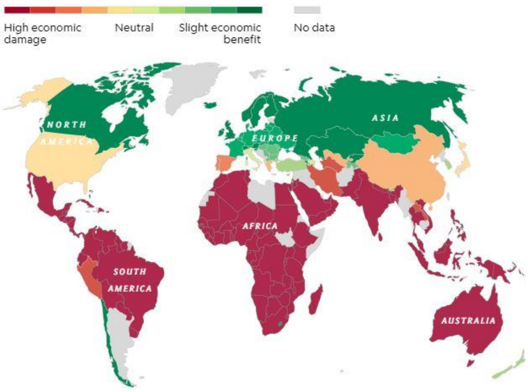
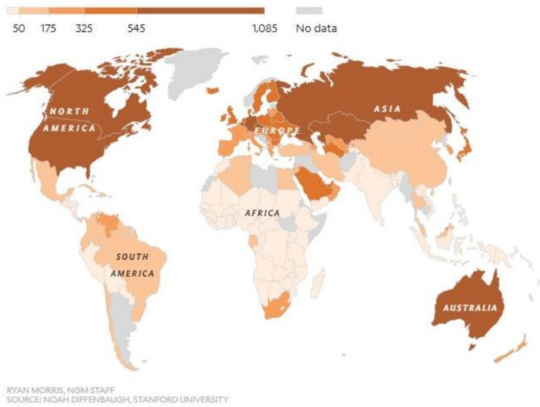


Figure 2. Cumulative carbon dioxide emissions per capita, in tons (1991-2010).



Source: Noah Diffenbaugh edited by National Geographic (2020).

The different severity of the impact in the different areas entails serious problems in the search for solutions, since it increases the incentives of the countries to behave in an advantageous way: the countries least affected by their geographical location, their greater capacity to adapt and their less vulnerability. They are also largely the most responsible and have little incentive to participate in abatement agreements that involve sacrifices (Vide et al., 2007).

2.2. Causes

Much of the debate over the attribution of climate change has now been resolved. It is clear that while natural factors, such as changes in solar intensity and volcanic eruptions, may explain much of the trend in global temperatures in the early 19th century, rising levels of greenhouse gases provide the only plausible explanation for the observed trend of at least the last 50 years. During this period, global average sustained warming contrasts sharply with the slight warming expected from natural factors alone (Jacobs, 2006).

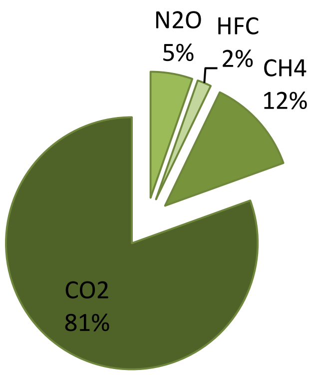
More specifically, climate change is the result of the clustering of certain gases, known as Greenhouse Gases (GHGs), on the atmosphere, which block heat from escaping and remain there.

Next, the evolution of greenhouse gases in Spain will be analysed to find out what the climate change situation is like.

2.2.1. Greenhouse gases evolution in Spain

First, it needs to clarify that CO_2 represents the 81% of the total GHG emissions followed by methane (12 %) as it can be observed in the figure 3. For that reason, this paper is going to focus on this specific gas.

Figure 3. GHG Emissions by gas in Spain (2018)



Source: Own elaboration with data from Instituto Nacional de Estadística (2021)

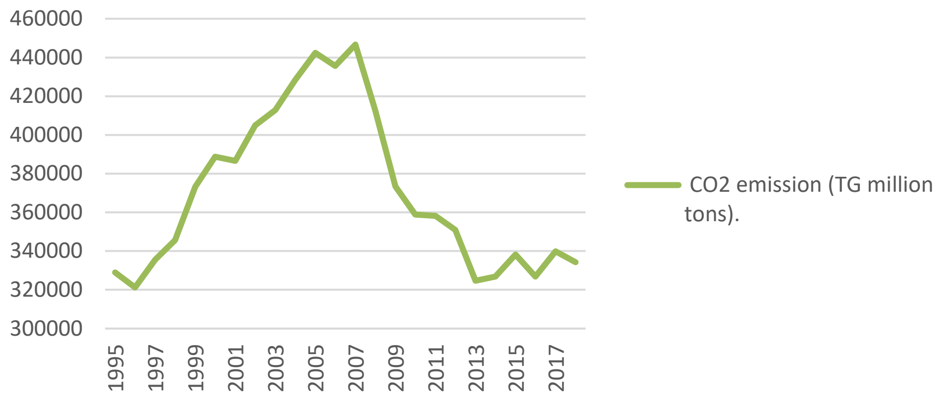
In addition, figure 4 includes long-term evolution of Spanish CO_2 emissions. It can be observed a clear upward trend of emissions in the first five years followed by a second period of decline. The last few years has been characterized by ups and downs but remaining quite constant

The first period, 1990-2005, the acceleration of the economy before the economic crisis meant an increase in emissions and demand for energy, which, as we will see later, is the sector that emits the most GHG emissions.

In the second period, 2007-2010, there is a decrease in GHG emissions caused by the contraction of the economy and, due to a greater share of renewable energy in the electricity generation mix. Finally, between 2010 and 2019, GHG emissions are generally constant although with a downward trend.

Greenhouse Gas (GHG) emissions nationwide were 323,220 million tons of CO_2-eq in 2019. The level of total gross emissions is + 12.3% compared to 1990 and -26.47% compared to 2005.

Figure 4. Evolution of the Spanish CO_2 emission (TG million tons).

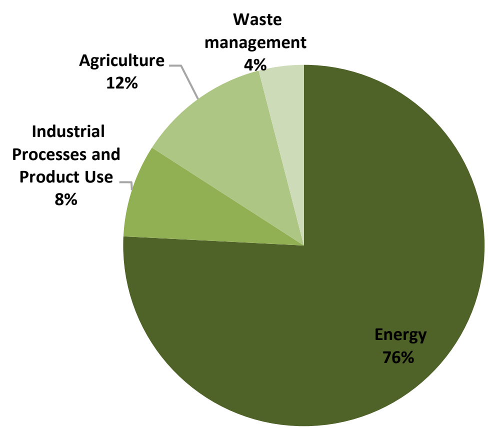


Source: Own elaboration with data from Instituto Nacional de Estadística (2021)

Knowing CO_2 emission is the main cause of climate change and its historical evolution, we could ask ourselves, which is the cause of the rise of CO_2 emissions. If we stop to think for a minute about the consumption decisions that we take on a daily basis, we will realize that most of them involve CO_2 emissions: taking the car, turning the heating on in winter or taking a shower, for instance. Indeed, about 90% of the energy we use comes from fossil fuels, which emit CO_2 when they are burnt, whilst enlarging the existent Greenhouse effect. Thus, the starting point of all these emissions seems to lay in humans (Hidalgo, 2019).

When breaking down the emissions of GHGs by the economic activities, we find that the energy sector accounts for 65% of the total emissions. Alongside, agriculture account for 11%, industrials process 10% and finally waste management 4%. The most part of energy sector emissions come from the electricity and heat production and transport

Figure 5. GHG Emissions by activity sector in Spain (2018)



Source: Own elaboration with data from Instituto Nacional de Estadística (2021)

Finally, in the table 1 is observed that Spain is among the ten countries that issued the most CO_2 in 2018 represented 7% of the2 total emissions in Europe. However, if we relativize and compare CO_2 emissions per capita, Spain is in the European average placing the position 19th. The same dynamic is experienced in the case of Turkey.

On the contrary, Luxembourg represents 0,25% of the total European emissions but in terms of CO_2 emissions per capita, it places the first position. Other different example would be Bulgary that maintains almost the same position under both terms.

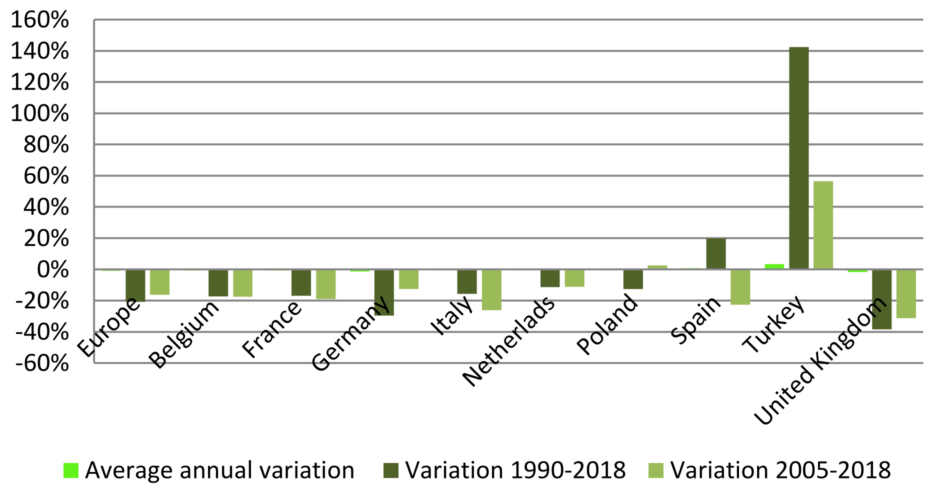
Table 1. CO_2 per capita (million tonnes/million people) ad total CO_2 emission (million tonnes) per European country (2018)

	Country	CO_2 emissions per capita	Country	Total CO_2 emissions
1	Luxembourg	20,33	Germany	888,72
2	Iceland	17,47	Turkey	533,05
3	Estonia	15,27	United Kingdom	498,75
4	Ireland	13,19	France	462,79
5	Czechia	12,17	Italy	439,26
6	Netherlands	11,63	Poland	415,86
7	Cyprus	11,33	**Spain**	**352,21**
8	Poland	10,95	Netherlands	200,46
9	Belgium	10,85	Czechia	129,39
10	Germany including former GDR	10,72	Belgium	123,64
19	**Spain**	**7,53**		

Source: Own elaboration with data from European Agency Environment (2021)

Looking at the graph 6, Spain, together with Turkey, is the only country with a positive average annual variation of its emissions within the period 1990-2018. Indeed, it is the second country to have a positive variation in its emissions since 1990.

Figure 6. GHG Annual variation of the ten most emitter country in Europe.



Source: Own elaboration with data from Instituto Nacional de Estadísitca (INE) and European Environment Agency (2021).

In conclusion, the main cause of climate change in Spain is the emission of CO_2 by the energy sector and compared to industrialized countries, Spain remains one of the countries where total emissions have increased the most since 1990. On the other hand, it should be highlighted that It is relatively normal for Spain to be one of the largest emitters in Europe given the size of its economy and, although there is much to do and improve, it must be celebrated that in per capita terms its weight is much less.

2.3. Consequences

Global warming causes serious damage to the environment and societies, but the main concerns are unmanaged systems and tipping points. The latter concepts are discontinuities in climatic behavior that bring the natural system to a new state, probably resulting in an irreversible bad balance.

The main causes of the tipping points are nonlinear reactions to stresses. These dynamics are far from being understood and even if they are, the difficulty to assess the impacts and the gravity of the consequences is much larger.

An example of these systems comprise the loss of the Greenland Ice Sheet, which is rapidly melting due to the current temperature increase (Brennan, 2020). Changes to the Greenland and Antarctic ice sheets are considerable societal importance, as they directly affect global sea levels. The full set of consequences of future melt remain uncertain, but even a small increase in sea level can have devastating effects on ports and coastal zones, changes in the patterns of ocean and atmospheric circulation, cause destructive erosion, wetland flooding, and aquifer and agricultural soil contamination with salt. (California Institute of Technology, 2019).

Then, when the Arctic warms and the ice recedes, positive feedback mechanisms are produced, among them, a lower capacity for reflection of the ice (albedo) and the release of dangerous greenhouse gases from their long storage in the permafrost (the permanently frozen soil layer), causing an increase in global climate change (Greenpeace, 2021)

Positive feedback flows, as can be deduced from the previous paragraph, are mechanism in which a disturbance in one climatic magnitude causes a change in a second magnitude, and the change in this ultimately leads to an added change in the first magnitude. This feedback loop makes climate change unpredictable and represents a threat to the runaway spiral of global warming (Ibáñez, 2020).

There are several positive feedback flows that accelerate the effects of climate change but it will not delve into them in depth in this work because it is not the objective of it.

On the other hand, unmanaged systems that largely operate with barely any human intervention are the most affected systems by global warming. These comprise, for example extreme weather as longer and stronger hurricanes, heat waves, or frosts. This causes, in addition to the impact on infrastructure and large monetary losses, the impact on natural ecosystems and represents a challenge for the development and maintenance of numerous economic activities that depend directly on them, deteriorating economic and social well-being. (Alvarez-Yepiz, & Martinez-Yrízar, s. f.)

Overall, I would like to highlight that the severity of such impacts depends on the system that is affected and the degree of human intervention placed on each system will potentially determine the extent of the damage caused by global warming.

2.3.1. Global economy impacts

Climate change have pervasive socio-economic consequences that not only affect major economic sectors such as agriculture, energy or healthcare, but also result in changes to the supply and demand for goods and services of all sectors of the economy, although with varying levels of intensity.

Therefore, in order to make an efficient climate policy, it is necessary to study how greenhouse gas emissions are going to affect global warming and the economy in the future. One of the reference authors in this study area is William Nordhaus.

William Nordhaus, winner of the 2018 Nobel Prize in Economics, studies the climate policy from the perspective of the cost-benefit analysis. The basic principle is that action must be taken, but only as long as the additional costs of reducing greenhouse gas emissions are less than the climate benefits of this reduction, a criterion that would give the optimal level of emissions (Roca, 2018). Based on this principle, Nordhaus (1992) developed the dynamic integrated climate-economy (DICE) model to study optimal climate policy.

The DICE model is a neoclassical growth model that accounts for how carbon emissions today will affect global warming, and economic output, in the future. The main innovation is the modelling of climate change and its effect on the economy.

In the latest revision of his model, Nordhaus (2018) estimates that the current trend would lead to an average temperature variation that would exceed 4 ºC by 2100, while the “economic optimum” from the point of view of cost-benefit analysis would lead to an increase in temperature of around 3.5 ºC

However, this model has a lot of controversial and criticism. Indeed, the same day Nobel award to Nordhaus was announced, the Intergovernmental Panel on Climate Change (IPCC) report was released. The reported called for a rapid and radical reduction of emissions to avoid that the average temperature exceeds pre-industrial levels by 1.5 ºC, since a change of 1.5 to 2 ºC, may cause the impacts to be dramatic..

On another hand, Kahn et al (2019) study the long-term impact of climate change on economic activity across countries, using a stochastic growth model where labour productivity is affected by country-specific climate variables. Using a panel data set of 174 countries over the years 1960 to 2014, they find that per-capita real output growth is adversely affected by persistent changes in the temperature.

They showed that if temperatures deviates from its historical norm by 1ºC annually, long term income growth will be lower by 0,0543 percentage points per year. Moreover, keeping the increase in the global average temperature to below 2ºC above pre-industrial levels as agreed in the Paris Agreement, will reduce global income by 1.07 percent by 2100.

However, an increase in average global temperatures of 4ºC reduces world's real GDP per capita by 7.22 percent by 2100, with the size of these income effects varying significantly across countries depending on the pace of temperature increases and variability of climate conditions in each country (Matthew et al 2019)

In addition, Burke et al. (2015) discovered the results of the effects of the climate change over the world are nonlinear. Looking across all countries in the world, they found that the effect of warming temperatures depends on when the average temperature started. The warmer average temperature to start, the more negative the impacts of additional warming.

Countries with cool average temperatures, such as countries in northern Europe, tend to see higher than average growth in economic output when temperatures are warmer than average. Countries with relatively hot average temperatures, such as countries in the tropics, tend to see slower than average economic growth when temperatures warm.

This nonlinearity of regional and global damages over time reflects a combination of several key mechanisms.

1. As regional temperatures increase, many of the negative impacts become more than proportionately stronger.
2. Nonlinearity arises from the limited possibilities in the economy to adjust to changes in factor supply and productivity.
3. Losses are larger in regions that are projected to have high growth rates, and whose share in global GDP thus rises over time.
4. Some of the impacts directly affect the growth rate of the economy, rather than merely the level of GDP. This holds especially for impacts that imply a destruction of the capital stock (OECD, 2015).

2.4. Impacts in Spain

Spain, because of its geographical location and socio-economic characteristics, is very vulnerable to climate change and is already being affected. The impacts of climate change can have particularly serious consequences, including the increasing of the temperature, declining water resources and coastal regression, biodiversity losses and alterations in natural ecosystems, increases in soil erosion processes and loss of life and property resulting from intensified adverse events associated with extreme weather events , such as wildfires, heat waves and possible flooding (Sanz & Galán, 2021). Some of these consequences will be briefly discussed below.

In addition, the effects of climate change will vary from area to area and are likely to magnify existing regional differences in natural resources and assets. An example of this is one of the most significant trends, the "mediterraneanization" of the northern peninsular and the "aridization" of the south (Moncloa, 2019).

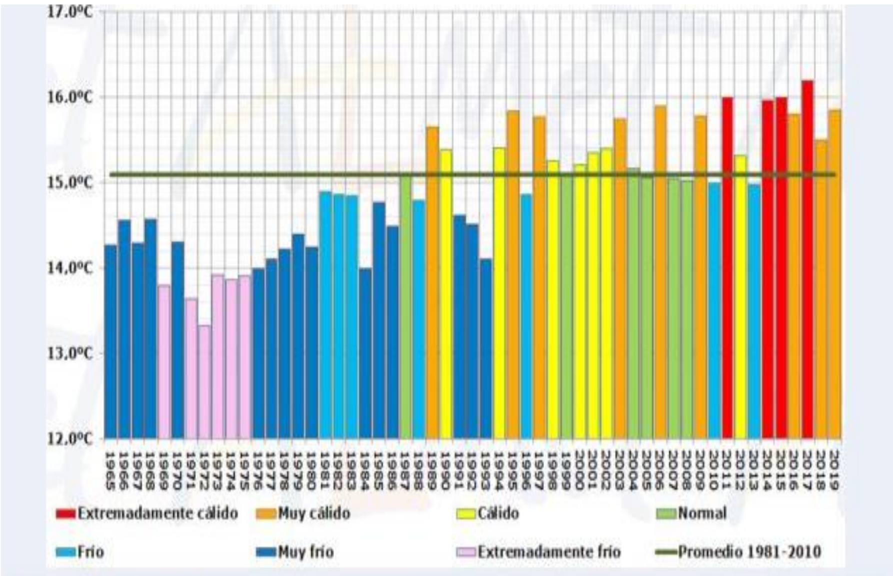
2.4.1. Impacts on the climate and environment

A. Increase of the temperature, heat waves and longer summers

The average temperature in Spain has risen around 1.7ºC since pre-industrial times (Aemet, 2019b). Indeed, 2019 has been extremely warm in most of mainland Spain, with an average temperature of 15.9ºC, a value that exceeds by 0.8ºC at the average annual value (reference period 1981-2010). It has been the sixth warmest year since the beginning of the series in 1965.

The Hawkins diagram, which chronologically represents the evolution of annual temperature, reveals a clear trend from 1971 to higher temperatures, both in average and high and minimum values (Aemet, 2019a).

Figure 7. Annual average temperature in Spain.



Source: Aemet (2019).

This thermal increase is most noticeable in spring and above all, in summer. It has been extremely warm in some points in the center and east of the Peninsula (Aemet, 2019d). According to Aemet's study, summer has increased by about 9 days on average per decade and currently spans 5 weeks longer than in the early 1980s (Aemet, 2019a)

Regarding heat waves, the data provided by Aemet (2019c) show that in the peninsula since 1984, the number of days that the heat wave temperature thresholds have been exceeded has doubled. Furthermore, the heat waves recorded in June, when they have the most health consequences, are now 10 times more frequent than in the 1980s and 1990s.

B. Precipitation, and rising sea level

Different regional studies analyzed precipitations trends covering different periods, but in general, they recorded dominant negative trends during the past decades. Camuffo et al. (2013) analyzed precipitation changes from two observatories in Spain and showed that the precipitation decrease between 1960-2005 in spring and summer is unprecedented since the beginning of the 19th century.

Moreover, Río et al. (2011) also analyzed the spatial distribution of rainfall trends (1961-2006) and revealed a decrease in rainfall in more than 28% of the Spanish territory during summer and winter (Ministry for Ecological Transition, 2018).

Finally, in relation to the ocean, sea level rise has been particularly notable since 1993 in the Strait area, Canary archipelago and Atlantic coast. The rise of the average sea level on the Atlantic-Cantabrian coast follows the overall average trend of 1.5 to 1.9 mm/year, between 1900 and 2010, and from 2.8 mm/year to 3.6 mm/year, between 1993 and 2010. However, there is greater uncertainty as to the average sea level in the Mediterranean due to regional effects (Losada, Izaguirre & Diaz, 2014).

C. Semi-arid climate expansion

One way to quantify the trend towards higher temperatures is through the evolution of the Köppen climate classification (based on temperature and precipitation and their distribution throughout the year) developed for three different reference periods (1961-1990 , 1971-2000 and 1981-2010).

The results show a clear increase in the extension of semi-arid climates that can be estimated at more than 30,000 km^2 (around 6% of the surface of Spain). The most affected areas are Castilla-La Mancha, the Ebro Valley and the southeast of the peninsula (AEMET, 2019).

2.4.2. Impacts on human health

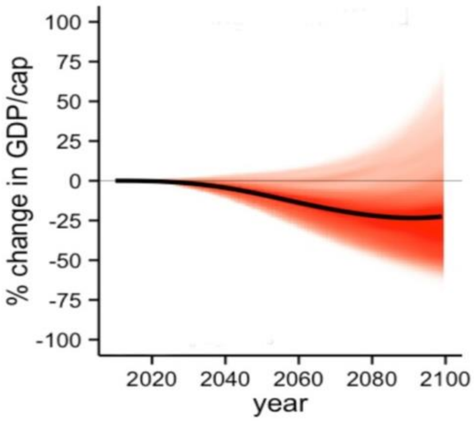
Climate change affects the health of the Spanish population through its direct effects, which are extreme thermal events, air pollution, mortality related to temperatures an with diseases transmitted by water and food, and with the effects on infections, injuries, mental health, nutritional elements. However, also through indirect effects caused by adaptation measures on climate, environmental, social, demographic and economic factors and consequently on health impacts.

The General Directorate of Public Health, Quality and Innovation (2013) identified as priority health effects those related to extreme temperatures and events, water and air quality, and vector-transmitted diseases.

2.4.3. Impacts on the economy

Burke, Hsiang, and Miguel (2015) calculated how climate change would affect GDP per capita in Spain between now and 2100. The black line in this plot represents the "best estimate" of impacts for Spain, while the red shaded area represents our uncertainty in this estimate. Based on the uncertainty shown in red, they were able to provide the estimated likelihood that by 2100; climate change will cause losses of at least 0%, 10%, 20%, and 50% in Spain.

Figure 8. Economy impact of climate change on Spain



Source: Burke, Hsiang, and Miguel (2015).

However, the size of the Spanish economy is very difficult to quantify and is subject to significant uncertainty. However, it is safe to say that climate change will be a persistent force for decades to come, affecting some of the foundations of the Spanish economic model. The promotion of the European Green Deal to policies that accelerate the transformation of the European economy and its transfer to Spain through the Integrated Energy and Climate Plan represents an opportunity to prepare and mitigate the net impact in the future (García, & del Val, 2020).

2.5. International Agreements and National Polices

Despite the difficulty of tackling the fight against climate change due to the complex association of public policies characteristic with the concept of public good, as it is explained in previous sections, the EU has always assumed a position of international leadership through a multilateral response based on the collaboration of all countries. In this matter, the different agreements have been defended, adopting ambitious policies and measures to mitigate and adapt to climate change.

Some of these more important agreements and conventions are the following

1991

The IPCC prepares its first assessment report:

It underlines the importance of climate change and defines it as a challenge that requires international cooperation to cope with its consequences. The report therefore plays a decisive role in the process of paving the way for the establishment of the United Nations Framework Convention on Climate Change (UNFCCC) (IPCC 2010)

1992

The United Nations Conference on Environment and Development in Rio de Janeiro (UNFCCC)

Governments are invited to sign the Convention on Climate Change, a text created at the United Nations headquarters in New York in the same year. The essential objective is to develop an international cooperative framework that allows all countries to address the risks posed by climate change and promote cooperation. For the first time, binding targets for reducing gas emissions are set for industrialized countries (United Nations 1992)

This Convention was initially signed by 166 countries and finally entered into force on 21 March 1994. It has now been ratified by 197 countries. (Iberdrola, 2019)

1997

Kyoto Protocol

The Kyoto Protocol is the world's first greenhouse gas emission reduction treaty. The Protocol legally links developed countries to emission reduction targets. (European Commission, 2021)

In particular, the Kyoto Protocol puts into operation the United Nations Framework Convention on Climate Change by committing industrialized countries to limit and reduce greenhouse gas (GHG) emissions in line with agreed individual targets. The Convention itself only calls on these countries to adopt mitigation policies and measures and to report regularly. It was adopted in 2005 (UNFCC,

1998-2005

Emissions Trading System

The European Union's Emissions Trading System, the world's first emissions trading scheme, is beginning to function as the main pillar of EU climate policy. (European Commission, 2021a)

2010

Cancun Agreement

Governments adopt the Cancun Agreements with the aim of helping developing countries deal with climate change. The Green Climate Fund is established. (UNFCC, 2021)

December 2015

The Paris Agreement

It is based on the Convention (UNFCCC) and, for the first time, makes all countries have a common cause to undertake ambitious efforts to combat and adapt to climate change, with increased support to help developing countries do so.

Its main objective is to keep the temperature increase well below 2ºC from pre-industrial levels and at the same time, efforts will continue to limit the temperature increase to 1.5Cº to avoid the most catastrophic impacts.

On 4 November 2016, it entered into force in general by being ratified by more than 55 parts totaling more than 55% of global greenhouse gas emissions. (European Parliament, 2021)

November 2019

Climate emergency declaration by the European Parliament

The European Parliament declares a climate emergency in Europe and around the world. MEPs want the Commission to ensure that all relevant legislative and budgetary proposals are fully aligned with the aim of limiting global warming below 1.5ºC. (European Parliament, 2019)

December 2019

Presentation of the European Green Deal

It is the roadmap for building a sustainable economy in the EU. It stablish an action plan to drive efficient use of resources by move to a clean, circular economy, restore biodiversity and reduce pollution (European Commission, 2021)

October 2020

European Climate Law

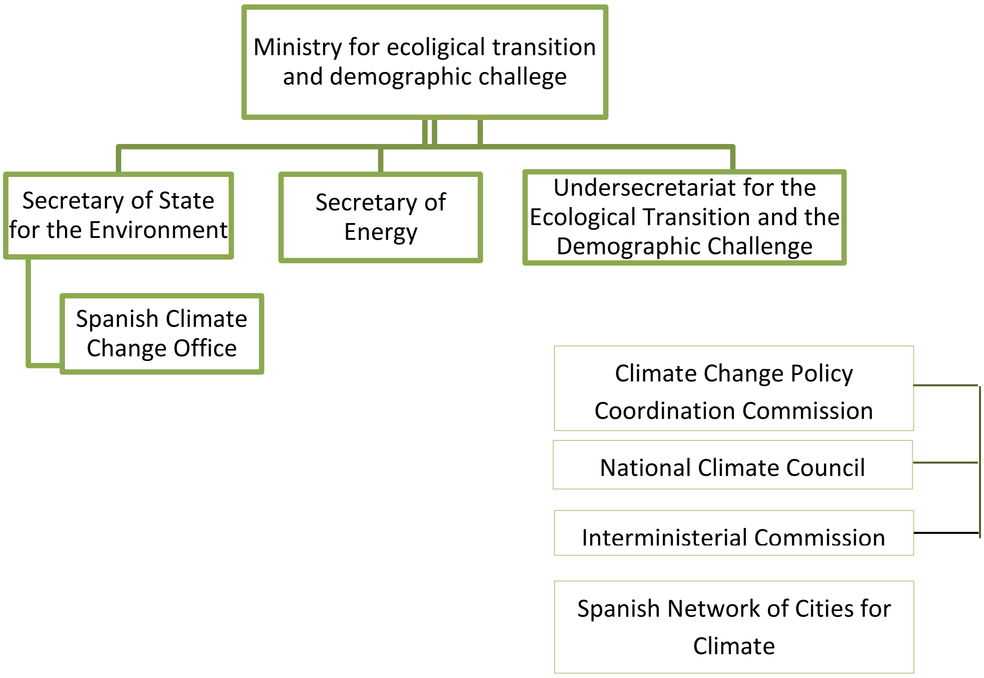
It aims to establish in the legislation the EU's climate neutrality target by 2050, in line with the scientific results of the IPCC and the Intergovernmental Science-Policy Platform on Biodiversity and Ecosystem Services (IPBES), and to contribute to the implementation of the Paris Agreement on Climate Change.

It aims to establish the framework for achieving EU climate neutrality. Its aim is to point out a path towards climate neutrality, as well as to increase the safety and confidence of businesses, workers, investors and consumers in EU engagement and to strengthen transparency and accountability, which will be in favor of prosperity and job creation. (European, Proposal for the Rule of Procedure of the European Parliament and of the Council establishing the framework for achieving climate neutrality and amending Regulation (EU) 2018/1999 (European Commission, 2020)

2.5.1. National Policies and Actions

In this context, Spain is firmly committed to the development of policies and measures that promote the reduction of greenhouse gas emissions and an adequate adaptation to the impacts of climate change. The agencies and institutions involved in the fight against climate change at the national level are those explained in the following paragraphs (Ministerio de Agricultura, Alimentación y Medio Ambiente, 2015).

Figure 9. Agencies and institutions involved in the fight against climate change at the national level.



Source: Own Elaboration.

The Ministry for Ecological Transition and Demographic challenge (Miteco), through the following Secretariats of State for the Environment (SEMA), the Ministry of Energy and the Undersecretary for Ecological Transition and the Demographic Challenge, directs and coordinates the implementation of competences in relation to the formulation of climate change policies among other issues. These powers are exercised through the General Direction of the Spanish Office for Climate Change.

This structure is supported by an inter-ministerial coordination system, the inter-ministerial Commission for Climate Change, attached to the Ecological Transition and demographic challenge. To strengthen coordination between territorial administrations, the National Climate Council and the Climate Change Policy Coordination Commission were created. In addition, in 2017, the Working Group for the Coordination of the Development of the Law on Climate Change and Energy Transition and the National Integrated Energy and Climate Plan, and the Inter-Ministerial Commission for the Development of the Spanish Circular Economy Strategy.

Finally, the vast majority of local governments are working very actively to prevent climate change. The development of these actions is part of the Spanish Network of Cities for Climate (RECC), formed by the Local Entities that are integrating climate protection into their municipal policies. (Miteco, 2020).

2.5.1.1. Policies and actions

Spain, as part of the EU, and as a signatory to the United Nations Framework Convention on Climate Change, Kyoto Protocol, Paris Agreement and the European Green Deal, has an obligation to implement the different rules agreed both internationally and at European level.

In order to fulfill its obligations and agreements, Spain published on May 2021, the **Climate Change and Energy Transition Law.** It is and institutional framework that aims to facilitate the progressive adaptation of the country's reality to the demands that regulate climate action and guarantee the coordination of sectoral policies. This ensures coherence between them and synergies to achieve the objective of climate neutrality.

It places the fight against climate change and the energy transition at the core of political action, as a key vector for the economy and society to build the future and generate new socio-economic opportunities (Agencia Estatal Boletín Oficial del Estado, 2021).

In addition, two new fundamental figures were created to determine the framework of action in terms of action against climate change.

i) National Integrated Energy and Climate Plan 2021-2030 (NIECP)

Its objective is to guide the main decisions on energy and climate policy and the public and private investments associated with it and ensuring the achievement of collective progress in the general and specific objectives of the Energy Union for 2030 and in the long term, in line with the 2015 Paris Agreement.

Spain's NIECP identifies challenges and opportunities throughout the five dimensions of the Energy Union: decarbonisation, including renewable energy; energy efficiency; energy security; the internal market for energy and research, innovation and competitiveness (Miteco, 2020).

ii) The Decarbonization Strategy

It projects a path in accordance with the decarbonization objectives of the economy for the year 2050 and with the actions planned for 2030, which will require the mobilization of different administrations and private actors.

Finally, publications on climate change are coordinated and organized through the **National Climate Change Adaptation Plan (NCCAP),** which establishes the national framework of reference and coordination for initiatives and activities for impact assessment, vulnerability and adaptation to climate change (Miteco, 2020).

The NCCAP has been developed through three successive work programs, which have jointly defined more than 400 actions, 80% already implemented or in the process of being implemented. (Miteco, 2020).

The actions created by these policies can be divided into three groups: international, sector and cross-sectoral policies. The following table summarizes main actions developed by each policies.

Table 2. Main actions developed by each type of policies.

<table>
<tr><td rowspan="2">Cross-sectoral policies</td><td>Diffuse Sectors Roadmap 2020</td><td>The roadmap proposes action measures in the fuzzy sectors that allows Spain to decouple growth and emissions (Miteco, 2014).</td></tr>
<tr><td>Climate project</td><td>Financial instrument that translates into a payment per ton of CO_2 equivalent (tCO_2e) reduced and verified promoted by the Carbon Fund for a Sustainable Economy (ESF-CO_2) (Miteco, 2019).</td></tr>
<tr><td rowspan="2">Sector policies</td><td>Environment Boost Plans (PIMAs)</td><td>Tool for promoting a set of concrete measures that contribute to the improvement of the environment Currently there are six plans: PIMA Cold, Transport, Earth, Air, Sun, Waste and Adaptation, Company. (Miteco, 2021.).</td></tr>
<tr><td>Biodiversity Foundation</td><td>Entity that contribute to the protection and conservation of our natural heritage and biodiversity. (Miteco, 2015).</td></tr>
<tr><td rowspan="2">International policies</td><td>Plans Directors of Spanish Cooperation</td><td>It aims to contribute to the application of the 2030 Agenda as a new international commitment and strategy to achieve the Sustainable Development Goals (SDG), under its motto of leaving no one behind. (Cooperación Española, 2021)</td></tr>
<tr><td colspan="2">Others: the Fund for the Internationalization of Enterprise (FIEM); The Spanish Development Finance Company (COFIDES); Spanish Export Credit Insurance Company (CESCE); And the Official Credit Institute (ICO) (Miteco, 2021.).</td></tr>
</table>

Source: Own elaboration.

2.5.2. Financing

Achieving the proposed climate change adaptation objectives requires alignment of all financial resources, both public and private. Indeed, the Paris Agreement itself recognizes, as one of its fundamental objectives, the need to ensure the coherence of financial flows with low-emission and climate-resilient development.

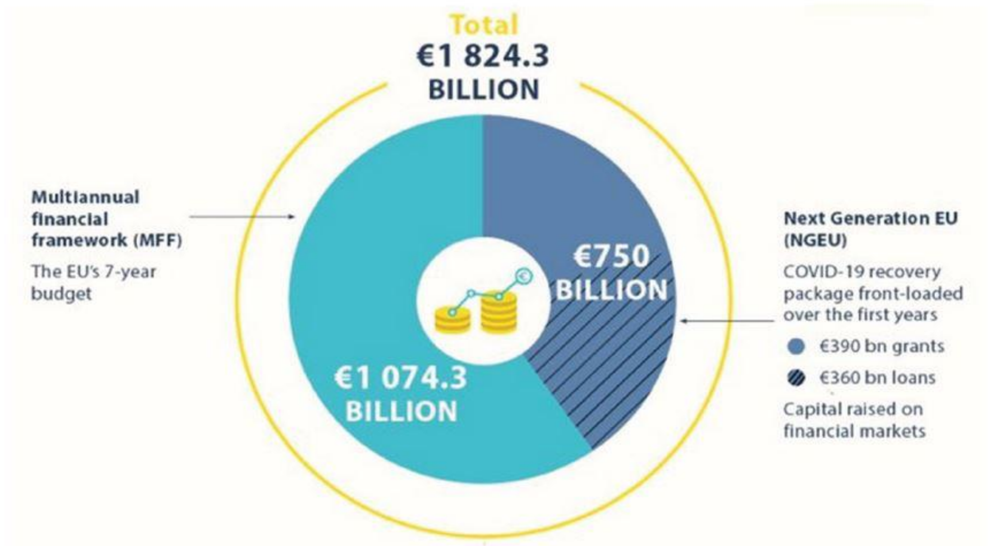
On the other hand, from an economic perspective, it is necessary to face the cost and financing that climate policies currently entail since, as seen in the previous section "global economy impacts", the risk of not doing it implies bearing higher future costs of no action. Therefore, not taking actions may cause a problem of intergenerational equity.

To fulfill this need, it was launched the **Multiannual Financial Framework 2021-2027 (MFF**) and, linked to this framework, the exceptional funds of the **Next Generation EU**. These financial instruments will help to combat the effects of the COVID-19 crisis and to develop the European green transition policies contained in the Green Deal, including the new and more ambitious European Adaptation Strategy.

The new Framework gives Member States a budget of EUR 1.824,3 billion euros (2018 prices), divided on:

a. Multiannual financial framework (MFF): 1.074,3 billion euros.
b. Next Generation EU (NGEU): 750 billion euros.

Figure 10. Overall budget 2021-2027



Source: European Commission, 2021

A) Multiannual Financial Framework 2021-2027

The objective of the MFF negotiations is to define, in general terms, the maximum limits of the amount of money that European Union can spend, the spending programmes that determine where the money should be allocated and the rules that establish how to finance the expenditures.

The Regulation provides for a long-term EU budget of 1.0743 billion euros for the EU27 at 2018 prices. As it is showed in the table 3, the MFF budget is divided in seven rubrics and 356.4 billion euros will be allocated to natural resources and environment that represents the 31,18% of the total budget (European Council, 2021).

Table 3. MFP 2021-2027. Global figures

Rubrics	Million euros (Constant price 2018)
Rubric 1. Single market, innovation and digital economy	132.781
Rubric 2. Cohesion, resilience and values	377.767
Rubric 3. Natural resources and environment	356.374
Rubric 4. Migración y gestión de fronteras	22.671
Rubric 5. Security and Defense	13.185
Rubric 6. Neighbourhood and rest of the world	98.419
Rubric 7. European Public Administration	73.103
Total	**1.074.300**

Source: Own elaboration from Ministerio de Política Territorial y Función Pública 2021

Table 4. Rubric 3, natural resources and environment.

Rubric 3. Natural resources and environment	Million euros (Constant Prices 2018)	
Agricultural and Fisheries Policy	342.876	
Pilar I (EAGF)	258.594	
Pilar II (EAFRD)	77.850	
FEMP	5.430	
Rest	1.002	
Environment and Climate Action	12838	
LIFE Programme	4.812	
Just Transition Fund	7.500	
Rest	526	
Total	**356.374**	**33,18% of the total MFP budget**

Source: Own elaboration from Ministerio de Política Territorial y Función Pública, 2021.

B) Next Generation EU

Two financial instruments are created under the Next Generation EU initiative:

a. Recovery and Resilience Mechanism (RRM)

Through this mechanism, Spain will access a total of 140,000 million euros between 2021 and 2026, of which about of 60,000 million will come in the form of transfers.

In order to have access for the RRM, Spain and the Member States must present National Recovery and Resilience Plans in which action programs are defined with the aim of intensifying the potential for growth, job creation and economic and social resilience, as well as accelerate green and digital transitions (Presidencia del Gobierno, 2021b)

The Plan is articulated in a coherent set of investments to be made between 2021 and 2023 and in an ambitious program of structural and legislative reforms aimed at addressing the main challenges of the country. It is structured around four transversal axes that will backbone the transformation of the economy as a whole and that are fully aligned with the strategic agendas of the EU, the 2030 Agenda and the United Nations Sustainable Development Goals: the ecological transition, the digital transformation, gender equality and social and territorial cohesion (Presidencia del Gobierno, 2021a).

A key element of the Recovery Plan is to accelerate the ecological transition. To achieve this, it is expected to dedicate a significant volume of public resources to promoting the green transition, with a contribution of 40.29% (Presidencia del Gobierno, 2021c).

b. React-EU

It will be used to combat the effects of the Covid-19 crisis and Spain will be endowed with 10.269 million euros. These resources will be implemented through the European Regional Development Fund (ERDF), the European Social Fund (ESF) and the European Aid Fund for the Most Deprived (FEAD).

Table 5. Multiannual Financial Framework 2021-2027 (Million euros). Principal distribution by Member State of directly allocated funds

Member States	RRM (Transfers)	React EU	Total
1. Italy	65.456	10.693	76.149
2. Spain	59.168	10.269	69.437
3. France	37.394	2.926	40.320
4. Poland	23.060	1.556	24.616
5.Germany	22.717	1.785	24.502
Total	**312.500**	**37.500**	**350.000**

Source: Own elaboration from Ministerio de Política Territorial y Función Pública, (2021).

3. Kaya Identity

It is a scientific evidence that the causes of climate change are anthropogenic according to the Intergovernmental Panel on Climate Change (5th IPCC Report). The recent Paris Agreement adopted at COP21 (December 2015) shows that it is not easy to reach agreements, since energy, economic, social and environmental factors are intermingled.

The debate about the main drivers of GHG emissions is long-standing. Historically, discussions have been structured around the interrelationships between demographic (population), economic (GDP and GDP per capita) and technological variables.

This notion was formalized in the so-called "IPAT Identity" which states that environmental impact (1) originate from three factors (Equation 1):

1. Population (P);

2. Per capita income (A - "influx");

3. Technology (T).

(1) Impact above environment = “Population” x “Income per capita “ x “Technology”

As Garza, Güell (2015) observed in their paper “Economía de los Recursos Naturales. Determinantes de las emisiones de CO_2 en un modelo STIRPAT” , Kaya model was proposed by Ehrlich and Holdren in 1971 and reformulated numerous times by different researchers such as Commoner (1972), Yoichi Kaya (1990), Dietz and Rosa (1997), Schulze (2002), Roca (2002), York et al. (2003), Xu et al (2005).

One of the most used proposals is the one made by the Japanese engineer Yohichi Kaya (1993). In his book, Environment, Energy, and Economy: strategies for sustainability, he devised a basic, elemental and simple formula in which he managed to link all the economic, energy and environmental factors that influence greenhouse gas emissions (GHG) to the Earth's atmosphere. This formula is known as the Kaya identity. (De la Cruz Alonso, 2016)

The Kaya identity is an analytical tool that is conventionally used to explore the main forces behind CO_2 emissions. According to this identity, emissions are broken down into the product of four basic factors, which are influenced by different factors (Duro Moreno & Padilla, 2005):

- Population
- GDP per capita (g) = It is the quotient between the GDP of the area and its population. It represents the level of economic activity in a given place as measured by GDP per capita.

- Energy intensity (ie) = It is the quotient between the total primary energy consumed divided by the GDP of the area.
- Carbon intensity (ic) = It is the quotient between the amount of CO_2 emitted by each source of energy consumed and / or produced, divided by the total primary energy consumed.

Being able to write the identity as: (2) CO_2 = population* g* ie* ic

Population is an important factor since more people means more needs, more demand for energy and at the end more emissions. In addition, it follows a growing trend that is difficult to modify (Portet Pimienta, 2018), since the current population projection of approximately seven billion will reach nine billion in 2050, so this characteristic may be an inconvenience when presenting initiatives for mitigation (Chica Moreu, 2015).

On the other hand, it is clear that both IPAT Identity and Kaya suggest that GHG emissions grow linearly with population growth, which actually depends on the interactions (real or modelled) of the population growth and economic growth as well as interrelationships with technology, economic structure and per capita income.

The per capita income measures the economic production of the area, being an indicator of the wealth of its inhabitants (Portet Pimienta, 2018). Developing countries aspire to the comforts of the developed world, which in turn increases its demands (Chica Moreu, 2015).

Energy intensity is an indicator of energy efficiency. As new technologies are developed, their efficiency improves and therefore, less energy consumption is expected to produce the same work. This can be translated to “less energy to increase GDP”.

Carbon intensity reflects the energy vector of a given place, that is, it reflects how much CO_2 equivalent we emit into the atmosphere for each unit of energy produced. Therefore, we can link the changes produced in CO_2 equivalent emissions with the changes in the use and production of the energy we use (Portet Pimienta, 2018).

In order to reduce CO_2 emissions, the increase produced by these two first factors must be offset by a greater decrease in the last two: in the energy intensity of the economy (E/GDP), less energy per unit of GDP, and greenhouse gas emissions from the energy system (CO_2/E) (Chica Moreu, 2015).

Kaya's Identity is a useful analytical approach to improve understanding of the driving forces of GHG energy emissions by breaking down GHG emission trajectories into the factors that explain them. However, none of the four "Kaya factors" (population, GDP per capita, energy intensity of GDP and intensity of energy emissions) can be considered independently of the others. Each factor plays a particular role within a complex and highly interconnected economic, social and technological system, posing substantial challenges in modelling and prospective analysis (Garza Güell, 2015).

For some time now, experts and researchers have been working to solve this difficulty. In this area, the work carried out by Dietz and Rosa (1997) stands out. They formulated a stochastic version of the IPAT equation, using representative variables of population, wealth and technological level. These authors designated their model with the term STIRPAT (Stochastic Regression Impacts on Population, Inflow and Technology).

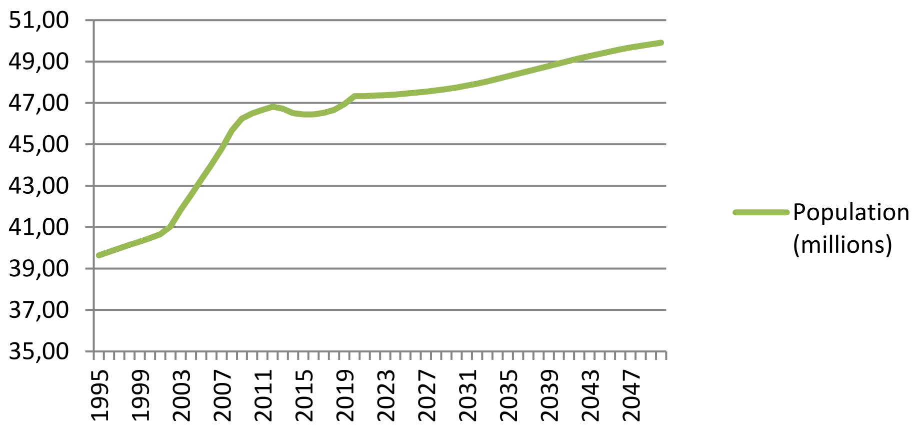
Next, each factor of the Kaya identity in Spain will be analysed to understand the evolution and the possible future forecast.

3.1. Individual analysis of each factor

3.1.1. Population

According to the latest information, published in December 2020 by the INE, it is estimated that Spanish population stood at 47.333.614 people on 1 January 2020. This data represents a year-on-year increase of 395.554 people (0.84%), prolonging the soft growth profile maintained since 2016 (see Figure 11).

Figure 11. Demography evolution of Spain (1990-2050) (million people)



Source: Own elaboration with data from Instituto Nacional de Estadística (INE) (2020).

As it is observed in the table 6, from 1990 to the current year, 2020, the population has increased by 21.82%. The population is expected to increase, from 2020 to 2050, by 5.3%

Table 6. Spanish population variation rate.

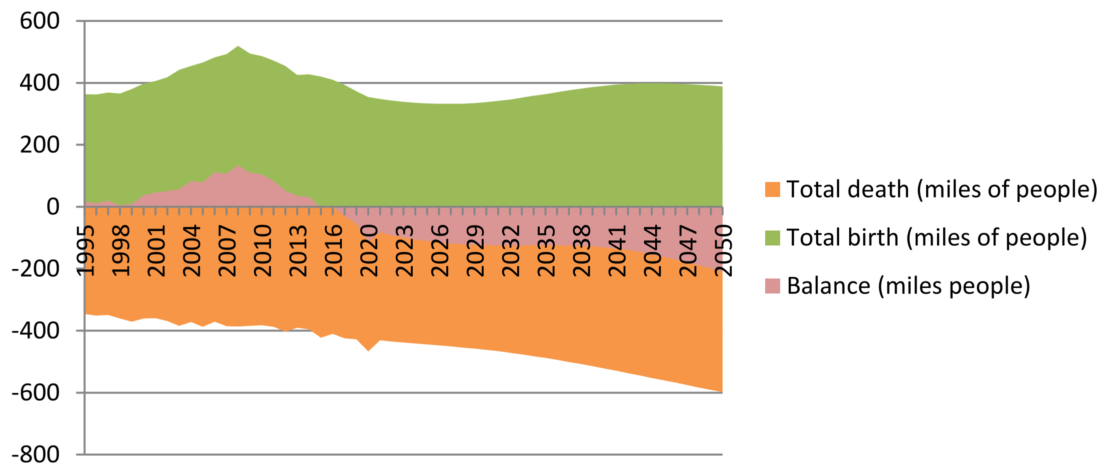
	1990-2020	2020-2050
Growth rate	21,82%	5,3%
Average annual growth rate	0,66%	0,21%

Source: Own elaboration with data from Instituto Nacional de Estadística (INE) (2020)

Population growth occurred despite the deterioration experienced by the vegetative balance (see Figure 12). Behind this negative vegetative balance, we find a great protagonist, the decline of births. Spanish fertility, being one of the highest in Europe, is now one of the lowest.

The evolution of the Spanish birth rate, despite having experienced a period of growth from 1999 to 2008, from the economic crisis its year-on-year growth has been practically negative until the current year. In addition, since 2015 the balance between births and deaths is negative.

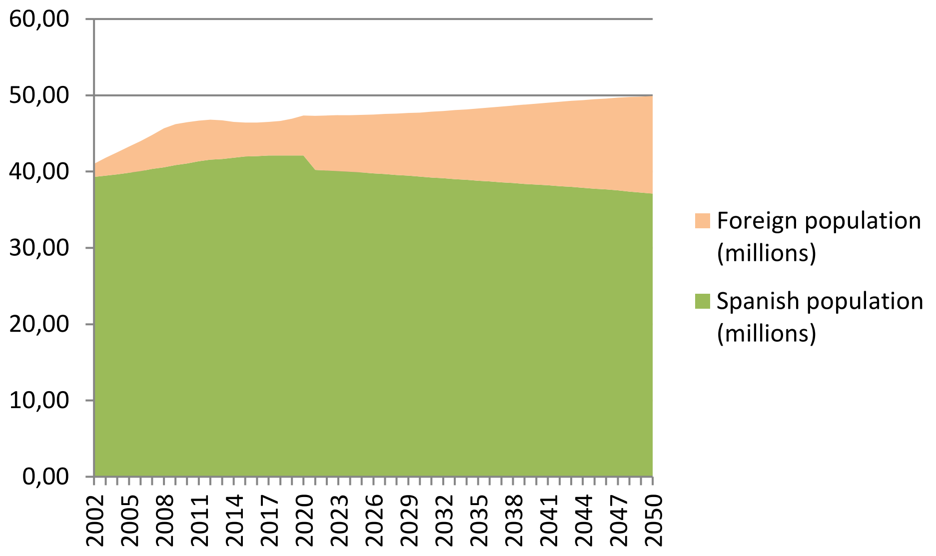
Figure 12. Spanish Vegetative Balance.



Source: Own elaboration with data from Instituto Nacional de Estadística (INE) (2020).

On the contrary, the migration balance accentuated its growth because of the economic recovery and made up the unfavourable behaviour of the vegetative balance (see figure 13). Moreover, the projections made by the INE show positive net migration flows across the projection horizon.

Figure 13. Population structure according nationalities



Source: Own elaboration from Instituto Nacional de Estadística (INE) (2020).

In conclusion, according to the demographic evolution of Spain observed, we can conclude that in the next few years the total population will continue to grow slowly, reaching a maximum of 50 million in 2050 the projections made. This slow growth will be characterized by:

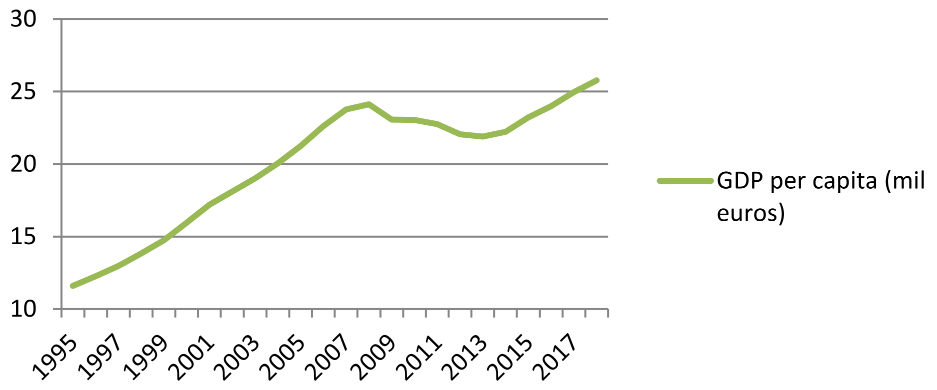
- An increase in the immigrant population in contrast to a decline in the national collective.
- A gentle upward trend of fertility.
- A substantial and progressive ageing population (Cuadrado, 2019).

3.1.2. GDP per capita

This factor is the relationship between a country's gross domestic product and the country's total population. It is the result from dividing the sum of all final goods and services produced by a country into one year among the average estimated population of the same year. In other words, it is an indicator of the country's wealth and the growth capacity (De la Cruz Alonso, 2016).

As it is observed in the figure 14, GDP per capita began in 1995 on an expansive path that was disrupted by the outbreak of the financial crisis in 2008. After 5 years of strong economic crisis, a positive phase of growth begins in 2015 and the fundamentals of which seem more solid than in past cycles. This paper ignore the obvious extraordinary situation Covid19.

Figure 14. GDP per capita at constant price (2013) in Spain (Thousand euros).



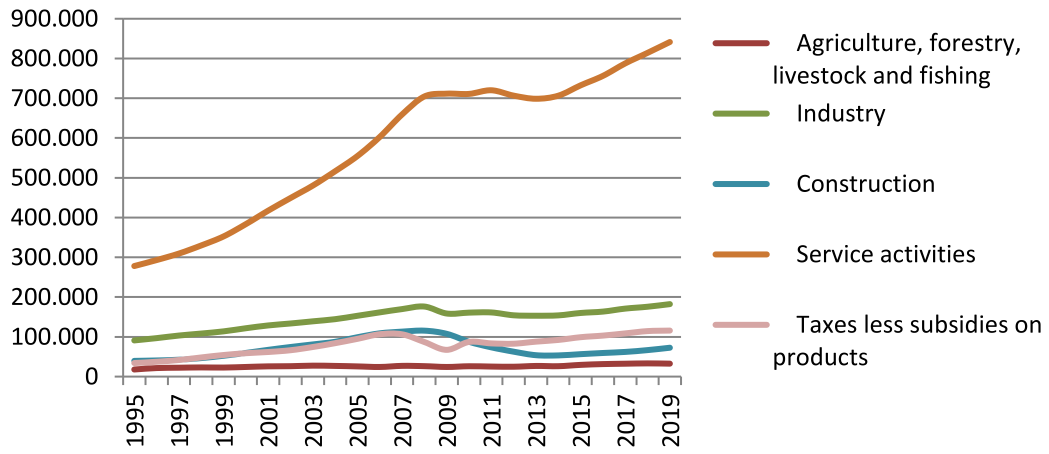
Source: Own elaboration from Instituto Nacional de Estadística (INE) (2020).

In the face of previous expansion phases, the economic cycle started in 2014 has had a more balanced pattern, growing above the main European partners, but without generating external imbalances or price tensions and with a healthy financial situation of companies and families. However, the Spanish economy continued to carry significant imbalances because of the 2008-2013 financial crises, mainly in terms of:

- A high debt-to-GDP ratio
- Hysteresis in terms of unemployment and high temporality rate
- Growing inequality in income distribution. (Mineco, 2020)

As we can see in the figure 15 the services sector has clearly been the predominant activity since 1995. Within this broad sector, we find that the transport, trade and hospitality group together with the GDP generated by the public administration the majority of the GDP of the services sector.

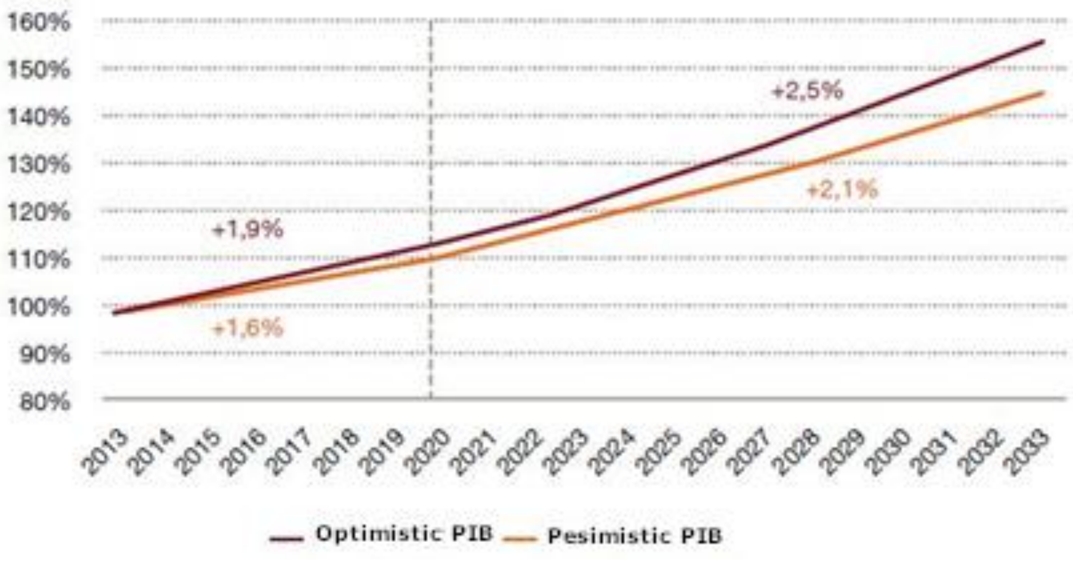
Figure 15. GDP at market prices per activity sector (million euros).



Source: Own elaboration from Instituto Nacional de Estadística (INE) (2020).

2033". According to these projections there are two different future visions. The optimistic outlook translates into higher GDP increase (2.5%) between 2021 and 2033 while the most pessimist view shows growth of 2.1%.

Figure 16. GDP future trend (2013-2033)(Relative value respect to PIB, 2012).



Source: PWC, "El cambio climático en España, 2033".

In conclusion, it seems that GDP is going to grow at a faster rate than population. This translates into a future increase in GDP per capita by 2033.

3.1.3. Energy intensity

Energy consumption is one of the activities that cause the most emissions, being responsible for about two thirds of the total emissions (European Environment Agency, 2017). Such is the importance of the problem than, from the European Commission (EC), many measures have been put forward to improve this situation.

Most European proposals are committed to improving energy efficiency as a measure that reduces the negative effects of climate change, whether on the production of goods or services. Improvements in energy efficiency lead to a reduction in energy consumption and, consequently, GHG emissions (Tarife Mora, 2019).

In macroeconomic terms, the most common way to measure energy efficiency is through energy intensity (IE). This indicator reflects the relationship between energy consumption and the volume of economic activity and is calculated as the ratio between energy consumption and gross domestic product (GDP) (Mendiluce, 2010).

IE= Primary energy/GDP.

Energy intensity is the amount of energy consumption per work unit and it is often used as an energy-conservation index for a country. Energy conservation means decreasing the quantity of energy used without changing the amount of work gained.

The idea of energy efficiency and energy intensity of GDP show how efficiently it is possible to increase production from the viewpoint of energy.

Energy intensity therefore provides useful information on the efficiency of energy use by the economy. It is therefore essential to analyse it in detail, including the factors that condition it, in such a way that it is possible to assess the reasons for past behaviours, and to properly design policies to reduce a country's energy intensity as a means of achieving the objectives of the reduction of cost, environmental impact and energy dependence (Mendiluce, 2010).

In the figure 17 is analysed the primary energy consumption evolution.

Primary energy consumption measures the total energy demand of a country. It covers consumption of the energy sector itself, losses during transformation (for example, from oil or gas into electricity) and distribution of energy, and the final consumption by end users (Eurostat, 2020).

A first stage, between 1995 and 2007, it is characterized by continued growth in the economy that demands energy at a similar rate. Another second period begins from the 2008 financial crisis, where there is a decrease of 8% for primary energy. Finally, in 2014 a period of activity recovery begins that persists to this day (Sánchez, 2015).

Figure 17. Primary energy consumption in Spain (Toe).

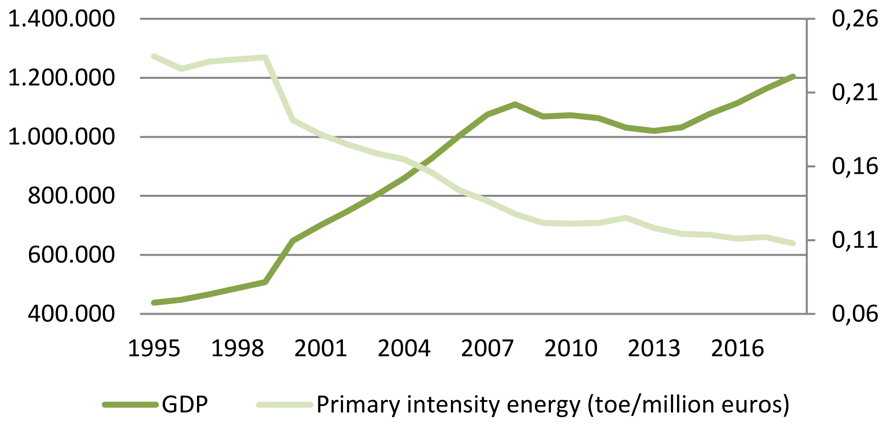
Source: Own elaboration from Eurostat (2021).

At the same time, as it is observed in the figure 19 since 1995, primary energy intensity decreased by 54%, thus consolidating a trend towards greater energy efficiency.

On the other hand, the primary energy intensity improvement has been due to increased consumption of renewable energy and high-efficiency electricity generation, in particular gas generation in combined cycle power plants, and cogeneration, which has resulted in improved efficiency of the transformation of primary energy into electricity.

In conclusion, the figure 18 shows that the energy intensity evolution reflects that since 2000 the growth of the energy economy has been detached. Thus, between 2000 and 2019, gross domestic product at constant prices increased while primary energy consumption declined.

Figure 18. GDP evolution versus energy intensity (EUR million, Toe/EUR Million).



Source: Own elaboration with data from Libros de Energia 2018 and Instituto Nacional de Estadística (INE) (2020).

One of the most important factors of correlation between climate change and economic growth is the use of fossil fuels (mainly coal, oil and natural gas) for energy production. Therefore, from the different institutions give great importance to the decarbonisation of the economy through the transformation of the energy model. This requires a transition from fossil fuels to efficiency and renewable energy. In addition, a significant part of thermal demand and transport need to be electrified by taking advantage of technological developments and predictable cost reductions.

Therefore, it is not only important to know the future evolution of energy intensity, but it is necessary to know whether it will make the transition to renewable energy.

The reduction in primary energy consumption calculated, through the data observed in the National Integrated Energy and Climate Plan 2021-2030 (NIECP), is equivalent to 1.9% per annum since 2017. This result, linked to an expected increase in GDP in the same period of the order of 1.7%, will result in an improvement in the primary energy intensity of the economy from 3.5% per annum until 2030. Because of the policies and measures contained in this plan, primary energy consumption (excluding non-energy uses) will be reduced to a year-on-year rate of 1.1% between 2017 and 2030.

Table 7. Evolution of the primary energy consumption, reducing energy uses (Toe).

Years	**2015**	**2020**	**2025**	**2030**
Coal	13.583	9.084	3743	2.133
Oil and derivations	53.045	55.619	49.302	40.646
Natural gas	24.538	26.690	24.257	24.438
Nuclear	14.903	15.118	15.118	6.500

energy				
Renewable energy	16.620	20.764	26.760	33.383
Industrial waste		302	303	381
Solid urban	252	168	142	66

waste (non-renewable)				
Electricity	-11	762	-1202	-3448
Fewer non-energy	-4.350	-5.105	-5.400	-5.639

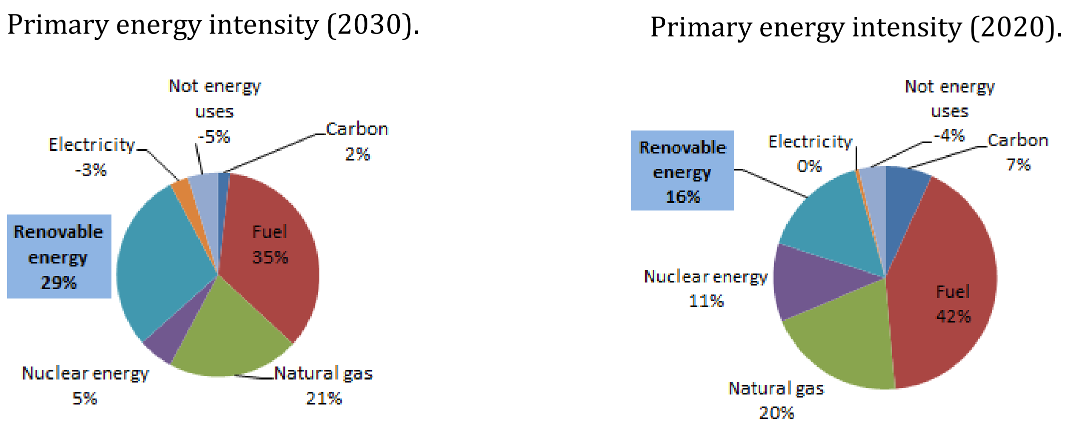
uses				
Total	**103.975**	**123.402**	**113.022**	**98.460**

Source: Miteco, (2021)

This improvement in primary intensity will result from the implementation of energy efficiency measures in the end use of energy and energy efficiency improvements in energy-using products themselves, in the transport and distribution of energy, as well as the increased penetration of renewable energies into the power generation park.

In figure 19 we can see how renewable energies accounted for 26% of primary energy by 2030 compared to 16% by 2020 (Miteco, 2020).

Figure 19. Primary energy intensity per sources (2020, 2030).



Source: Own elaboration with data from Miteco 2021.

In conclusion, the projected energy intensity will be lower than today and is characterized by greater development of renewable energy.

3.1.4. Carbon intensity

Through this factor, we are able to reflect how much equivalent CO_2 we emit to the atmosphere for each unit of energy produced. Therefore, we can link the changes in CO_2 equivalent emissions with the changes in the use and production of the energy we use.

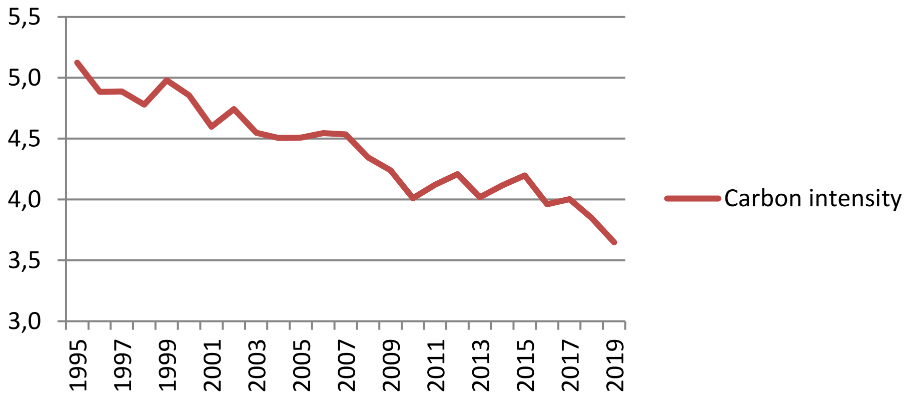
These emissions vary depending on the energy source used. The largest source is produced by the use of coal as fuel, followed by oil and natural gas.

The trend in recent years is that energy consumption, as has been observed above, will follow this upward line as well as downstream fossil resources, so attempts are being made to progressively replace coal use for electricity production, with alternatives that do not emit as much CO_2 into the atmosphere or are free to do so; such as renewable energy.

In particular, the decrease in CO_2 emissions observed between 2009 and 2012 can be mainly attributed to three factors: improving the energy intensity, developing renewable energy sources and economy crises (De la Cruz Alonso, 2016).

Spain's carbonization intensity was reduced 28,8% in the period 1995-2019, thus observing a steady declining trend.

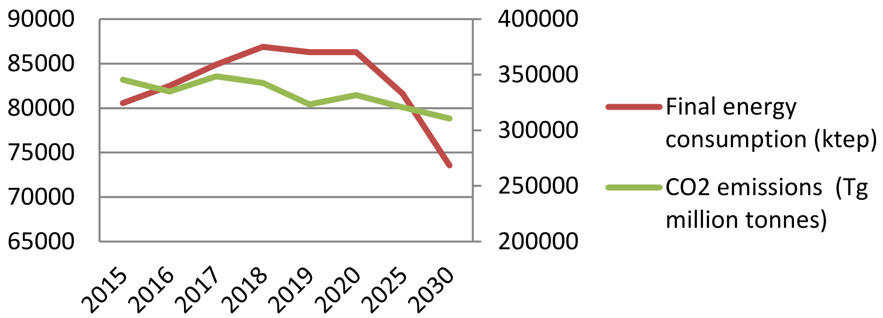
Figure 20. Carbon intensity evolution in Spain (CO_2 (Tg)/ final energy consumption (Toe))



Source: Own elaboration with data from Instituto Nacional de Estadística (INE) (2020).

The figure 21 shows a projection studied obtained from the study carried out by the Ministry of Ecological Transition. It represents a global scenario without disaggregated.

Figure 21. Final energy consumption (ktep) versus CO_2 evolution (Tg million tonnes)



Source: Own elaboration with data from INE, MITECO and Integrated National Plan for Energy and Climate 2021.

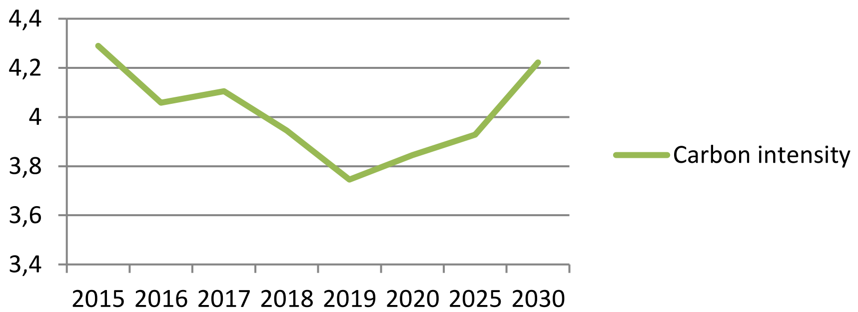
The figure 22 shows a general negative trend in GHG emissions, from 2015 and continued until 2030 although we can find some variations. The projection of GHG emissions for the 2020, 2030 horizons presents two phases (Miteco, 2017).

Until 2020, projected emissions remain virtually constant with a slight downward trend (annual reduction rates of -2.6%). In the second period between 2020 and 2030, there was a further reduction in emissions compared to the previous period (-6.36%).

On the other hand, the final energy consumption presents two phases. Since 2015 to 2025 the projection show an increase of 7,1% and in the last period a great decrease can be observed (9,98%).

In conclusion, in the first period (2015-2020) CO_2 emissions tend to decline as energy final consumption tends increases and these results in a trend in the negative carbonization index. In contrast, during last period (2020-2030) the evolution of the carbon intensity results in a positive trend. The main reason is the change in the trend of final energy consumption to a decreasing evolution. Moreover, the CO_2 emissions will experience a decline trend.

Figure 22. Carbon intensity future trends (2015 – 2030) (CO_2 (Tg)/ final energy consumption (Toe)).



Source: Own elaboration with data from National Plan for Energy and Climate 2021

Next, we will proceed to the joint analysis of the four factors of the identity.

3.2. Integrated analysis

The study has been carried out on the four Kaya identity factors; none has been disaggregated into several, and applied to Spain over a period of 23 years (1995-2018).

The reliable sources of information from which the study starts are the databases of the National Statistics Institute (INE), the European statistical office (Eurostat) and various reports written by PWC and Miteco.

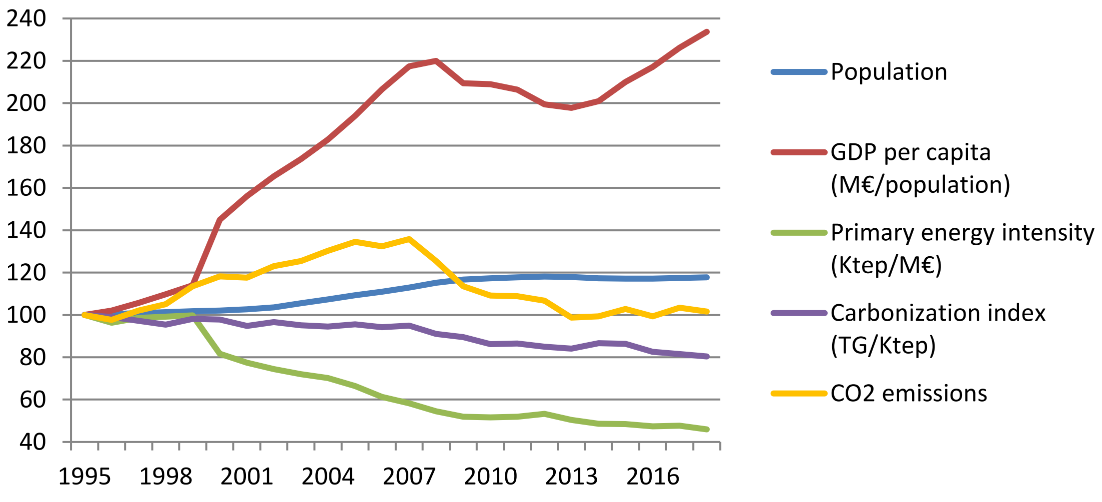
Next, each of the four factors will be analysed, based on what was seen in the previous section, studying its evolution in history over the last decades to the present.

From 1995 to early 2008, the Spanish economy experienced an average annual GDP increase of 3.5% at the same time that CO_2 emissions and primary energy consumption increased, respectively, by 25% and 38%.

Starting in 2008, like the rest of the Euro zone, it suffered a drop in its macroeconomic indices, giving way to a period of recession. This economic crisis, together with the increase in policies associated with the implementation of renewable energies, has led to a reduction in CO_2 emissions during the period 2008-2014 by 21% and primary energy consumption by 17%.

During the economic recovery in 2014 and its consolidation in subsequent years, it is possible to identify an improvement in economic growth, and with it, an increase in CO_2 emissions and primary energy consumption can be observed, but at a much lower level than in previous periods. This could mean a decoupling of economic growth with CO_2 emissions and greater efficiency in the energy sector.

Figure 23. Evolution of the Kaya Identity factors (Index 100= 1995).



Source: Own elaboration.

After applying the collected data, no evidence has been seen to affirm that the population is a determining factor in CO_2 emissions. However, GDP per capita, energy intensity, and carbonization index have strong impact.

Regarding GDP per capita, it is observed a very similar growth evolution with respect to CO_2 emissions until 2014. During the economy recovery phase, per capita wealth continues to rise while CO_2 emissions begin to stabilize.

This change in the both factors evolution correlation may be explained through the theory of the Kuznets Curve (EKC).

The hypothesis proposed by the EKC implies that CO_2 emissions and GDP per capita have an inverted-U-shaped relationship, so that an economy in its initial stage generates high levels of pollution, and as it develops it is capable of decrease pollution levels (Iglesias, Carmona, Golpe & Martín n.d.)

As Roca & Padilla (2003) explained, the relationships between economic growth and various environmental pressures are undoubtedly complex. Economies vary over time in terms of the relative weight of various activities and in terms of the techniques used. Therefore, we cannot assume easily that a certain scale increase in economic activity will have an equivalent increase in each one of the flows that are at the base of the different environmental problems.

To examine the strength and direction of the linear relationship between the evolutions of both factors, it was used the Pearson correlation coefficient and a dispersion diagram.

Regarding the first one, the value of the correlation coefficient can vary from −1 to +1. An absolute value of 1 indicates a perfect linear relationship. A correlation close to zero indicates that there is no linear relationship between the variables.

The sign of the coefficient indicates the direction of the relationship. If both variables tend to increase and decrease at the same time, the coefficient is positive. If one variable tends to increase while the other decreases, the coefficient is negative.

Table 8. CO_2 and GDP per capita correlation coefficient.

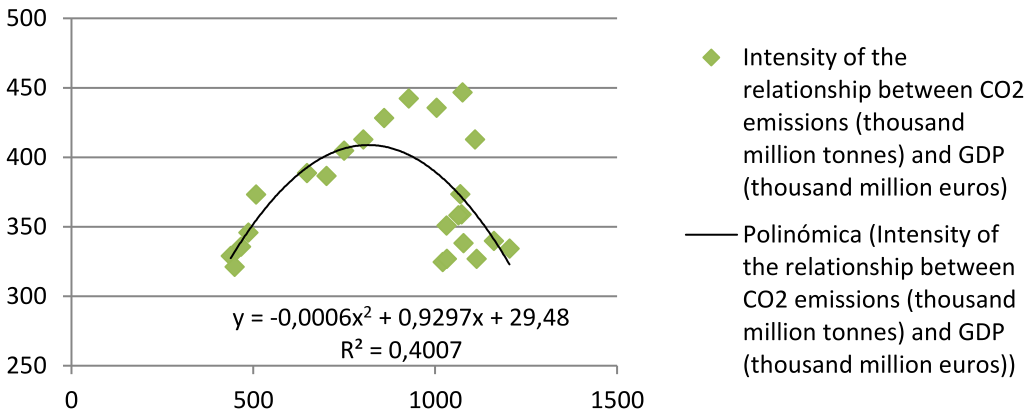
1995-2008	**2008-2014**	**2014-2018**	**1995-2018**

0,937	0,944	0,456	0,492

Source: Own elaboration.

Both factors show that during the first two periods, the correlation is positive and the value is almost one meaning that there is a strong linear relationship between the CO_2 and GDP. However, the last period show a very weak positive correlation. The results match with the evolution observed in the dispersion diagram and the assumptions made in the previous paragraphs, Spain is experimenting a weak decoupling.

Figure 24. Dispersion diagram between CO_2 emissions (thousand million tonnes) and GDP (thousand million euros)



Source: Own elaboration

Next question would be the following, what has slowed the growth rate of CO_2 emissions? The answer is in the energy intensity and the carbonization index. A continuous decrease can be observed in both factors during the period studied.

In terms of energy intensity, it is observed in the figure 26 that GDP grew faster than primary energy consumption, consolidating a great trend towards energy efficiency.

Regarding the carbonization index, the figures 25 shows a continuous, although less pronounced, decreasing evolution, meaning that primary energy consumption has grown more than CO_2 emissions. Indeed, since 2013 both components have tended to evolve in the opposite direction, while primary energy consumption continues to increase, the growth of CO_2 emissions slows down. Taking these results into account, it seems there is a decoupling between CO_2 emissions and primary energy consumption.

Figure 25. Evolution of the GDP, Primary energy consumption and Primary energy intensity (Index 100= 1995).

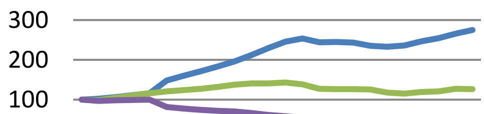
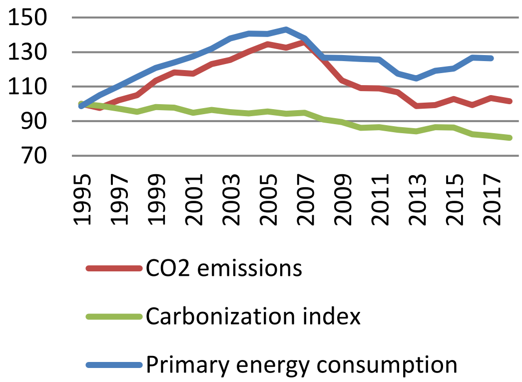


Figure 26. Evolution of the CO_2 carbonization index and primary energy consumption (Index 100= 1995).



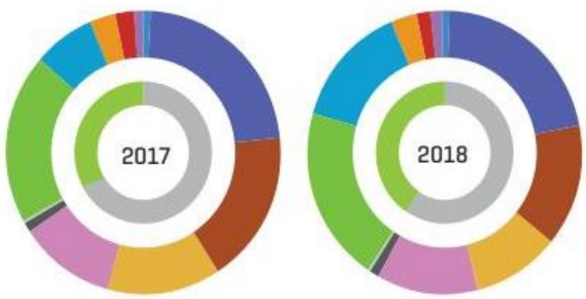
Source: Own elaboration.

The decrease in energy consumption has been the key to slowing down the growth of CO_2 emissions. This trend can be attributed, in large part, to the decrease in the burning of coal for the generation of electricity and natural gas in combined cycle plants and the increase in the penetration of renewable energies, especially hydroelectric and wind power production (Secretaria Confederal de Medio Ambiente y Movilidad de CCOO, 2019).

As it is observed in the figure 27, the contribution of renewable energies to peninsular electricity generation has registered in 2018 the fourth highest value in the entire historical series, increasing its share in electricity generation to 40.1%, compared to 33.7% in 2017. The higher production of hydroelectric and wind energy have been the cause of this change in the peninsular generation mix (Red Eléctrica de España, 2018).

Figure 27. Structure of the national electricity generation (%).

	2017	2018
TURBINACIÓN BOMBEO	0,9	0,8
NUCLEAR	22,4	21,5
CARBÓN	17,1	14,1
CICLO COMBINADO	13,6	10,7
COGENERACIÓN	11,3	11,9
RESIDUOS NO RENOVABLES	1,0	0,9
RESIDUOS RENOVABLES	0,3	0,3
EÓLICA	19,1	19,8
HIDRÁULICA	7,4	13,8
SOLAR FOTOVOLTAICA	3,2	3,0
SOLAR TÉRMICA	2,2	1,8
OTRAS RENOVABLES	1,5	1,4



	2017	2018
RENOVABLES	33,7	40,1
NO RENOVABLES	66,3	59,9

Source: Red Eléctrica de España, 2018

Finally, the fact that the population has not revealed large differences to explain emissions, rules out any future policy aimed at reducing the impact of demographic factors on the volume of emissions. On the other hand, it is necessary to orient the production structure towards the use of more sustainable energy generation alternatives.

4. Conclusions

Climate change is a problem closely linked to development, associated with our growth model based on the burning of fossil fuels and inefficient consumption and production patterns. In fact, the main cause of climate change in Spain is the emission of CO_2 by the energy sector.

Spain is already in a process of climate change and according to the European Environment Agency (2017), is the European country most vulnerable to climate change. Numerous studies, such as those developed by the IPCC, coincide in pointing to the Mediterranean region as one of the areas of the planet most vulnerable to climate change.

Due to its geographical location and its socio-economic characteristics, Spain faces important risks derived from climate change that directly or indirectly affect to a very broad set of economic sectors and all Spanish ecological systems, accelerating the deterioration of essential resources for our well-being, such as water, fertile soil or biodiversity and threaten the quality of life and health of people.

For this reason, reducing carbon dioxide (CO_2) emissions is currently one of the main priorities of Spanish policy and the international community. However, despite the clarity of this objective, it is difficult to determine which measures have the strongest effects on CO_2 emissions. To design appropriate strategies, policy makers need detailed knowledge of causality and effects.

In order to analyse the drivers of CO_2 emissions, Kaya's identity is an interesting tool that provides a conceptual framework to characterize them.

The main conclusion derived from the analysis of the Kaya Identity in the present work is that environmental policy actions to reduce CO_2 emissions should focus on achieving efficiency improvements in the industrial sector and on reducing energy intensity. This will only be possible by transforming the current dominant energy model towards other forms of cleaner energy based primarily on renewable resources.

These transformations should be seen as an opportunity and not a threat, since they offer new employment and business opportunities and a modernization of the production model and the energy system.

Likewise, it must be taken into account that the existing interrelationships between the different sectors and agents force actions to be carried out in a context characterized by "everything affects everything". Ensuring the transversally of climate change and energy transition policies and their coordination is essential. For this reason, achieving climate neutrality requires a firm and coordinated policy, as well as the necessary investments, for the conservation and improvement of biodiversity.

Moreover, it should highlighted that, although it is not analysed in this work, it is interesting to mention two variables that may have contributed to the decrease of CO_2 emissions.

The first is the structural transformation of the economy, which, as the IPCC (2014) has observed, "one of the main methods of mitigating carbon emissions is to move away from high-carbon industries, such as construction and manufacturing, to less carbon intensive industries such as education and banking".

In this way, from the point of view of the global evolution of the Spanish economy, its sectoral structure has evolved from an industrial economy to one of services. This could have meant the drop in energy intensity, as the service sector is less carbon intensive compared to manufacturing. Thus being able to contribute to the reduction of carbon emissions.

The second is the increase in the price of CO_2 in the European emissions market due to the reforms carried out by the community institutions. This system, known by its acronym ETS, forces all large industries to pay for the carbon dioxide they emit, which makes coal plants lose competitiveness since they are the ones that have to spend the most on it. Indeed, this situation has caused the closure of several high-emitting industries (La Vanguardia, 2018).

Finally, through this work, the complexity of the concept of climate change, its causes, impacts and solutions is highlighted. This phenomenon opens up many questions and discussions that are very interesting and important to analyze, but which are impossible to cover in a single document.

5. Bibliography

AEMET (2019a). *Efectos del Cambio Climático en España*. http://www.aemet.es/es/noticias/2019/03/Efectos_del_cambio_climatico_en_espanha

AEMET (2019b). *El calor como nueva normalidad*. http://www.aemet.es/es/noticias/2019/12/Rueda_prensa_invierno_2019

AEMET (2019c). *Informe sobre el Estado del Clima 2019*. http://www.aemet.es/documentos/es/conocermas/recursos_en_linea/publicaciones_y_estudios/estudios/Informes%20estado%20clima/Resumen_ejecutivo_informe_clima_2019.pdf

AEMET. (2019d). *INFORME SOBRE EL ESTADO DEL CLIMA DE ESPAÑA*. https://www.aemet.es/documentos/es/conocermas/recursos_en_linea/publicaciones_y_estudios/estudios/Informes%20estado%20clima/Informe_estado_clima_2019.pdf

Agencia Estatal Boletín Oficial del Estado, (2021). *Ley 7/2021, de 20 de mayo, de cambio climático y transición energética.*

https://www.boe.es/diario_boe/txt.php?id=BOE-A-2021-8447

Agencia Europea del Medio Ambiente (2017). *Climate change impacts and vulnerabilities 2016.*

http://www.eea.europa.eu/publications/climate-change-impacts-and-vulnerability-2016

Alvarez-Yepiz, J. C., & Martinez-Yrízar, A. (n.d.). *Huracanas, sequías y heladas: eventos climáticos extremos*. Web ecología UNAM. Recuperado 2021, de http://web.ecologia.unam.mx/oikos3.0/index.php/oikos-historico/numeros-anteriores/165-eventos-climaticos-extremos-en-%20%20ecosistemas?tmpl=component%26print=1%26page=

Borunda, A (2021, 10 febrero). *Inequality is decreasing between countries—but climate change is slowing progress*. National Geographic. https://www.nationalgeographic.com/environment/article/climate-change-economic-inequality-growing

Brennan, P. (2020, 21 agosto). *Study: 2019 Sees Record Loss of Greenland Ice*. Climate Change: Vital Signs of the Planet. https://climate.nasa.gov/news/3010/study-2019-sees-record-loss-of-greenland-ice/

Burke, M., Hsiang, S., & Miguel, T. (2015a). *Economic Impact of Climate Change on Spain*. Standford. https://web.stanford.edu/~mburke/climate/map.php

Burke, M., Hsiang, S., & Miguel, T. (2015b). *Understanding the historical response of economic output to temperature*.

https://web.stanford.edu/~mburke/climate/historical.php. https://web.stanford.edu/~mburke/climate/historical.php

Caixa Catalunya. (2007). *Aspectos del Cambio Climático en España*. http://aeclim.org/wp-content/uploads/2016/01/aspectos-economicos-cambio-climatico.pdf

California Institute of Technology. (2019, 10 diciembre). *Greenland's Rapid Melt Will Mean More Flooding*. Jet Propulsion Laboratory. https://www.jpl.nasa.gov/news/greenlands-rapid-melt-will-mean-more-flooding

Cerrillo Barcelona, A. (2020, 8 enero). *España abandona el carbón: la competencia de las renovables y el alto coste de los derechos de emisión deciden…* . La Vanguardia. https://www.lavanguardia.com/natural/20200106/472723824052/carbon-energia-espana-espana-co2.html

Chica Moreu, C. (2015). *Identidad de Kaya. El mundo necesita energía limpia, barata y accesible. ¿Es posible?* https://www.camins.cat/wp-content/uploads/2017/06/Aigua-45.pdf

Cuadrado, P. (2019). *Evolución reciente y proyecciones de la población en España*. Banco de España.

De la Cruz Alonso, E. (2016). *Estimación de las emisiones de CO2 en Europa a través de la Identidad de Kaya*. https://udcgal-my.sharepoint.com/personal/ana_baneira_suarez_udc_es/Documents/TFG/biblio grafia/Kaya%20identity/KAYA/Estimaci%C3%B3n%20de%20las%20emisiones%20de%20CO2%20en.pdf?CT=1617097487531&OR=ItemsView

Deloitte. (2020, 21 diciembre). *Los fondos Next Generation EU en los PGE 2021*. Deloitte Spain. https://www2.deloitte.com/es/es/pages/about-deloitte/articles/fondos-next-generation-eu-pge-2021.html

Dirección General de Salud Pública, Calidad e Innovación. (2013). *Impactos del Cambio Climático en la Salud*. https://www.mscbs.gob.es/ciudadanos/saludAmbLaboral/docs/CCCompleto.pdf

Duro Moreno, J. A., & Padilla, E. (2005). *Análisis de los factores determinantes de las desigualdades internacionales de las emisiones de CO2 per cápita aplicando el enfoque distributivo: una metodología de descomposición por factores de Kaya*. Instituto de Estudios Fiscales.

E. Kahn, M., Mohaddes, K., N. C. Ng, R., Pesaran, M. H., Raissi, M., & Yang, J.-C. (2019). *Long-Term Macroeconomic Effects of Climate Change: A Cross-Country Analysis*. International Monetary Fund.

European Comission. (2017, 16 febrero). *EU Emissions Trading System (EU ETS)*. Climate Action - European Commission. https://ec.europa.eu/clima/policies/ets_en

European Comission. (2019). *EU Budget for the Future*. https://ec.europa.eu/info/sites/info/files/factsheet-modern-eu-budget-future-challenges.pdf

European Comission. (2020a). *The EU Green Deal – a roadmap to sustainable economies*. Switch 2 Green. https://www.switchtogreen.eu/the-eu-green-deal-promoting-a-green-notable-circular-economy/#:%7E:text=The%20European%20Green%20Deal%20provides,restore%20biodiversity%20and%20cut%20pollution.

European Comission. (2020b, marzo 4). *European Climate Law*. Climate Action - European Commission. https://ec.europa.eu/clima/policies/eu-climate-action/law_en

European Council. (2020, 17 diciembre). *Presupuesto de la UE a largo plazo 2021–2027 y paquete de recuperación*. https://www.consilium.europa.eu/es/policies/the-eu-budget/long-term-eu-budget-2021-2027/

European Council, (2021). Infographic – EU Budget 2021-2027 and recovery plan.

https://www.consilium.europa.eu/en/infographics/recovery-plan-mff-2021-2027/

European Parlament. (2021). *Legislative train schedule*. https://www.europarl.europa.eu/legislative-train/theme-a-european-green-deal/package-climate-action-ghg-emissions-reduction#:%7E:text=The%20EU%20ratified%20the%20Paris,force%20on%204%20November%202016.

European Parlament. (2019, 28 noviembre). *El Parlamento Europeo declara la emergencia climÃ¡tica | Noticias | Parlamento Europeo*. Noticias Parlamento Europeo. https://www.europarl.europa.eu/news/es/pressroom/20191121IPR67110/el-parlamento-europeo-declara-la-emergencia-climatica

Eurostat. (2020). *Energy consumption in 2018. Primary and final energy consumption still 5% and 3% away from 2020 targets*. https://ec.europa.eu/eurostat/documents/2995521/10341545/8-04022020-BP-EN.pdf/39dcc365-bdaa-e6f6-046d-1b4d241392ad

Fournier, C. (2020, 12 febrero). *The People Least Responsible For Global Warming Will Suffer The Most From Its Consequences*. Youmatter. https://youmatter.world/en/climate-change-consequences-social-inequality/

García, G., & del Val, D. (2020). *The climate change challenge for the Spanish economy*. https://www.sefofuncas.com/pdf/Garcia%209-1.pdf

Garza Güell, J. (2015). *Economía de los Recursos Naturales. Determinantes de las emisiones de CO2 en un modelo STIRPAT*. https://zaguan.unizar.es/record/32581/files/TAZ-TFG-2015-3481.pdf

Greenpeace. (2021.). *Consecuencias del deshielo del Ártico - ES*. Greenpeace España. Recuperado 2021, de https://es.greenpeace.org/es/trabajamos-en/oceanos/artico/consecuencias-del-deshielo-del-artico/

Hacienda. (2021). *ANEXO DE LOS FLUJOS FINANCIEROS ESPAÑA-UNIÓN EUROPEA*. https://www.sepg.pap.hacienda.gob.es/Presup/PGE2021Proyecto/MaestroDocumentos/PGE-ROM/doc/3/5/N_21_A_A_4_1.PDF

Ibañez, O. (2020, 12 diciembre). *RETROALIMENTACIÓN: CAMBIO CLIMÁTICO*. Cambio Climatico. https://cambioclimatic.com/retroalimentacion-cambio-climatico/#:%7E:text=Retroalimentaci%C3%B3n%20positiva%3A%20o%20efecto%20bola,ser%C3%ADa%20el%20vapor%20de%20agua

Iberdrola. (2019, 3 diciembre). *International Agreements On Climate Change*. https://www.iberdrola.com/environment/international-agreements-on-climate-change#:%7E:text=During%20the%20summit%2C%20the%20United,been%20ratified%20by%20197%20countries.

Iglesias, G. (2020). *Energía, Medio Ambiente y Desarrollo Sustentables* [Slides]. ESAN

Iglesias, J. & Carmona, M. & Golpe, A. & Martín Manuel J. s.f. La Curva de Kuznet y la Emisión de CO2 en España (1850 – 2008). https://core.ac.uk/download/pdf/60665752.pdf

IPCC (2007). *IPCC - Intergovernmental Panel on Climate Change*. https://archive.ipcc.ch/organization/organization_history.shtml

IPCC (2014). *Climate Change 2014 Synthesis Report* https://www.ipcc.ch/site/assets/uploads/2018/05/SYR_AR5_FINAL_full_wcover.pdf

IPCC (2018). *Global warming of 1.5°C.* https://report.ipcc.ch/sr15/pdf/sr15_spm_final.pdf

Losada, I. J., Izaguirre, C., & Diaz, P. (2014). *Cambio Climático en la Costa Española*. https://www.miteco.gob.es/es/cambio-climatico/temas/impactos-vulnerabilidad-y-adaptacion/2014%20INFORME%20C3E%20final_tcm30-178459.pdf

Mendiluce, M. (2010). *Análisis de la Evolución de la Intensidad Energética en España*. Economics for Energy.

Meteorología, A. E. (2021). *El calor como nueva normalidad*. Agencia Estatal de Meteorológica - AEMET. Gobierno de España. Recuperado 2021, de http://www.aemet.es/es/noticias/2019/12/Rueda_prensa_invierno_2019

Meteorología, A. E. (2019a). *Efectos del Cambio Climático en España*. Agencia Estatal de Meteorológica - AEMET. Gobierno de España. http://www.aemet.es/es/noticias/2019/03/Efectos_del_cambio_climatico_en_espanha

Meteorología, A. E. (2019b). *Efectos del Cambio Climático en España*. Agencia Estatal de Meteorológica - AEMET. Gobierno de España. http://www.aemet.es/es/noticias/2019/03/Efectos_del_cambio_climatico_en_espanha

Meteorología, A. E. (2019c). *Efectos del Cambio Climático en España*. Agencia Estatal de Meteorológica - AEMET. Gobierno de España. http://www.aemet.es/es/noticias/2019/03/Efectos_del_cambio_climatico_en_espanha

Michael, J. (2006). *Stern Review: The Economics of Climate Change*. http://unionsforenergydemocracy.org/wp-content/uploads/2015/08/sternreview_report_complete.pdf

Ministerio de Agricultura, Alimentación y Medio Ambiente. (2015). *Principales ejemplos de financiación climática de España a nivel nacional e internacional*. https://www.miteco.gob.es/es/cambio-climatico/publicaciones/publicaciones/informe-principales-ejemplos-financiacion-climatica-espana_tcm30-178452.pdf

Ministerio de Asuntos Económicos y Transformación Digital (Mineco). (2020). *Informe de Situación de la Economía Española*. https://www.mineco.gob.es/stfls/mineco/comun/pdf/201009_situacion.pdf

Ministerio de Hacienda. (2021). *Fondos Comunitarios: Periodo 2021–2027*. https://www.dgfc.sepg.hacienda.gob.es/sitios/dgfc/es-ES/ipr/fcp2020/Paginas/inicio.aspx

Ministerio para la Transición Ecológica (2018) *Inundaciones y cambio climático*

https://www.miteco.gob.es/es/agua/temas/gestion-de-los-riesgos-de-inundacion/libro-cambio-climatico-inundaciones-web-06092019_tcm30-499367.pdf

Ministerio de Política Territorial y Función Pública, (2021). *Representación Permanente de España ante la UE*

https://www.navarra.es/documents/48192/6189906/MFP+2021+-+2027+Global+%2B+Distrib+EEMM.pdf/9503fa71-a82e-faf5-cc75-c14f6c7f743e?t=1611661366562

Miteco. (2021a). *Cooperación Internacional*. https://www.miteco.gob.es/es/cambio-climatico/temas/cooperacion-internacional/

Miteco. (2021 b). *Funciones y estructura*. https://www.miteco.gob.es/es/ministerio/funciones-estructura/

Miteco. (2021c). *Oficina Española de Cambio Climático*. https://www.miteco.gob.es/es/cambio-climatico/temas/organismos-e-instituciones-implicados-en-la-lucha-contra-el-cambio-climatico-a-nivel-nacional/oficina-espanola-en-cambio-climatico/

Miteco. (2021d). *Planes PIMA*. https://www.miteco.gob.es/es/cambio-climatico/planes-y-estrategias/PIMAS.aspx

Miteco. (2021e). *¿Qué es LIFE?* https://www.miteco.gob.es/es/ministerio/servicios/ayudas-subvenciones/programa-life/que-es-life/

Miteco. (2014). *Hoja de Ruta de los Sectores Difusos*. https://www.miteco.gob.es/images/va/Hoja%20de%20Ruta%202020_tcm39-178253.pdf

Miteco. (2017). *Proyecciones de Emisiones de Gases a la Atmósfera*. https://www.miteco.gob.es/es/calidad-y-evaluacion-ambiental/temas/sistema-espanol-de-inventario-sei-/espana-2017-proyeciones-informeresumen-corregido-junio2017_tcm30-378888.pdf

Miteco. (2019a). *BOE num.198*. https://www.boe.es/boe/dias/2019/08/19/pdfs/BOE-A-2019-12266.pdf

Miteco. (2019b). *CONVOCATORIA 2019 DE PROYECTOS CLIMA FONDO DE CARBONO PARA UNA ECONOMÍA SOSTENIBLE*. https://www.miteco.gob.es/es/cambio-climatico/temas/proyectos-clima/informacionbasicaconvocatoria2019_tcm30-489595.pdf

Miteco. (2019c). *IMPACTOS Y RIESGOS DERIVADOS DEL CAMBIO CLIMÁTICO EN ESPAÑA*. https://www.miteco.gob.es/es/cambio-climatico/temas/impactos-vulnerabilidad-y-adaptacion/impactosyriesgosccespanawebfinal_tcm30-518210.pdf

Miteco. (2020a). *El MITECO incrementa su presupuesto un 132% para impulsar la transición ecológica, avanzar hacia la neutralidad climática en 2050 y abordar el reto demográfico*. https://www.miteco.gob.es/es/prensa/ultimas-noticias/el-miteco-incrementa-su-presupuesto-un-132-para-impulsar-la-transici%C3%B3n-ecol%C3%B3gica-forward-towards-the-neutrality-clim%C3%A1tica-en-2050-y-address-el-ret/tcm:30–516034

Miteco. (2020b). *Plan Nacional Integrado de Energía y Clima 2021–2030*. https://www.miteco.gob.es/images/es/pnieccompleto_tcm30-508410.pdf

Nordhaus, W., (2018). "Projections and Uncertainties about Climate Change in an Era of Minimal Climate Policies". American Economic Journal: Economic Policy.

Nordhaus, W. (2014). "The Climate Casino. Risk, Uncertainty and Economics for a Warming World". Yale University Press

Organization for Economic Cooperation and Development (OECD). (2015). *The Economic Consequences of Climate Change*.

https://espas.secure.europarl.europa.eu/orbis/sites/default/files/generated/document/en/OECD%20Climate%20Change.pdf

Portet Pimienta, P. (2018). *Analysis of the future CPR 6.0 scenario of GHG emissions and corresponding temperature increases on the Earth's surface*. https://upcommons.upc.edu/bitstream/handle/2117/132033/TFG.pdf?sequence=2&isAllowed=y

Presidencia del Gobierno. (2019). *El primer informe anual del estado del clima muestra una España más cálida y con menor disponibilidad de agua que hace 50 años*. La Moncloa. https://www.lamoncloa.gob.es/serviciosdeprensa/notasprensa/transicion-ecologica/Paginas/2020/020720-informe_clima.aspx

Presidencia del Gobierno. (2020). *La Moncloa. 02/07/2020. El primer informe anual del estado del clima muestra una España más cálida y con menor disponibilidad de agua que hace 50 años [Prensa/Actualidad/Transición Ecológica y el Reto Demográfico]*. La Moncloa. https://www.lamoncloa.gob.es/serviciosdeprensa/notasprensa/transicion-ecologica/Paginas/2020/020720-informe_clima.aspx

Presidencia del Gobierno (2021a). *La Moncloa 08/03/2021. Fondos europeos para la recuperación: NextGenerationEU.*

https://www.lamoncloa.gob.es/temas/fondos-recuperacion/Paginas/fondos-europeos.aspx

Presidencia del Gobierno (2021b). *La Moncloa 27/04/2021. Plan de Recuperación, Transformación y Resiliencia*

https://www.lamoncloa.gob.es/temas/fondos-recuperacion/Documents/30042021-Plan_Recuperacion_%20Transformacion_%20Resiliencia.pdf

Presidencia de Gobierno (2021c). La Moncloa 30/04/2021. *Plan de Recuperación, Transformación y Resiliencia: España Puede*

https://www.lamoncloa.gob.es/temas/fondos-recuperacion/Paginas/plan-de-recuperacion.aspx

Qué es el cambio climático. (2021). Miteco. Recuperado 2021, de https://www.miteco.gob.es/es/cambio-climatico/temas/que-es-el-cambio-climatico-y-como-nos-afecta/

Red Eléctrica de España, (2018). Comprometidos con la Energía Inteligente. https://www.ree.es/sites/default/files/11_PUBLICACIONES/Documentos/InformesSistemaElectrico/2018/inf_sis_elec_ree_2018.pdf

Roca Jusmet, J. et Padilla Rosa, E. (2003). Emisiones atmosféricas y crecimiento económico en España: la curva de Kuznets, 2003. Universitat Autónoma de Barcelona

Roca Jusmet, J. (2018). Ecología Política, 56 (páginas.: 24-27) La economía del cambio climático de William Nordhaus, premio Nobel 2018.

Sanchez Duran, R. (2015). *25 años de energía y economía, primera parte: eficiencia energética*. Endesa.

Sanz, M. J., & Galán, E. (2021). *IMPACTOS Y RIESGOS DERIVADOS DEL CAMBIO CLIMÁTICO EN ESPAÑA*. https://www.miteco.gob.es/es/cambio-climatico/temas/impactos-vulnerabilidad-y-adaptacion/impactosyriesgosccespanawebfinal_tcm30-518210.pdf

Secretaria Confederal de Medio Ambiente y Movilidad de CCOO (2019). Evolución de las emisiones de gases de efecto invernadero en España (1990-2018). https://www.ccoo.es/94c96567fa3b77d183b8a4c638e5a1fd000001.pdf

Tarife Mora, M. (2019). *La intensidad energética y la urbanización*. https://riull.ull.es/xmlui/bitstream/handle/915/13555/La%20intensidad%20energetica%20y%20la%20urbanizacion..pdf?sequence=1&isAllowed=y

Tel Hidalgo, P. (2019). *Climate Change Economics*. https://ddd.uab.cat/pub/tfg/2019/208145/TFG_ptelhidalgo_treball.pdf

UNFCC. (2021 a). *Intro to Cancun Agreements*. https://unfccc.int/process/conferences/the-big-picture/milestones/the-cancun-agreements

UNFCC. (2021b). *What is the Kyoto Protocol?* https://unfccc.int/kyoto_protocol

UNITED NATIONS. (1992). *UNITED NATIONS FRAMEWORK CONVENTION ON CLIMATE CHANGE*. https://unfccc.int/resource/docs/convkp/conveng.pdf

William Nordhaus (2018). Climate change: The Ultimate Challenge for Economics.

https://www.nobelprize.org/uploads/2018/10/nordhaus-lecture.pdf