UNIVERSIDADE CATÓLICA PORTUGUESA

The Economic Performance of Bioeconomy

The Case of EU27

by

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by

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ABSTRACT

This dissertation tries to show the importance of bioeconomy through the analysis of its economic performance in the European region, by creating a dashboard numerical model and, posteriorly, the presentation of economic indicators, in Power BI. Moreover, it analyses how bioeconomic performance relates to European Union's policies towards a sustainable economy, with the inclusion of indicators that measure and relate to sustainability. By analyzing bioeconomic performance and sustainability parameters, with the help of a modern data analysis dynamic tool as Power BI, an overview on current bioeconomic performance within European Union's 27 Member States, and bioeconomy's sectors, is achieved, enlightening how bioeconomy is evolving and is characterized in the European context.

KEYWORDS: Bioeconomy; Economic Performance; EU27; Sustainability

RESUMO

Esta dissertação tenta mostrar a importância da bioeconomia através da análise da sua performance económica no contexto da região da União Europeia, por via da criação de um modelo numérico numa *dashboard* e, posteriormente, a apresentação de indicadores económicos, no *Power BI*. Adicionalmente, analisa de que forma é que a performance económica se relaciona com as políticas da União Europeia de promoção de uma economia mais sustentável, através da inclusão de indicadores que medem e se relacionam com a sustentabilidade. Analisando a performance bioeconómica e os parâmetros de sustentabilidade, com a ajuda de uma ferramenta moderna e dinâmica de análise de dados como o *Power BI*, uma visão geral sobre a atual performance bioeconómica dos 27 Estados-Membros da União Europeia, assim como sobre os setores da Bioeconomia, é conseguida, esclarecendo de que forma é que a bioeconomia se está a desenvolver e é caracterizada no contexto Europeu.

PALAVRAS-CHAVE: Bioeconomia; Performance Económica; Sustentabilidade; UE27

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LIST OF ABBREVIATIONS

BE	Bioeconomy
CE	Circular Economy
EC	European Commission
EU	European Union
FAO	Food and Agriculture Organization of United Nations
GDP	Gross Domestic Product
GE	Green Economy
GHG	Greenhouse Gases
IACGB	International Advisory Council on Global Bioeconomy
JRC	European Commission's Joint Research Centre
OECD	Organization for Economic Co-operation and Development
NACE	Nomenclature of Economic Activities
NGO	Non-Profit Governmental Organization
R&D	Research and Development
UNEP	United Nations Environment Program
UK	United Kingdom
USA	United States of America

"Thus, my urgent request to decision-makers, funders, media representatives, but also NGO's is: Join forces, and don't start a lengthy quarrel who is to be integrated by whom. The world outside Europe dashes along to build-up, scale up and speed up a new Bioeconomy World!",

Chris Patermann,
in an interview for Il Bioeconomista (2015-11-19) (Bonaccorso, 2015)

INTRODUCTION

While developing this dissertation during a worldwide pandemic, it appears evident that, once started, the bioeconomic evolution, development, discussion and focus will (as it should) takes increasingly more important and relevant roles.

Humankind is facing nowadays a series of economic, environmental and social related challenges that are intertwined, making this a challenging era. With worldwide population constantly increasing, demanding higher supply for products and services, it creates a greater pressure in countries' economies, politicians and organizations. To meet modern needs for a higher demand with limited supply of resources, a more sustainable economic path has inevitably to take place in detriment of old economic policies. Bioeconomy acts has an *avant-guard* solution, allowing economies to transition into a new way-of-thinking, where bio-based industries gain importance, allowing to create more output, in a more sustainable way. Bioeconomy is everywhere and its applications are infinite, shifting from an only-profit economic thinking to a more balanced one, that privileges biological production, using renewable sources of energy, considering the negative impacts on the environment, although not neglecting technology, research and innovation, appropriating them at its favor.

Two main research questions are addressed in the current work. Firstly, the economic performance of bioeconomy in the 27 Member States of the European Union is analyzed, in order to understand the real bioeconomic panorama. Secondly, the question of whether countries' performance in bioeconomy is related to sustainability paraments stablished by European Union's climate policies or not. In order to achieve this, an interactive numerical dashboard report was constructed with data related to both economic and sustainability-related indicators.

What the work here presented intends to do, besides answering its research questions, is to merge two distinct areas of interest, which individually are gaining nowadays more relevance, being increasingly developed, taking advantage of a powerful data analysis tool such as Power BI, applying it to an emerging field, as is the case of bioeconomy, proving the importance of creating synergies between different expertise areas.

Therefore, this dissertation starts, in Part I, with a literature review on bioeconomy's concept, definition, evolution in time, visions and value attribution, in order to tackle the main basic framework that characterizes bioeconomy as a new science, allowing to understand with full scope the work developed, initializing the study, functioning as in introduction to the field.

In Part II, after the main sustainability targets and goals for EU being explored, the methodology for constructing the analytical report on Power BI is explained, allowing to not only better understand results presented, but also to provide the reader with a full insight on the dashboard's possibilities and potential. Finally, on the last chapter of this part, results will be presented, based on the dashboard constructed, using own-elaboration graphics and visuals, supporting the conclusions made.

At last, the main conclusions are presented, in order to summarize takeaway key-points reached by the work developed.

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PART I

THEORETICAL OVERVIEW ON BIOECONOMY

To properly understand what is being presented in the forthcoming two parts of this dissertation, it is utterly important that a theoretical contextualization is made, in order to provide a strong base that allows to correctly interpret this work. This is what it is intended in Part I, which focus primarily on the foundations of bioeconomy. This introductory part will not only serve its purpose for those who do not know a great deal about bioeconomy, but also for those who already have a vast degree of knowledge in the area, since it works as an introductory resume, in time and space.

In that way, this first part is divided in four different chapters, each one covering a particular core aspect within bioeconomy.

Starting in **Chapter 1 – *Introduction to Bioeconomy*** –, the origins of bioeconomy will be traced back, additionally analyzing its evolution in time. This provides a historical analysis and gives the reader a deeper knowledge on progress made so far in this field. Moreover, it will be made a literature review on the concept of bioeconomy, searching for its meaning and perceiving its different definitions around the world.

Proceeding to **Chapter 2 – *Visions of the Bioeconomy*** –, it will be given a complementary knowledge to the prior chapter, since it introduces a new perspective about how to look at bioeconomy, suggesting a more intricate and complex definition of this field.

On the next chapter, **Chapter 3** – ***Circular, Green and Bio Economies*** – it will be given an analysis on all three concepts, intending to perceive their differences and similarities, providing a more generic view and contextualization to bioeconomy and where it stands in general economy.

Since the following parts of this work will be focused on analyzing numerical variables that determine the importance of bioeconomy in European countries, it is important to also understand, even if superficially, how main actors within this field attribute its value. This is the focus of **Chapter 4** – ***Value Attribution in Bioeconomy*** – , that allows a comprehensive understanding of what Value is in bioeconomy.

Succeeding reading the first part, and combining information provided by all four chapters, the reader should then be ready to fully understand the following sections, since he/she will have acquired all basic knowledge about bioeconomy.

CHAPTER 1

INTRODUCTION TO BIOECONOMY

When first talking about bioeconomy to anyone who does not belong to the scientific field, the most frequently asked question is "*But what is bioeconomy?*". This entails an important aspect, since it proves this is indeed a recent, unknown topic to most people.

It is intended, in this first chapter, to uncover the basics about bioeconomy, giving a general and introductory knowledge to anyone who is starting their studies in this topic. The need for this initial approach to bioeconomy is connected and supports understanding of next chapters, assuring their easy comprehension.

Having this lack of knowledge in consideration, it is crucial to start this work with an appropriate evolution on bioeconomy, from when it was first originated until nowadays. Later on, the chapter continues with a full analysis on the definition of bioeconomy, by deepening research about its conceptualization, through a literature review. Finally, a simple schematic of bioeconomy's constitution will culminate the present chapter.

1.1. Origin And Evolution Of Bioeconomy

For anyone who is at "Start Line", it arises the necessity to trace the origin of utilization of bioeconomy's concept in different fields, which will prove beneficial to better understand its implications for the economy. As a social science, it might be difficult to measure, both quantitatively and qualitatively, in a concrete or infallible way, the direct impact of bioeconomy in general economy.

Following footprints on the concept of bioeconomy and when it was first used, it is found that it was around 1960 that a small hint of bioeconomy's term was provided in academia, by Jirì Zeman (Nicolas Georgescu-Roegen, 2011), when Jirì sent a letter mentioning bioeconomy, referring to it as a new economy where the biological substances had to be taken into consideration. This idea promoted inclusion of acknowledgement of biological substances in economic processes (Demaria & Alisa, 2015).

Later on, in 1970, Nicholas Georgescu-Roegen, linked this concept to its contributions in the academic field and used it as a banner to sum up its main conclusions. The most important contribution from Georgescu-Roegen's conclusions about what later became bioeconomy, was his concern that an unlimited growth of the economy should be carried out without any concern for laws of nature, which tell us resources are, contradictorily, limited (Nicholas Georgescu-Roegen, 1971).

Years later, another root of a bioeconomy-related term appeared, although not used as we know it today. This contribution was made in a paper written by geneticists, suggesting that their discoveries in life sciences would change the economic sector, glimpsing the term bioeconomy, characterizing it as a field that promotes the use of biotechnology to improve and transform industrial processes (Enriquez, 1998, p. 925).

Looking closer to the European case, and its first use of the bioeconomy term, it can be found that inclusion of its principles in general economic policy was promoted by members of staff from European Commission, being one of them Christian Patermann, a key actor. According to Patermann, the use of bioeconomy's concept happened at a conference of Ministers of the Environment (this information was detailed during a personal communication with Dr. Christian Patermann, dating 29.04.2013, in Berlin) (Birner, 2018, p. 19), and from there on they saw its potential to respond to modern economic challenges (Birner, 2018, p. 20). A new and more refined concept was later developed – knowledge-based bioeconomy – to face challenges in innovation policy at that time in EU. In 2000, the European Council, at a conference in Lisbon, defines this "knowledge-based bioeconomy" as a reflection of their vision to achieve economic growth, using high-technology industries (European Council, 2000).

Now that primordial theoretical origins of bioeconomy are unambiguously specified above, it is interesting to analyze its evolution in a quantitative light.

Findings from research carried on by Mittra and Zoukas (2020) show that the use of bioeconomy's term has increased over time. Furthermore, it is perceived that this increase was incremental, especially since 2012. Until the aforementioned year, total number of publications related to bioeconomy exceeded slightly 50 publications. However, from 2012 until 2017[1], it was showed that in recent years the number of publications related to this term added to more than 250 (Mittra & Zoukas, 2020).

Examining other papers conducting similar searches, conclusions are more or less the same, indicating a pattern in results in this type of studies.

In an academic research conducted by Bugge et al. (2016), where a bibliometric analysis of scientific literature related with bioeconomy was made, a total of 453 papers were published, using terms selected by the authors, from 2005 until 2014[2]. Keywords chosen were: "bioeconomy, bio-based economy, bio-based industry, circular economy and bio, bio-based society, bio-based products, and bio-based knowledge economy" (Bugge et al., 2016, p. 2). Moreover, analyzing this over time, it is perceived an accentuated increase in the number of papers published in average, per year, since 2012 (Bugge et al., 2016, p. 3).

Although time periods analyzed in both studies are not equal, they encompass the same years, with the first research surpassing the second regarding its time scope, the conclusions collide with one another. Therefore, the emergence and presence of bioeconomy has been more notorious within academia, at an increasingly growth throughout time.

[1] Last year until when research was conducted.
[2] Last year until when research was conducted.

Additionally, it can be verified that numerical evolution of the use of bioeconomy's term is compatible with its historic evolution. After seeking for its origin and analyzing its usage over time, the remaining topic to enclose this introductory tail about bioeconomy is a historical-political perspective around the world, where its developments and marks can be identified.

The political consideration for bioeconomy in Europe was accentuated in 2005, when European Commission did a conference named "New Perspectives on the Knowledge-Based Bio-Economy" (European Commission, 2015). In 2007, another important remark was made at a workshop held in Germany, from which "Cologne Paper of 2007" resulted (European Council, 2007). In 2013, the latest program from EU – Horizon 2020 – also contributed for emancipating bioeconomy as a strong independent field. From this point on, a lot of countries in Europe started their own bio-based economic strategies. Although, and as it will be deepened later, there were variations, within different European countries, regarding the extent of policies or their focus. This will add to the list of reasons why a demystification of bioeconomy's concept is utterly important – topic properly addressed in the coming section –, since some differences on country's policy making occur due to its alternate conceptualizations.

Moving forward and looking closely at the historical global evolution, it can be found that, as it happened in EU, similar advances were made. Since early 2000's it can be noticed an increase in discussion in this field. In 2012, Obama Administration implemented an official strategy with bioeconomic principles entitled "National Bioeconomy Blueprint". In this strategy, bioeconomy is defined, meeting the perspective defended by EU in the same time period, focusing on both biotechnological innovation and resource substitution perspectives. Other countries, like Malaysia and South Africa, additionally released economic policies with bio-related purposes (Birner, 2018, p. 21). In 2015, the first global conference addressing this matter was held in Berlin – "Global Bioeconomy Summit" – bringing together for debate over 80 countries.

This last-mentioned conference proves the increasing necessity felt by key actors and governments, from all over the world, in solving worldwide economic problems that arise from aggressive consequences that Climate Change imposes, turning individual consumers more aware, forcing individual and global action.

By analyzing bioeconomy's historical evolution, the same main conclusion is found, both in timeline facts and numbers. Even though first traces of a bioeconomy concept could be identified long before, it was only from 2000 on, that its discussion has been increasing globally, especially in the last decade, where main economic regions developed specific bio-related economic strategies, identifying this as a pivotal moment in bioeconomy's history, as also showed by numerical observations.

1.2. Definition Of Bioeconomy: Literature Review

In the last decade, there has been an increased discussion in different topics that require rapid and urgent solutions, such as climate change, food security, health and energy (Garud & Gehman, 2012; Markard et al., 2012). These can be characterized as "Grand Challenges", since they are not only persistent, but complex. Although bioeconomy is nowadays still an uncertain concept in its core definition, it is introduced as a solution to overcome these "Grand Challenges" (Bugge et al., 2016, p. 8). Even having a key role in solving these problems in society, there seems to be some difficulties in determining what bioeconomy stands for and its implications.

One of the problems that arises from confusion or misinterpretation of bioeconomy's concept is the difficulty it originates when policymakers try to analyze and measure the impact of its contribution to economy, on both regional, national and international levels (Mittra & Zoukas, 2020).

What is mentioned above proves, once again, the necessity for the current section, since a clarification of bioeconomy's concept is critical for the remaining analysis. What is here proposed is to identify different lines of thought that lead to construct a complete and contemporary bioeconomic concept. Therefore, an analysis through time will be made, to determine primary concepts formulated by the first authors that tried to conceptualize bioeconomy, culminating in its current formulation.

1.2.1. Bio-Based Economy vs. Bioeconomy

For anyone starting research about bioeconomy, one of the doubts that should be cleared out is the existence or not of differences between *Bio-based Economy* and *Bioeconomy.*

Hausknost et al. (2017) defends that both concepts should be distinguished from one another, suggesting that bioeconomy refers to methods of converting raw materials into bio-products, while bio-based economy refers only to the raw materials industry (Hausknost et al., 2017). Additionally, other authors defend a distinction between both concepts. Simplifying what was said by Hausknost et al. (2017), bio-based economy considers the production of non-food goods, while bioeconomy is an extension to it, additionally considering production and use of food and feed (Staffas et al., 2013).

Accordingly, some countries make distinctive boundaries between bio-based economy and bioeconomy, consequence of focusing on different aspects. Henceforward, the equivalent will happen with the definition of bioeconomy itself. Nevertheless, the main distinction pointed is between the production and use of biomass. Bioeconomy englobes production and use of biomass, while bio-based economy admits only biomass's use, excluding food and feed (Ben Allen et al., 2015).

However, this it is not a view stressed out by many other key authors and figures, leading to conclude that commonly both concepts are essentially considered synonymous (Mittra & Zoukas, 2020, p. 4), since bioeconomy englobes what is covered by bio-based economy.

Additionally, it is evident in multiple websites and publications from EC and other European entities that they consider both concepts as complementary, not taking in consideration their minor discrepancies.

Equally, for purposes of this study, it shall be considered that both concepts, when mentioned, mean the same, since its differentiation will not be relevant to achieve its goals. Nevertheless, the recognition that both definitions are, in fact, slightly different represents added value and, therefore, the information should remain at the back of one's mind, being worth mentioning.

1.2.2. Key Authors and Their Contributions

Digging into bioeconomy's bibliographic references, being a recent-investigated theme, there are authors constantly appearing, whose names are undoubtfully kept as important, whether because they produce a lot of research themselves or because they are often cited by fellow researchers. In order to achieve consistency throughout this chapter, the same line of thought of analyzing contemporary authors will be followed, attempting to have up-to-date information regarding bioeconomy's definition. Moreover, given that an evolutionary contextualization of bioeconomy itself was already made, the time evolution of its upgraded definitions by the same authors won't be here exhausted. Nevertheless, since its conceptualization evolved rapidly in a short period (McCormick & Kautto, 2013), different authors and years will be covered. In fact, it is not without grounds that some authors defend that bioeconomy is an "emerging concept" (Wesseler & von Braun, 2017).

Birch (2007) argues that bioeconomy "can be seen as a virtual abstraction of economic practices even if the claims made about it are compared with the evidence used to support those claims" (Birch, 2007, p. 88), inserting an alternative perspective, which contemplates wider technical processes that emphasize virtual bioeconomy and its practices regarding economy's valuation (Birch, 2006, 2007, 2017; Birch & Tyfield, 2013).

Moreover, bioeconomy can be defined as an economic regime, where technological and scientific knowledge acquired in life sciences can create economic value (Styhre & Sundgren, 2011). In addition, this view corelates bioeconomy with economic growth and technological development, disregarding local and social aspects (Kitchen & Marsden, 2011; Pülzl et al., 2014).

In a broader view, bioeconomy can be interpreted as one where inputs of an industry – that can be material, chemicals, energy – should derive from biological resources that are renewable, with help from Research & Development (R&D) and Innovation, in order to enable transformational processes in production chains (McCormick & Kautto, 2013; Pfau et al., 2014).

Recently, Mittra and Zoukas (2020) conducted an analysis to determine what are papers referring to when using the term bioeconomy, concluding that "they are mainly talking about using biological processes in new ways to drive sustainable energy production, or contribute to environmental protection" (Mittra & Zoukas, 2020, p. 8). Although research about the areas of expertise where the term bioeconomy was applied was additionally conducted, suggesting that since it is exhausted in numerous disciplines it would have different meanings, the authors concluded that often scientific academics tend to limit its definition to "use of industrial biotechnology to meet growing energy needs in a more sustainable way" (Mittra & Zoukas, 2020, p. 8). As a start to demystification of the concept, this appears to be a simple and concise interpretation. However, this simple definition takes a more complex note when it is suggested that bioeconomy is additionally a political, scientific and technological project, where all forms of science are being used to transform economy, and ultimately, society (Mittra & Zoukas, 2020, p. 12). This definition acquires a bigger recognition when other authors agree with the same principal, one that suggests bioeconomy as a policy concept (Birner, 2018) or a political project (Goven & Pavone, 2015).

From all these definitions, and as pointed by Priefer et al. (2017), it appears that tension between a technology-based approach versus a social and ecological approach is installed (Priefer et al., 2017). This will meet the view suggested by Bugge et al. (2016), as it will be discussed in detail during Part I, that there can be three different views/perspectives on bioeconomy, making it a "notion" (Bugge et al., 2016, p. 11).

1.2.3. Key Countries and Organizations and Their Contributions

Many countries have been developing various strategies for biotechnology and bio-based production. In result, it has been tried to combine these separate strategies into a general bioeconomy concept (Staffas et al., 2013).

Beginning the knowledge-acquisition on this theme, it is important to take an overlook on how bioeconomy is distributed worldwide. Consequently, it is pertinent to analyze the output provided by German Bioeconomy Council. Even though their findings[3] cannot be shown with full scope, **Figure 1** displays a complete overview on the world's bioeconomy, dating March 2019. Examining this map, it is easily perceived which countries are more/less developed. As it would be expected, in majority, less developed countries do not have a specific strategy for bioeconomic policies, while more developed countries are leading the race.

With this analysis, it is effortless to detect which countries or regions of the world should be considered when it comes to define bioeconomy's concept. Having more developed bioeconomy policy strategies, regions that have "dedicated" strategies are pioneers and leading bioeconomic revolution. In that way, emphasis in this remaining section will be positioned on regions classified as having "dedicated bioeconomy strategy" or "bioeconomy-related strategy".

The "dedicated bioeconomy strategy" should be linked to a country when its national strategy includes programs with specific focus on bioeconomy and

[3] For a detailed analysis verify the address: https://biooekonomierat.de/en/international/index.html

structured bioeconomic strategies in place, with targets and policies well defined. Conversely, if a country does not have such specific strategy, it should be classified under the label "bioeconomy-related strategy", meaning that it has a strategy developed for a sector or multiple sectors of activity that are related to bioeconomy, as agriculture or forestry, without having a structured bioeconomy strategy specifically.

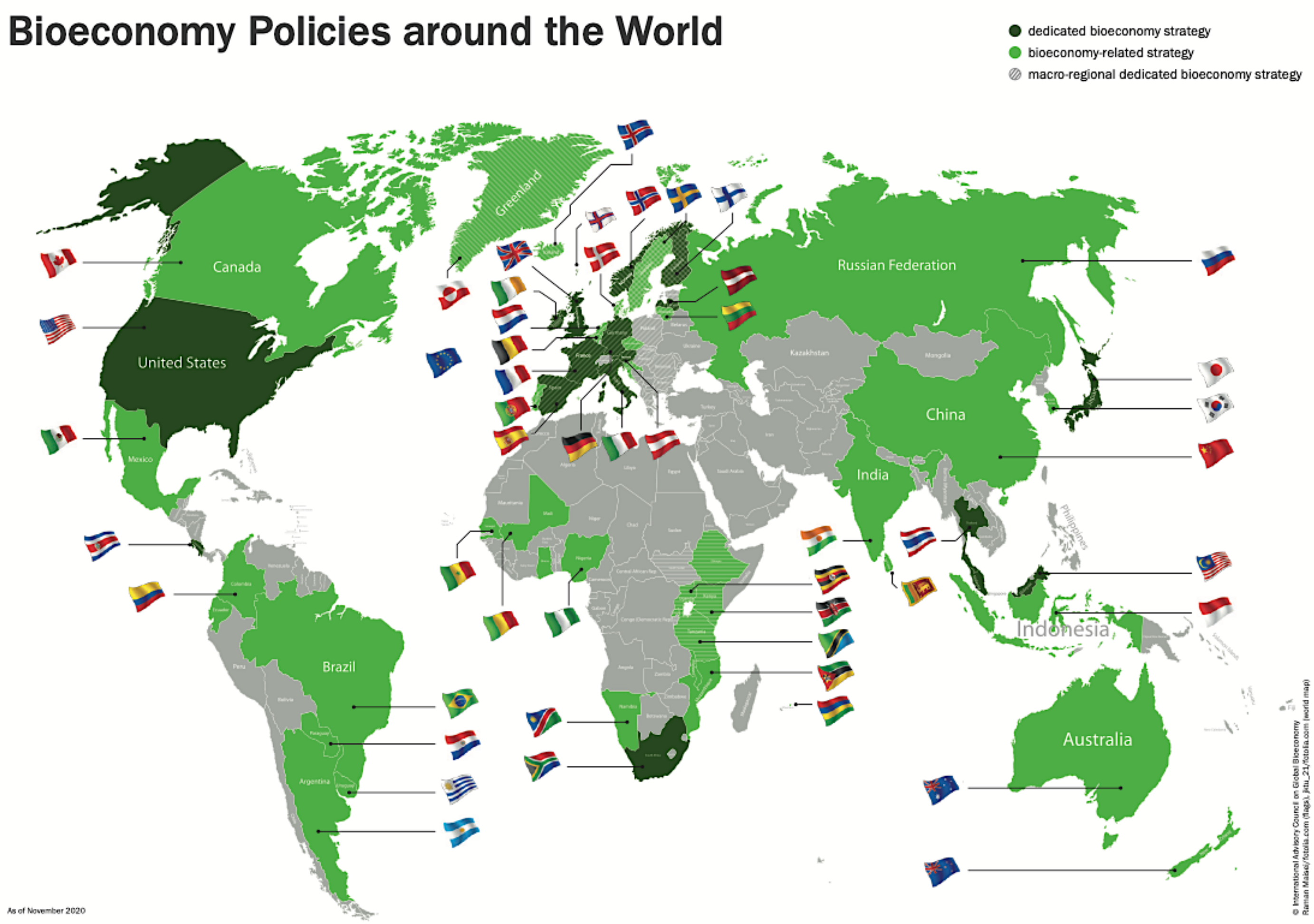

Figure 1. Worldwide Perspective over Bioeconomy's Strategies

Source: (German Bioeconomy Council, 2019)

For an initial perspective, it makes sense to explore the definition of bioeconomy for the OECD, since it represents a worldwide organization. In one of its last-updated reports, from 2009 – *The bioeconomy to 2030: Designing a Policy Agenda* – there is a chapter dedicated to defining bioeconomy. For the OECD, bioeconomy is constituted by three parts, being them biotechnological knowledge, renewable biomass and integration across applications. The "biotechnological knowledge" is referred to when technological knowledge is used to develop new processes for bio-production. The "renewable biomass" is referred because its use leads to more efficient bioprocesses, and therefore, sustainable production. Lastly, the third element of the definition, intends to connect the generation of generic knowledge with value creation in production chains, resulting in different field applications (OECD, 2009). This broader definition provided by the OECD assumes a "latent value" on natural biological processes, also being usually defined as "bio-value", which reinforces the existence of untapped potential in, not only conventional, but also new biological material, with tendency to prioritize sustainable and natural resource management aspects of bioeconomy (Mittra & Zoukas, 2020, p. 9).

However, in a recent publication, the OECD redefined bioeconomy as a group of economic activities where biotechnology is the main contributor for primary production and industry, with a deeper influence on those where advanced life sciences are applied to conversion of biomass into materials, chemicals or fuels (OECD, 2018).

Analyzing the specific case of FAO, it can be perceived that a complete definition of bioeconomy is also given. For this organization, bioeconomy is production and use of biological resources, processes and principles, in a way that provides sustainable solutions for both goods and services, across sectors. FAO complements this, by adding that bioeconomy requires three elements: a) renewable biomass and efficient bioprocesses; b) technology and biotechnology; and c) different sector's integration (Bracco et al., 2018). This grasps the concepts shown in the forthcoming chapter, incident on bioeconomy's visions.

Moreover, still focusing on an international context, the IACGB, initially formed with the intention of serving as a support team for the Global Bioeconomy Summit of 2015, but remaining active since, also defines bioeconomy. According to this institution, bioeconomy is "the production, utilization, conservation, and regeneration of biological resources" (Global Bioeconomy Summit, 2020, p. 14), which can include "related knowledge, science, technology, and innovation" (Global Bioeconomy Summit, 2020, p. 14), in order to reach sustainable solutions in every economic sector, moving towards sustainable economies.

Addressing now a powerful economy in the world, advanced in its bioeconomic development, bioeconomy can be identified as one "based on the use of research and innovation in the biological sciences to create economic activity and public benefit" (U.S. Office of Science and Technology Policy, 2012, p. 7). This definition was released under President Obama's leadership, when an official bioeconomy strategy was made formal in the United States. Completing the aforementioned definition, bioeconomy represents "the infrastructure, innovation, products, technology, and data derived from biologically-related processes and science" (U.S. Office of Science and Technology Policy, 2019, p. 3), which propels economy to expand, upgrades public health and promotes security.

Moving forward, to South America, although there are few countries that have concrete bioeconomic strategies currently established, it is worth considering at least one as an example. Argentina succinctly refers to bioeconomy as a form of sustainable production, of goods and services, using or transforming biological resources (Bracco et al., 2018).

On the African region, the only country that has a "dedicated bioeconomy strategy" representativeness is South Africa, defining bioeconomy as an incorporation of biotechnological activities and processes that will produce economic outputs, specially of industrial application (Bracco et al., 2018). As it happened in the previous section, it appears that also countries assume different visions. From what it is mentioned, South Africa's conceptualization of bioeconomy does not integrate a societal strand.

In Malaysia, changing the magnifier to Asia, biotechnology is the main focus regarding their bioeconomic policy and strategy. It englobes all economic activity that derives from continued commercial application of biotechnology (Arujanan & Singaram, 2018). This seems to be the tendency, as explained and deepened in Chapter 2, in all Asian countries – following an approach that relies on innovation and efficiency in technological areas, applying them to production and conversion of renewable biological resources. Reinforcing this, China promotes bioeconomy, and foments its political interest, through development of biotechnology (German Bioeconomy Council, 2019).

Lastly, shifting focus to the European region, some definitions proposed by leading countries are worth mentioning. Norway, for example, has a dedicated bioeconomy/bio-based strategy and refers to bioeconomy as a "sustainable, effective and profitable production, extraction and use of renewable, biological resources for food and feed, health products, energy, industrial materials, chemicals, paper, textiles and numerous other products" (Norwegian Ministries, 2016, p. 3). Along with Norway, the UK identifies its bioeconomy as "the economic activity derived from utilizing biological resources or bioprocesses to produce products such as food, feed, materials, fuels, chemicals, biobased products and bioenergy" (Department for Business Innovation & Skills, 2015, p. 6), distinguishing it from bio-based economy, which its perceived to include "products derived wholly or in part from biological resources" (Department for Business Innovation & Skills, 2015, p. 6).

Contrarily, other European countries, like Portugal, do not have a dedicated bioeconomic strategy at date, not defining it.

Another mandatory perspective is European Commission's definition, particularly important for this dissertation, since the main focus and scope are European countries. With numerous reports published, European Commission's website details the definition defended and supported by this entity. There it can be read that bioeconomy "means using renewable biological resources from land and sea, like crops, forests, fish, animals and micro-organisms to produce food, materials and energy" (European Commission, 2019). Moreover, on a report from EC, it is affirmed that "bioeconomy covers all sectors and systems that rely on biological resources (animals, plants, micro-organisms and derived biomass, including organic waste), their functions and principles" (European Commission, 2018a, p. 27).

Both OECD and EC are described by Hilgartner as anticipatory enterprises (Hilgartner, 2007), since they are engaged in foreseeing technological advances and are future-oriented. Their motivation to build a sustainable bioeconomy impacts strategies and practices of all organizations, independently of the concretization of their futuristic expectations (Mittra & Zoukas, 2020).

Onward, when bioeconomy is mentioned, due to the emphasis on the European region, it is assumed that it refers to the definition proposed by the EC, unless referred otherwise.

1.3. Bioeconomy's Composition

Considering a generic, worldwide theoretical contextualization on bioeconomy's definition was already made, the remaining question left without an answer is the one proposed in the beginning – "*What is Bioeconomy?*". Not being able to tackle in exhausted detail every theme, this section will focus exclusively on the European perspective on what bioeconomy englobes.

Addressing latest reports from the EC, a composition of its bioeconomy can be perceived: "It includes and interlinks: land and marine ecosystems and the services they provide; all primary production sectors that use and produce biological resources (agriculture, forestry, fisheries and aquaculture); and all economic and industrial sectors that use biological resources and processes to produce food, feed, bio-based products, energy and services" (European Commission, 2018a, p. 4).

Using biomass[4] for energy – bioenergy – is the main source of renewable energy in EU, representing a share close to 60%, in 2019 (European Commission, 2018c). In

[4] Energy derived from conversion of natural, biological sources.

Europe, bioenergy derives from feedstock, as biomass from agriculture, forestry and other biological waste. Since bioenergy is the only renewable source of energy capable of producing heat, cooling, electrical power and transport (Bioenergy Europe, 2019), it represents an important source for any country intending to bet strongly on bioeconomy.

For an easier comprehension, it is presented **Figure 2**, which simplifies what is being defended by EC, and should be considered as the composition of bioeconomy intertwined in their policy making. Focusing on biomass as principal source of energy, by analyzing the illustration below, it can be perceived a division of bioeconomy's constitution into production and use of biomass, identifying their derived sectors of action.

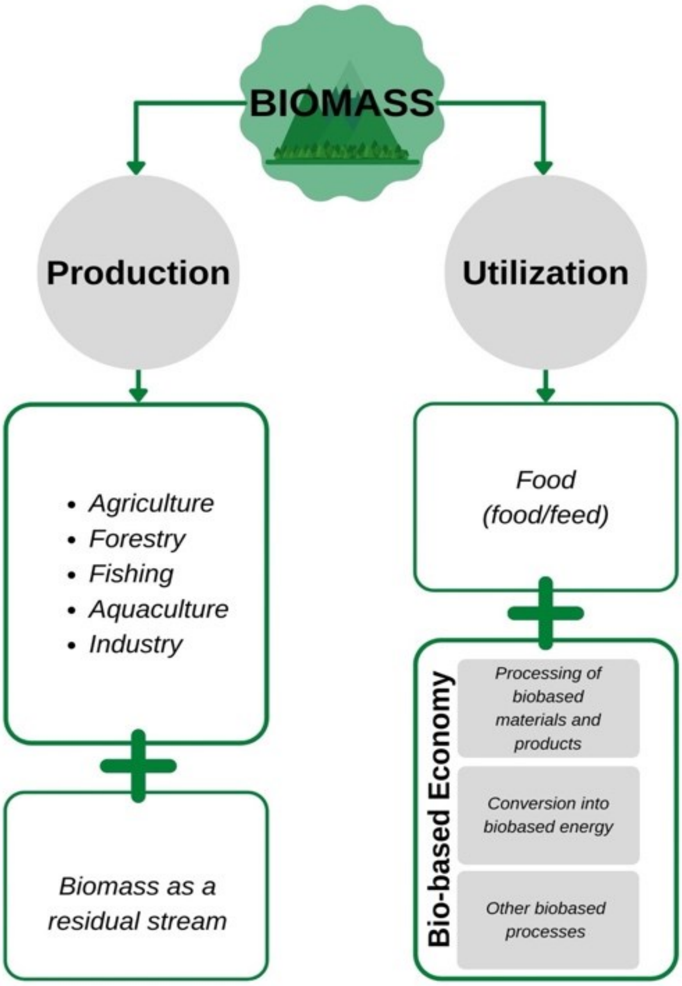

Figure 2. Bioeconomy's Composition in Europe

Source: Adapted from *The Bioeconomy: A Primer* (pg. 6) by Mills, E., 2015, TNI, Hands on the Land.

CHAPTER 2

VISIONS OF THE BIOECONOMY

By now, no confusion should remain about what bioeconomy is and what it stands for. Nevertheless, this section is included in order to categorize bioeconomy, deepening the knowledge. The following presented division was suggested by Bugge et al. (2016), who conducted a research whose results led to an academic analysis of actions applied by intervenients in the sector (Bugge et al., 2016). This view is one that appears to have more supporters, being fostered by other authors.

There are additional studies that suggest a division of bioeconomy, although different from Bugge's. This is the case of Hausknost et al. (2017), which defends that bioeconomy can be categorized as following: "industrial/biotechnology vs. agroecology-oriented" and "growth-seeking vs. socio-economic sufficiency or degrowth" (Hausknost et al., 2017).

Having in sight the topic's demystification, it is opted for the simpler view, the one proposed by Bugge et al. (2016), also defended by other academics. As it was seen, the origin and spread of bioeconomy's concept across different fields of study makes this a broad and diffuse concept. Therefore, dividing bioeconomy into categories aims to better understand it – meeting the primary goal of this work.

2.1. BIO-TECHNOLOGY, BIO-RESOURCE AND BIO-ECOLOGY

As above-mentioned, this three-parted-vision is based on one proposed by Bugge et al. (2016). Additionally, there are other authors who defend this division of bioeconomy in different groups (Devaney & Henchion, 2018; Scordato et al., 2017; Wreford et al., 2019), although each author sometimes defends a different pilar for their constitution. In order to clarify what is being proposed, it is briefly detailed below what each vision is fundamentally based on:

1. **Bio-technology vision** – puts emphasis on technology as a driver, that promotes research and commercialization in various sectors.
2. **Bio-resource vision** – defends a bioeconomic conceptualization which focuses on biological raw materials of each sector, reinforcing importance of R&D, in order to establish new value chains. Potential of used resources is underlined by their upgrade or conversion.
3. **Bio-ecology vision** – highlights ecological processes that help optimize energy and nutrients' usage and promotion of biodiversity, potentializing integrated systems.

The resumed definitions described above, should not be perceived as mutually exclusive. Contrarily, they should be understood as complementary, connected and as "ideal type visions of the bioeconomy" (Bugge et al., 2016, p. 9). Different actors within bioeconomy will prefer one vision over the other, although all visions try to solve the same problems.

It is interesting to point that two of the biggest organizations that play an important role within bioeconomy follow different visions. While OECD focus on a bio-technology type of bioeconomy, the EC focuses on a bio-resource type of bioeconomy (Bugge et al., 2016, p. 9). Nevertheless, problems being addressed are identical, despite the path to solving them being based on alternative roads. In order to understand these three visions, the remaining objective of this chapter is to analyze each vision in depth.

2.1.1. Bio-Technology Vision

The bio-technology vision's main goal is focused on economic growth and job creation, disregarding sustainability as a key aspect, even though climate change issues and environmental questions are taken into consideration (Staffas et al., 2013). This focus will clearly imply that ethical concerns that originated bioeconomic discussion can be disregarded under this bio-technological vision.

According to this stream, economic growth will be reached through capitalization of biotechnology – as in its direct application or as R&D –, being the stakeholder's investment the central aspect to create scientific knowledge in products, as well as in production processes (McCormick & Kautto, 2013). It is considered that resource scarcity can be overcomed by technological progress in the production, that, once optimized, will generate close to zero waste. Given that research plays a significant role, the same actors who often develop knowledge are also the ones that apply and develop bioeconomic strategies in the field (Bugge et al., 2016, p. 10).

In terms of geographical scope, since its main premise is the biotechnological research and development, economic growth will be centralized in limited global clusters, where pharmaceuticals, biotech firms or public research-related entities (Bugge et al., 2016, p. 11), to name a few, can be found. In fact, biotechnology can be identified nowadays as a big part of a new era of technological and economical competition (Langeveld, 2015; Li et al., 2006; Meyer, 2017).

2.1.2. Bio-Resource Vision

In the bio-resource vision, although economic growth is also an objective, it allies itself with sustainability. Value creation is generated by the capitalization on the bio-resources, culminating in bio-innovation, generating not only economic growth but also environmental sustainability. Since focus is in developing new bio-based products, with help of technological advances, positive impacts on the environment will be a consequence (Bugge et al., 2016). Processing and converting bio-resources into new products is the factor that adds value, being waste an important aspect to consider, namely its minimization along value chains (this waste will be availed as an input in renewable energies).

Considering the focus to be on bio-resources, land use is of upmost importance, being necessary not only to increase its productivity, but also to channel degraded lands into production of biofuels (European Commission, 2012). While in the previous vision, actors of the sector were often coincident, in the bio-resource view there must be collaboration across sectors, in order to bioeconomic innovation take place, although this is often disregarded (McCormick & Kautto, 2013).

Due to its nature, this vision impacts rural areas more significantly, since bio-production plants can be found in such regions (Bugge et al., 2016).

2.1.3. Bio-Ecology Vision

Finally, the bio-ecology vision, which main concern is sustainability, implicitly defends that economic growth and job creation should come as secondary concerns. Having this as its pilar, value creation will come from promoting biodiversity, conservating nature and preventing soil degradation (Levidow et al., 2013).

Another interesting point, differentiating this vision from others, is waste treatment concern. Waste will only be of value at the end of the chain, after reusing and recycling bio-products, suggesting a circular and self-sustained production (McCormick & Kautto, 2013). In that way, the creation of sustainable biological practices, including in re-use, recycling and land use is promoted and defended. Scientific knowledge in form of bio-ecological engineering techniques is also present, since the aim is to develop systems requiring as less inputs as possibly needed (Bugge et al., 2016, p. 12).

Similarly to the bio-resource vision, geographical emphasis will be on rural areas, adding peripheral regions as well. Value creation in these areas comes from focusing on high quality products that have their own identity, not being necessarily produced in a context of mass growth production (and, therefore, with help of genetically modified crops, for example). The difference from the remaining two visions is that the bio-ecological vision defends local development and does not call for external cooperation, as in the bio-resource vision (McCormick & Kautto, 2013).

2.1.4. Summarized Comparison

Summarizing what has been described regarding all visions, **Table 1** expresses their key characteristics, making distinguish and understanding them easier.

	BIO-TECHNOLOGY VISION	BIO-RESOURCE VISION	BIO-ECOLOGY VISION
Objectives	Economic Growth and Job Creation	Economic Growth and Sustainability	Sustainability
Value Creation	Applying biotechnology knowledge and Commercialization of R&D	Improving processes, with focus on conversion and upgrading bio-resources	Integrating bio-ecological production systems and territorial identity high-quality products
Drivers & Innovation	R&D and Investment funders of public and private scope	Interdisciplinary cooperation to promote a network of production	Circular and self-sustained production mode
Regions of Focus	Global clusters Regions of interest	Rural regions	Rural regions Peripheral regions

Table 1. Bioeconomy's Visions Main Characteristics

Source: Adapted from *What Is the bioeconomy? A Review of the literature (pg. 10) by M. Bugge, T. Hansen, A. Klitkou, 2016, Sustainability.* Copyright 2016 by the Authors.

A conclusion can be made that the two first approached visions are of a more technological or scientific ground. Bio-technology vision focuses on technological research and bio-resource vision focuses on developing processes of biological raw materials, modifying value chains. On a more sustainable tone, bio-ecology aims to improve ecological processes ultimately optimizing the use of scarce resources. In this way, the first two visions overlap each other, at some extent, and should be used complementary. Should the governments, actors and intervenients within bioeconomy apply biotechnology to the bio-resources vision, perhaps they would ultimately produce more effective and complete strategies.

Aforementioned visions should not be understood as mutually exclusive, as mentioned before. In countries that formalize bioeconomic strategies, it happens that a given vision is usually emphasized, being substitution of biological resources in fossil fuel production a uniformly common goal. Despite that, most countries simultaneously advocate an additional complementary view, adding to the main one (Arujanan & Singaram, 2018; Li et al., 2006; Trigo et al., 2013).

Nevertheless, there are cases where countries pursue all three visions, having them present in their strategies, as the United States (US), for example. Over the years, the US have been producing and publishing strategies based on different visions of bioeconomy (National Academies of Sciences Engineering and Medicine, 2020).

From what has been shown, specially from **Table 1**, an additional characteristic to bioeconomy can be administrated (though already observed): <u>multifaceted</u> (Bugge et al., 2016, p. 14).

CHAPTER 3

CIRCULAR, GREEN AND BIO ECONOMIES

Following the two previous chapters, where the foundations of bioeconomy are being fomented, a new question may arise – "Why a comparison between Circular, Green and Bioeconomy is important?". One keyword intrinsically connected with bioeconomy's concept is 'Sustainability'. When various perspectives on what sustainability entails arise across different actors in this field, an emergence of colliding views will naturally happen (Munda, 1997).

Whereas all three concepts propose a transformation or adaptation to current economic needs, of a more sustainable conduct, it creates added value to compare their views, in order to better understand their differences and similarities, ultimately comprehending bioeconomy itself. Moreover, there is a great number of authors in academia who call attention to relationships between Circular, Green and Bioeconomy (D'Amato et al., 2017, p. 717). Some authors identify an interconnection between all three concepts (Hagemann et al., 2016; Ollikainen, 2014; Székács, 2017), and others suggest the existence of a hierarchical relationship (Loiseau et al., 2016).

Chapter 3 begins with a specific analysis on Circular and Green Economy. Considering that bioeconomy's definition was already exhausted on Chapter 1, there is no need to duplicate the work. Finally, this section will end with a comparison of all three types of economy. Additionally, as discussed previously, different conceptualizations about bioeconomy are adopted by different countries. All things considered, since Part II will focus on countries that belong to EU, the current chapter targets the European vision of all three concepts, not neglecting yet broader conceptualizations.

3.1. Circular Economy

CE's concept originates between the 70's and 80's as a rethinking of processes made in industries at that time, opposing to linear economy, since it defends that economic actors cannot exert net effects on the environment. This can be achieved by redesigning life cycles of products, having in consideration reduction of the amount of input needed for the industry and reduction of waste production within industries (D'Amato et al., 2017, p. 717). The main idea behind CE is the appropriation of by-products of a certain industry as resources to another, implying cooperation in supply chains.

As written in a recent report from OECD, CE seeks to: "maximise the value of the materials that circulate within the economy; minimise material consumption, paying particular attention to virgin materials, hazardous substances, and waste streams that raise specific concerns (such as plastics, food, electric and electronic goods); prevent waste from being generated; reduce hazardous components in waste and products" (OECD, 2019, p. 2).

Regarding the European case, in 2015, EC launched its first action plan focusing on CE (European Commission, 2020a). However, the European Commission recently adopted a new action plan, that meets its new agenda and objectives for sustainable growth (European Commission, 2020b). This new action plan predicts measures to be applied at many levels, such as promotion of less waste production and incentivizing industries to adopt principles of producing sustainable products.

3.2. Green Economy

The concept of GE was first introduced by Pearce et al. (1989) due to the undervaluation of environmental and social costs in price systems at the time (Blanc, 2011). Despite, GE is a concept recently popularized, being described by Barbier (2012) as a form of thinking that brings together both environmental conservation and poverty alleviation (Barbier, 2012).

In the EU, a range of measures related to GE are being integrated into strategic documents, such as "Europe 2020" and "Resource Efficiency Roadmap" (Mazza et al., 2012), aiming to turn EU's countries in resource-efficient, green, competitive low-carbon economies.

In a broader view, UNEP identifies GE as one that is low carbon, resource efficient and socially inclusive, resulting in improved human well-being and social equity, aiming to reduce environmental risks and scarcity (UNEP, 2011).

3.3. The Comparison

From what has been learned so far, differences between all concepts seem slight or not relevant, indicating this might be a matter of definition of concepts. "What are the connections between the three concepts?" is the interesting question to analyze now.

A view defended by some authors suggests that BE should be considered as part of GE, which implies that renewable energy sources that do not depend on biological resources can integrate GE, but not BE. This is the case of solar or wind energy, for example (Birner, 2018, p. 26). Additionally, CE is narrower in scope, compared to BE, and consequently, than GE (Birner, 2018, p. 27).

As it happens with BE, all three individual concepts are applied differently by economic actors, since they interpret them in alternative forms. In a political front, the identical happens with different economic regions or entities, when they adhere to alternate approaches regarding implementation of instruments towards a more sustainable economy, based whether on circular, green or bio-economic principles. For instance, China prefers to implement instruments based on CE principles, while

EU develops its strategy based on not only circular, but also bio-economy principles (D'Amato et al., 2017).

A study by D'Amato et al. (2017), making a comprehensive comparison between all concepts, can help better identify existing differences and similarities. As results show, the concepts of CE and BE have been more in use since the early 2000's, being GE a recent bloomer, starting to be notably used since 2010. Another finding is the geographical distribution of each concept's usage. In Europe, all three concepts are equally used, while in China there is a predominance of CE, and in the US of GE and BE. Additionally, CE and BE are more frequently used in developed countries, being GE a more widespread concept, used worldwide (D'Amato et al., 2017, p. 719).

Global usage of GE's concept is linked with UNEP advocating it. Interestingly, the increase of its usage in literature is connected with publication of the report published by UNEP in 2011, as showed by results in a study conducted by D'Amato (D'Amato et al., 2017, p. 724).

These geographical results are aligned with what is already known about bioeconomy. The predominance of its usage in the European region is highly connected with the fact that EC and regulatory entities started to emphasize this topic, by promoting strategies combining sustainability goals with economic growth. Therefore, work developed in Part II has a stronger associated reliability and confidence, since it is indeed bioeconomy, over circular and green economy, the main focus in the European Union – the region of interest.

Academics argue that CE and BE represent complementary ideas, even if distinct in their core (Wesseler & von Braun, 2017). Others conclude that literature about CE encompasses ideas from both green and bioeconomy, namely biomass, renewables and recycling, re-use and extended products life cycle (D'Amato et al., 2017). It is also suggested that, unlike the others, GE focus in detail on sustainability aspects connected with social, tourism, nature conservation and education dimensions, being characterized by nature-based solutions more locally, considering ecological and social dimensions. Another distinctive aspect of GE is that it seems to be the only concept that addresses development of justice and public participation in a sustainable way. That being said, GE defends that, in the long run, conservation and restoration of natural processes is more effective in terms of costs (D'Amato et al., 2017).

Regarding CE, this subject relates more to how resources are used within supply chains. Conversely, BE focus more on how resources (already in use) are actually used. (D'Amato et al., 2017, p. 725).

Supporting the idea that GE can include some aspects defended by both CE and BE, Kleinschmit et al. (2014) suggests that BE can be perceived as a part of GE, although some aspects are given different importance (Kleinschmit et al., 2014, p. 403). Loiseau et al. (2016) additionally interprets CE and BE as subordinates of GE, being this last one more inclusive (Loiseau et al., 2016).

In terms of limitation, there is a main, shared conclusion in literature: all three concepts fail to address properly the economic growth issue. This may happen due to the premise that uncorrelated unlimited growth with crescent sustainability (Lorek & Fuchs, 2013), defended by most scholars in the area. The conclusion is that all three sustainability concepts have alternative angles, and therefore, imply different views on sustainability. Additionally, another conclusion was reached: BE's concept is the one less correlated with strong sustainability, when compared to GE and CE (Loiseau et al., 2016).

Ultimately, all concepts can, and should, supplement each other, having synergies amongst them. Since GE is a broader concept, including assumptions from the other two, it is considered an "umbrella concept" (D'Amato et al., 2017; Loiseau et al., 2016).

On the contrary, CE and BE can't be directly linked to one another, although there are some authors nowadays starting to defend CE's principles to be included in BE, originating new concepts, like 'circular bioeconomy' (B Allen, 2016). In the same way, GE principles could be appropriated by CE, namely nature-based solutions (Ten Brink et al., 2012).

Finally, it can be concluded that all concepts are important in their own way, all leading to more sustainable economies. Instead of thinking in them in a conflicting or independent view, economies should beneficiate from an inclusive approach, one where all beneficial aspects of all concepts are incorporated, promoting their impacts.

Additionally, it should be retained that, to fight contemporary problems, the important are the actions that derive from application of all distinct approaches, with focus on reaching their proposed common goal: reconcile economic growth, social harmony and sustainability. Despite which concept countries, policy makers, or any other actors, choose to incorporate in their strategies, the most relevant aspect is to acquire any of their principles in economic and political plans, improving future production and assuring a sustainable path.

As sustainability and its discussion increases all over the world, one should not forget that all three concepts are constantly gaining/losing momentum and, therefore, are in continuous evolution, not being of a static conceptualization, constantly resulting in more adapted views of the real world and its necessities.

CHAPTER 4

VALUE ATTRIBUTION IN BIOECONOMY

Understanding the concept of bioeconomy was an initial, yet important, step to conduct the research suggested in this dissertation. Additionally, so it will be the understanding of how 'value' is measured within bioeconomy. Since most outputs of bioeconomy are a mixture of a large set of inputs in completely different industries, how can policy makers or innovators measure its size and growth?

Further on, since the main goal is to analyze the importance of bioeconomy within the EU, it is reasonable to only look at measurements of value made in this region.

The relevance of evaluating bioeconomy's importance, and continued attempts to improve its measurement, relates with the need to channel investment funds and R&D developments to bio-based production sectors. If the analysis made is optimistic, consequently there will be a global effort to redirect additional funds towards bioeconomy, affecting global behavior.

There are various researchers who address this matter, recognizing difficulties entailed in properly measuring bioeconomy, and effects it can imply. Although the notable increase in biotechnology, numbers not always show exactly that: "(…) in 2014 the life sciences sector was neither producing proportionally more products and services nor proportionally higher revenues than four or five years earlier (…)" (Birch, 2017, p. 461). This proves how dissociated value and valuations can be, specially within a sector, such as bioeconomy, which definition has blurred frontiers.

In order to shed some light into this topic, below there is a summary of some strategies developed to calculate bioeconomy's value, allowing to understand various options and their differences.

One of the latest approaches followed by the EU is based on an "Output-based" method, used to calculate the following specific indicators generated in bioeconomy: jobs, productivity, turnover and added value. Firstly, biomass content of bio-based products that are not completely bio-based is calculated – such as textile made cotton. Secondly, it is determined each sector's contribution to bioeconomy, according to the NACE[5] classification (Ronzon & M'Barek, 2018). This approach was developed by Piotrowsky et al. (2018), in collaboration with the JRC. The assessment about European bioeconomy, from 2008 until 2015, was made with estimates from EUROSTAT, focusing on the aforementioned indicators. If a sector can be fully connected to bioeconomy, all measures are directly taken from the databases. These sectors comprise agriculture, forestry, fishery (primary biomass production), food, beverages, paper and paper products and tobacco. Complexity in valuation of bioeconomy increases when it concerns sectors that partly contain bio-based products. This is the case for textiles and textile products sector, forest-based industry sector, chemicals and plastics sector and pharmaceuticals sector. What is done in these sectors is to predict the share that is bio-based and only use these predictions to originate results (Piotrowski et al., 2008).

The "physical supply and use flows" is an alternative approach that uses data from supply and use flows (in physical units) to determine weights of contribution of bioeconomy. Combining this measurement with additional data, biomass flows help better understand how the same biomass type can be used to produce alternative products. Moreover, this information allows to perceive cross sectorial effects and impacts of substituting non-bio-based products with equivalent bio-based ones (Kuosmanen et al., 2020). However, given scarcity of biophysical data, this is a difficult measure to implement. The Netherlands uses this method to calculate indicators of sustainability, through CO2 emissions, and circularity of bioeconomy, for example.

[5] NACE – Nomenclature of Economic Activities – is the European statistical classification of economic activities, allowing to group organizations according to their business activities.

Additionally, the Germans use flows of renewable materials to measure their bioeconomy. It consists in combining material flows with sectors relevant to bioeconomy. This sectorial approach estimates the production of biomass and partly or fully bio-based materials, semi-finished or end-use products (their manufacturing and processing) (Iost et al., 2019). Once again, economic activities are classified with NACE and the ones that are relevant for bioeconomy are selected.

To finish, in Finland, statistics calculated for bioeconomy are based on just five indicators: output, value added, investments, employment and exports (of bioeconomy goods only) (Kuosmanen et al., 2020).

When it comes to valuation studies, the ideal it to capture not only the objective, but also the subjective elements that determine value (Helgesson & Muniesa, 2013). Consequently, economic and non-economic evaluation practices to value profit and worth can be better understood (Lamont, 2012). If applied to bioeconomy, this objective-subjective approach would allow to perceive the social changes that current political projects have on industries, surpassing narrower views of meeting numerical expectations. A broader conceptualization of value that considers underlying social practices would be beneficial to understand implications that bioeconomy has in different sectors.

Moreover, the definition of bioeconomy that is chosen by different actors or countries will directly impact the way it is measured in terms of value, and therefore, leading to different results and findings (Mittra & Zoukas, 2020, p. 18). This will culminate in alternative decisions by stakeholders, in time and space.

What can be withdrawn from the aforementioned measuring approaches is that bioeconomy's value can be determined through various approaches and alternative tools/metrics, resulting in different narratives and conclusions about its scale and scope (Mittra & Zoukas, 2020, p. 16), in global and national economies, and ultimately, in society. This will make cross-section comparisons between different sectors and countries hard to conduct. However, a generalist and inclusive approach in terms of value will force actors to consider multiple ways in which economic and non-economic value contributes to alternative social contexts. In turn, this leads to a more correct illustration of changes that political bioeconomic projects drive in society, supported by scientific and technological advances, culminating in completely new business models that work specifically towards solvability of global problems (Mittra & Zoukas, 2020, p. 17).

Given that what is proposed with this dissertation is an analysis within EU's context, it is only reasonable to follow their directives regarding the approach of measuring bioeconomy. Therefore, as it will be further detailed in the forthcoming section, the followed approach is the "output-based" method, adopted by EC and EUROSTAT, the two main entities from where numerical data will be sourced and collected on Part II.

PART II

BIOECONOMY IN THE EUROPEAN UNION

Following Part I, where the core knowledge about bioeconomy was addressed, on Part II the focus will be redirected to analyzing the European Union's bioeconomy performance.

Before starting with the numerical analysis, detailing the methodology followed and the main conclusions of the work developed, a brief contextualization on the European bioeconomy should be made. Consequently, Part II starts with a dedicated chapter that analyses the contributions of the European Union, through their official entities, for its bioeconomic strategy and policy. Therefore, **Chapter 5 –** ***Strategy and Policy*** – intends to detail the strategies and policies followed by the European Union (namely, the European Commission) in recent years. With this, a solid background for the forthcoming chapter will be provided, since the main goals and targets towards a more sustainable economy in the EU will be explained simply, resulting in a better understanding for the numerical analysis developed posteriorly.

The subsequent chapter, **Chapter 6 –** ***Methodology: Constructing the Dashboard*** – , will exhibit the study conducted on this work, starting by detailing the methodology applied and explaining the main assumptions that were considered in developing the dashboard created. Every core aspect regarding the creation of the dashboard will be detailed, including its baseline structure, data model and dashboard's final visual presentation.

After introducing and showing the dashboard, a summary numerical analysis will be made, in order to provide the resulting main conclusions, achieving the main goal of this dissertation's work. Therefore, **Chapter 7 – *Bioeconomy in Numbers*** – will provide the reader with knowledge about the general bioeconomic reality in European Union, throughout the years, based on the numerical analysis achieved by the construction of the dashboard. An indicator-by-indicator analysis will be made, gathering main information about each selected indicator in the EU context, on both economic and sustainable strands. Additionally, as a culmination of this analysis, an overall interpretation of the results will be made, to shed a light on the general bioeconomic panorama in the EU.

CHAPTER 5

STRATEGY AND POLICY

The current chapter will provide a contextualization on strategy and policy for bioeconomy implemented by EU. Although recent, bioeconomy is rapidly growing to be relevant within policy makers and economic actors. The EU is no exception, and bioeconomic or bioeconomic-related strategies are nowadays developed, or under development, in different Member States.

5.1. STRATEGY

What does EU bioeconomy's strategy aim to achieve? The main goal for existence of a specific bioeconomic strategy is to allow interconnection between sustainable use of renewable biological resources with protection and restoration of biodiversity, ecosystems and natural capital. In the long run, EU intends to use bioeconomy as a tool to provide balanced growth on societal, environmental and economic fields. To achieve this, it is urgent to reinforce circularity and sustainability principles.

When looking back in history, a trace can be made on major politic landmarks that contributed to implement and develop bioeconomic strategy in EU.

In 2005, program "Knowledge-based Bioeconomy" (Albrecht et al., 2010) aimed to integrate research and development into primary production. Later, in 2007, "Cologne Paper" (European Council, 2007) presented itself as a declaration of intentionality over bioeconomy developments within EU. In 2010, Germany was the first EU country to launch its "National Bioeconomy Strategy" (Federal Ministry of Education, 2010), leading the way for EU, in 2012, to launch a communication on bioeconomy[6].

Finally, in 2018, an update to the 2012 strategy was made, gathering organizations of economic and environmental interest, to review and complement EU's strategy for bioeconomy (European Commission, 2018). There are five primary goals to be achieved, addressed in the 2012 Bioeconomy Strategy by EC (European Commission, 2012). These five objectives can be listed as:

(1) ensuring **food security**;
(2) managing **natural resources sustainably**;
(3) **reducing dependence on non-renewable** resources;
(4) **mitigating** and **adapting** to climate change;
(5) creating **jobs** and maintaining EU **competitiveness**.

The implementation of these five primary objectives can be done by means of measures, according to EU's Action Plan (European Commission, 2018b). The Action Plan's main priorities are:

(1) **strengthening** and **scaling up** the **bio-based sectors**;
(2) deploying **local bioeconomies** across Europe in a fastened manner;
(2) understand **ecological boundaries** of bioeconomy.

Revision of the 2012 Strategy is made to boost and accelerate implementation of its original measures, in order to quickly achieve a sustainable European bioeconomy. It is also an adjustment to recent developments in policy making, answering more

[6] By 2020, Portugal, for example, announced developments leading to the implementation of a national bioeconomy strategy (Estratégia Nacional para a Bioeconomia Sustentável 2030).

efficiently to international goals, such as “Paris Agreement”[7] and “Sustainable Development Goals”.

5.2. POLICY

Although no specific EU bioeconomy legislation exists, sectorial legislation has a vast impact over bioeconomic policy. Therefore, EC provides, in its official website, detailed information about various sectors of importance for bioeconomy[8].

A general perspective of each Member State’s bioeconomic advances can be seen in an interactive dashboard, provided by the EC[9]. There it can be found the main entities that regulate or intervein on Nation’s bioeconomies, alongside with their bioeconomic strategies and plans.

On a macro level, EU is starting to stablish specific policy rules to reinforce importance of urgent implementation of its strategy and, ultimately, reaching its goals.

Review strategy of 2018 contributes, along with other things, to “European Green Deal”, which is one of the priorities identified by EU to focus on, between 2019 and 2024.

The “European Green Deal”, which focus on turning Europe the first climate-neutral continent, through a resource-efficient and competitive economy (European Commission, 2021), has one main goal to reach year 2050 with no net emissions of greenhouse gases. Furthermore, EU proposed an “European Climate Law” (European Commission, 2020c, p. 1) in order to make this a **legal obligation** for all Member States.

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[7] An agreement which objective is to keep global temperature increase below 2°C and pursue efforts to keep it under 1.5°C.

[8] For detailed information visit: https://knowledge4policy.ec.europa.eu/bioeconomy/topic/policy_en

[9] For detailed information visit: https://knowledge4policy.ec.europa.eu/visualisation/bioeconomy-different-countries_en

This proves as an example where policy rules are created towards implementation of European bioeconomy strategy.

In the present work, the sustainability analysis, which will be conducted and further explained in Chapter 7, will address indicators present on **Table 2,** which summarizes EU's goals for Climate Action, regarding **greenhouse gases, renewable energy** and **energy efficiency.**

Policy and Targets for EU Climate Action			
Short-Run Targets			
	Greenhouse Gases	Renewable Energy	Energy Efficiency
2020 Climate & Energy Package	20% reduction in **emissions** (from 1990 levels)	20% share for **renewables**	20% **improvement**[10]
2030 Climate & Energy Framework	40% reduction in **emissions** (from 1990 levels)	32% share for **renewables**	32.5% **improvement**[11]
Long-Run Targets			
2050 Neutrality	**No net emissions** of greenhouse gases		

Table 2. EU's Targets and Goals for 2020, 2030 and 2050

Source: (European Commission, 2019)

[10] Equivalent to a final energy consumption of no more than 1.086 million tonnes in 2020
[11] Equivalent to a final energy consumption of no more than 956 million tonnes in 2030

CHAPTER 6

METHODOLOGY: CONSTRUCTING THE DASHBOARD

The final purpose of this dissertation is analyzing economic performance of bioeconomy in EU. Therefore, being a developed economic region, providing lots of official information, there were various tools one could have chosen to analyze bioeconomy impact in EU's economy.

The study's primary objective is to understand numerical data relevant for bioeconomy's sector in EU, using official databases, in order to shed a light of its economic performance, in each Member State.

After collecting the intended data, an interactive dashboard was developed to examine more intuitively numbers in use, easily allowing reaching conclusions.

Regarding programs used to proceed with analysis of data, there were used two tools simultaneously. The main program, where the model and dashboard itself were constructed, was Power BI Desktop. Additionally, Excel functioned as a complement, to perform further calculations.

Therefore, Chapter 6 will provide a description of the work developed towards constructing the dashboard in question, explaining with full scope methodology applied and assumptions considered.

Various indicators were chosen to procced with this analysis, falling in two different categories: "**Economy-oriented indicators**" and "**Sustainability-oriented indicators**". "Economy-oriented indicators" allow to analyze countries' economic performance in the bioeconomic sector, while "Sustainability-oriented indicators" will show countries' performances in contributing to fight climate related issues. These indicators, of a sustainable nature, were chosen to ultimately reach an answer to the following – "Are countries with a better economic performance in bioeconomy also the ones leading by example, and therefore, presenting better sustainability results?".

Since the approach being followed regarding attribution of value in bioeconomy is the one chosen by EC (namely, an "output-based" method), the choices one had to make when selecting indicators for analysis were intimately connected with this premise. Consequently, the economic-related indicators chosen were: **employability**, **labour productivity**, **turnover**, **value added** and **GDP**.

Regarding sustainability-related indicators, the choices made were connected to climate policy followed by EC, specifically the "2020 Targets". In that way, the three indicators named in this strategy plan were chosen – **greenhouse gases emissions**, **share of renewable energy** and **energy efficiency.** Additionally, a fourth indicator was chosen, to relate sustainability to economic processes – the **circularity** in the economy.

Regarding economic-related indicators, for economic performance analysis, there are two different original datasets that feed the dashboard. As for the sustainability-related indicators, five different datasets were chosen.

Moreover, general methodology applied to all databases can be simplified as follows:

1. Each original database was downloaded in '.csv' format from the source;
2. Each original file was loaded directly into Power BI Query Editor;
3. Necessary modifications to the original data were made using Power BI Query Editor;
4. When any additional calculation was needed, the original '.csv' file was loaded to Excel, and intended formulas were applied;
5. Calculations' results were saved on Excel and loaded directly on Power BI as a new table, replicating modifications made to the original dataset, obtaining homogeneity.

All beforementioned steps guarantee that future updates on source files will be easily performed without altering the data model and the dashboard's presentation.

In order to better understand the databases used and their connections with indicators and tables created, **Table 3** presents a scheme of the dashboard's model structure, including each database's sources.

	Source	Data's Information	Chosen Indicators	Tables on the Dashboard
Economy-oriented Indicators	EUROPEAN COMISSION	**Data name:** Jobs and Wealth in the European Union Bioeconomy **Data code**: Dataset_JRC_-_Bioeconomics[12]	Employed People	▪ Dataset_Bioeconomics ▪ GrowthRate_Bioeconomics ▪ WeightSector_Bioeconomics ▪ Weight_VA_GDP
			Labour Productivity	
			Turnover	
			Value Added	
	EUROSTAT	**Data name**: GDP and main components (output, expenditure and income) **Data code**: nama_10_gdp[13]	GDP	▪ Dataset_GDP ▪ GrowthRate_GDP ▪ Weight_VA_GDP
Sustainability-oriented Indicators		**Data name:** Air emissions accounts by NACE Rev. 2 activity **Data code**: env_ac_ainah_r2[14]	Greenhouse gases	▪ Dataset_AirEmissions ▪ GrowthRate_AirEmissions ▪ 2020Target_AirEmissions
		Data name: Greenhouse gas emissions, base year 1990 **Data code**: T2020_30[15]		
		Data name: Share of Renewable Energy in Gross Final Energy Consumption **Data code**: T2020_31[16]	Share of Renewable Energy	▪ Dataset_ShareOfRenewables ▪ GrowthRate_ShareOfRenewables
		Data name: Energy efficiency **Data code**: nrg_ind_eff[17]	Energy Efficiency	▪ Dataset_EnergyEfficiency ▪ GrowthRate_EnergyEfficiency
		Data name: Circular material use rate **Data code**: env_ac_cur[18]	Circularity Rate	▪ Dataset_CircularityRate ▪ GrowthRate_CircularityRate

Table 3. Databases and Indicators in use

[12] https://datam.jrc.ec.europa.eu/datam/mashup/BIOECONOMICS/index.html
[13] https://ec.europa.eu/eurostat/databrowser/view/nama_10_gdp/default/table?lang=en
[14] https://ec.europa.eu/eurostat/databrowser/view/env_ac_ainah_r2/default/table?lang=en
[15] https://ec.europa.eu/eurostat/databrowser/view/T2020_30/default/table
[16] https://ec.europa.eu/eurostat/databrowser/view/t2020_31/default/table?lang=en
[17] https://ec.europa.eu/eurostat/databrowser/view/nrg_ind_eff/default/table?lang=en
[18] https://ec.europa.eu/eurostat/databrowser/view/env_ac_cur/default/table?lang=en

6.1. EXPLAINING THE DATABASES

Some assumptions were applied to all databases identically. Therefore, an explanation won't always be necessary for all variables included in different databases, since it corresponds to a general principle. Only variables that present unique features and should be further explained will be presented or pointed out.

Therefore, an initial analysis was made to the primary database that feeds the dashboard – "Jobs and Wealth in the European Union Bioeconomy" – and preceding databases will be dealt with in similarly, meaning they follow the same principles regarding time series, countries and sectors of the main database.

In order to better understand what will be here detailed, **Figure 3** shows all tables originated in Power BI Query Editor, from all source databases and excel result files.

All queries created, i.e., tables represented in **Figure 3**, were separated according to previous division into economic-oriented and sustainability-oriented indicators. Additionally, dimension tables, which correspond to the three query tables inserted on folder "General", were included, allowing interconnection between all tables, representing variables that are always present in every table, and that will be used to filter information and results in the final dashboard.

Following sections will explain assumptions for all main tables, separating the analysis in three parts, each one corresponding to folders created in Query Editor, seen on **Figure 3**. However, since some tables were created following the same principles, they will be explained only once. This is the case for all tables which names start with "GrowthRate" and "Weight". These tables correspond to "Additional Calculations", and since the first table explained is "Dataset_Bioeconomics", their explanation will appear on this section, meaning their corresponding additional calculations' tables will be explained, albeit the process applied to remaining ones was the same. Each data table's preview can be found on **Appendix A**.

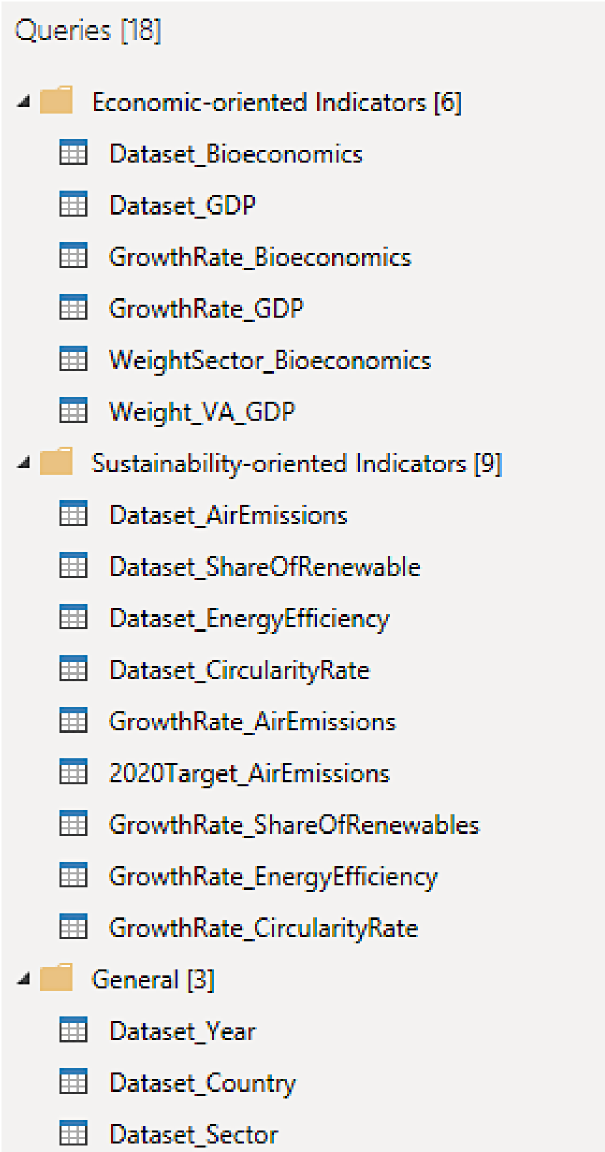


Figure 3. Queries created in Power BI

6.1.1. "General" Queries

All "General" dimension queries, represented on **Figure 4**, were created having the main dataset as their source, with exception for "Dataset_Year" dimension, as it is explained below. This means that the original file that feeds table "Dataset_Bioeconomics" is being used to feed these dimensions, having in consideration removal of columns that were not necessary for these "General" dimensions' creation.

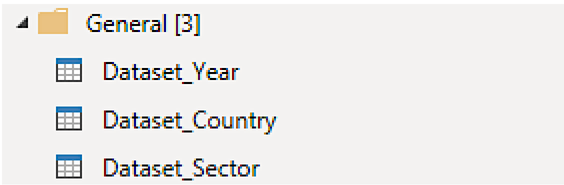


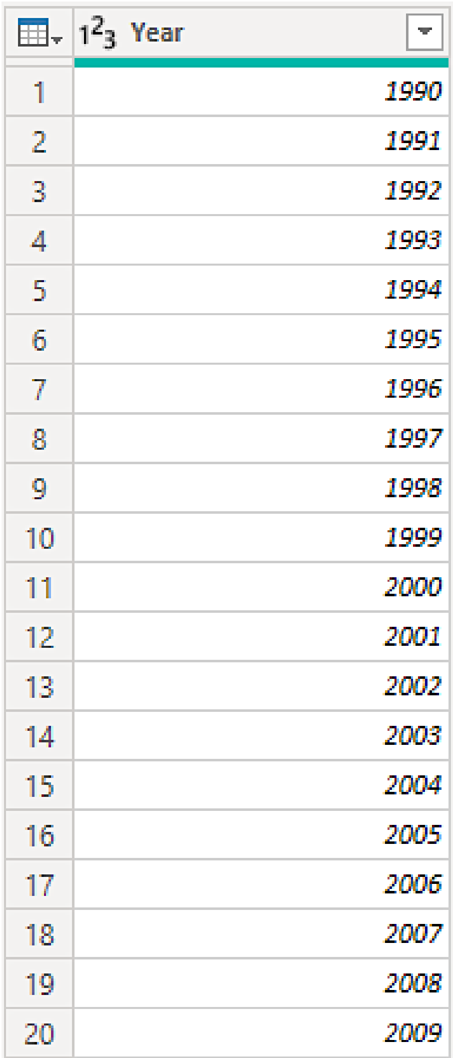
Figure 4. "General" Queries

6.1.1.1. "Dataset_Year" Dimension

Since this dimension is meant to regulate the dashboard's time scope, the principle of inclusion was considered. This translates, in practice, to allow this dimension to assume the latest and most recent years considered in the totality of all databases used. That is the reason why the main database was not used as a source. Instead, a one-column table was created, with the "Year". Representation of this dimension can be seen on **Figure 5**.

Since "Air Emissions" analysis is the only one covering a different time scope, due to policies and strategies being made consider comparisons with 1990, this was the first year introduced in the dimension. As for the last year considered, it was opted to conciliate it with the last year from the main database – 2018.

In the future, as original databases will be updated, presenting values for more years, so will this dimension. The time series considered is annual, meaning datasets present values on an annually basis.



	Year
1	1990
2	1991
3	1992
4	1993
5	1994
6	1995
7	1996
8	1997
9	1998
10	1999
11	2000
12	2001
13	2002
14	2003
15	2004
16	2005
17	2006
18	2007
19	2008
20	2009

Figure 5. Preview of Dimension Table "Dataset_Year"

6.1.1.2. "DATASET_COUNTRY" DIMENSION

This dimension was created to guarantee that analysis is always within the same countries scope, being originated from the list of countries that represent EU in the main dataset. Additionally, this procedure guarantees that all tables can relate only with countries here considered.

There are two columns that reflect this variable, being them "Country" and "Country's Code". Variable 'Country' lists all values considered in the dataset, i.e., 27 Member States of EU and aggregate of all Member States. To every country there is a codified representation showed in variable "Country's Code".

Due to alteration, in 2020, from 28 to 27 Member States, the original dataset has two different compositions for representing EU: "European Union (27 countries, from 01/02/2020)", with a corresponding code of "EU27_2020", and "European Union (28 countries)", with a corresponding code of "EU28". Given that, at the time the dashboard was developed, UK was already excluded from EU, a total of 27 Member States were considered. Therefore, EU28 variables were disregarded, and the name of "European Union (27 countries, from 01/02/2020)" variable was altered to simply "All Member States", with a corresponding code name of "EU27".

This table is represented as "Dataset_Country" on the data model. **Figure 6** shows its preview and how both variables connect to each other, enlisting the considered countries.

	Country	Country's Code
1	All Member States	EU27
2	Austria	AT
3	Belgium	BE
4	Bulgaria	BG
5	Croatia	HR
6	Cyprus	CY
7	Czechia	CZ
8	Denmark	DK
9	Estonia	EE
10	Finland	FI
11	France	FR
12	Germany	DE
13	Greece	EL
14	Hungary	HU
15	Ireland	IE
16	Italy	IT
17	Latvia	LV
18	Lithuania	LT
19	Luxembourg	LU
20	Malta	MT
21	Netherlands	NL
22	Poland	PL
23	Portugal	PT
24	Romania	RO
25	Slovakia	SK
26	Slovenia	SI
27	Spain	ES
28	Sweden	SE

Figure 6. Preview of Dimension table "Dataset_Country"

6.1.1.3. "DATASET_SECTOR" DIMENSION

In order to divide bioeconomy into sectors, firstly there is the need to determine which sectors can be included in it. The original main dataset includes sectors that can be related fully or partly[19] to bioeconomy, according to official statistical classification of economic activities used by EC – NACE Rev.2 (Ronzon & M'Barek, 2018).

[19] Since NACE classification cannot differentiate bio-based from non-bio-based activities.

Additional specific methodology can be found on Ronzon et al. (2017) and Piotrowski et al. (2018) to understand attribution of sectors to bioeconomy (Piotrowski et al., 2018, p. 3; Ronzon et al., 2017, p. 2).

A new dimension table containing the sectors' names and their corresponding codes was inserted in the data model, allowing future correlations or to verify which sectors' codes are in use. This table was named "Dataset_Sector" and it is shown on **Figure 7**.

	Sector	Sector's Code
1	Agriculture	A01
2	All Bioeconomy	bTOTC
3	All Economy	TOT_NACER2
4	Bio-based chemicals, pharmaceuticals, plastics and rubber (excl. biofu...	bCHEM
5	Bio-based electricity	bD3511
6	Bio-based textiles	bTEXT
7	Fishing and Aquaculture	A03
8	Food, beverage and tobacco	C10-12
9	Forestry	A02
10	Liquid biofuels	bFUEL
11	Paper	bC17
12	Wood products and furniture	bC16-bC31

Figure 7. Preview of Dimension Table "Dataset_Sector"

Two additional modifications to each sectors' name were made. Value named "Bioeconomy" was altered to "All Bioeconomy", representing aggregation of the total sectors that form bioeconomy. Finally, value "Total Sectors" was altered to simply "All Economy"[20], representing the totality of all sectors in a country's economy.

In the original dataset, beside NACE sectors related to bioeconomy, chosen according to EC's definition and vision about bioeconomy, sub-sectors of each main sector were also discriminated. Once more, for simplification, the "Sector" variable was filtered to consider exclusively parent categories of bioeconomic sectors. Since a filter was applied, this enables to add remaining sub-sectors to the dashboard in the

[20] This sector is only associated with indicator "Employed People" and it won't be available for the remaining economic indicators in analysis.

future, in case that information serves some ulterior purpose. Therefore, all main sectors considered for analysis and present in the final dashboard are represented on **Figure 7**. Sector "All Bioeconomy" will, therefore, represent the sum of all sectors represented in bioeconomy, i.e., all parent-sectors identified in "Sector" column. Identically, sector "All Economy" will present values for the totality of NACE sectors considered in the economy.

6.1.2. "ECONOMIC-ORIENTED INDICATORS" QUERIES

Databases explained on the following section are the ones that originate queries showed on **Figure 8**. Given that constitution of each dataset is, partially, formed by "General" queries, no additional explanation will be needed for variables "Year", "Country" and "Sector", since they represent and were subjected to the same alterations.

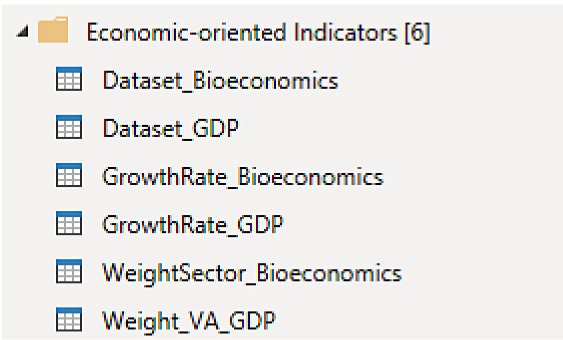


Figure 8. "Economic-oriented Indicators" Queries

6.1.2.1. DATABASE "JOBS AND WEALTH IN THE EUROPEAN UNION BIOECONOMY"

The main dataset chosen for constructing the dashboard is one provided by EC in their public records. This dataset was a product of collaboration of nova-Institute and JRC. Several sources were used to construct this dataset, but mainly, the numbers were collected from EUROSTAT, aggregating information about all 27 Member States, from 2008 until 2018 (considering February of 2021 last update).

This dataset was directly downloaded from EC's official website into a *'.csv'* file, in order to allow necessary modifications on data, fitting it to the dashboard. This source file will be feeding four indicators analyzed on the final dashboard: Employed People, Labour Productivity, Turnover and Value Added.

Modifications to the original dataset were made directly inside Power BI Desktop program, using Power Query Editor. In order to allow smooth construction of the final dashboard, additional considerations were taken. Below it is explained how every variable (i.e., every column) of the *'.csv'* file was dealt with.

6.1.2.1.1. STRUCTURE

INDICATORS

This "Indicator" variable corresponds to the measure chosen to evaluate economic performance of a country in bioeconomy. There were four indicators considered: "Apparent Labour Productivity", "Number of persons employed", "Turnover" and "Value added at factor cost". As for remaining specifications for each indicator, they are explained and described below.

(a) Employed People: it is defined as total number of people who work[21] at a given unit and people who work outside[22] the unit but belonging and being paid by it. People that are absent from a short period of time[23], on strike, part-time workers who are not on payroll, seasonal workers, apprentices and home-office workers on payroll are equally included in this measure. Employees that are absent for an indefinite period are not considered.

[21] It includes working proprietors, partners who work regularly and unpaid family workers who work at a unit.
[22] This includes sales representatives, maintenance and repair teams and delivery personnel.
[23] It corresponds to sick, paid or special leaves.

(b) Labour Productivity: it is defined as value added at factor cost divided by the number of persons employed, giving as a result the productivity of labour.

(c) Turnover: contains the total amount invoiced by a given unit, in a reference period. This measure identifies market sales of goods and services supplied to other parties.

(d) Value Added: it is the gross income from operating activities, after adjustments for operating subsidies and indirect taxes are made.

UNITS

The "Unit" column is directly related with the "Indicators", allowing to identify in what unit each indicator is being measured. In this way, for the indicators chosen, the following correspondence will consequently happen:

	Indicator	**Unit of Measure**
(a)	Employed People	Number of People Employed
(b)	Labour Productivity	1000 EUR per Person
(c)	Turnover	Million EUR
(d)	Value Added	Million EUR

6.1.2.1.2. ADDITIONAL CALCULATIONS

Using the same origin database file, some additional calculations were made to complement original data. Two additional calculations were made: "**Growth Rate"** and "**Weight"**.

The "Growth Rate" will allow to see evolution and (de)growth tendencies for each indicator, along the years. Resulting values from this calculation were achieved using Excel's Pivot Tables and formulas and loaded directly into Power BI as a new table, under the name "GrowthRate_Bioeconomics".

As for the “Weight”, the same method was applied, although calculus made is different. The original data was analysed on Excel and applied formulas allowed to achieve intended results. Result values obtained in table “Weight_Sector_Bioeconomics” represent the percentage of a given sector on “All Bioeconomy” or “All Economy”.

Since the only indicator that originally has values for “All Economy” is “Employed People”, this will be the only case when the respective result column will show values different from zero. For all remaining indicators, the weight, when calculated, is only for a certain sector in total bioeconomy.

6.1.2.2. DATABASE “GDP AND MAIN COMPONENTS (OUTPUT, EXPENDITURE AND INCOME)”

Another database chosen was one that provided information about each country’s GDP, for the same time period as aforementioned database. The same will happen with forthcoming databases when originally collecting data on the source: first year chosen is always 2008 and last year is the most recent one available for that specific data. This decision was made to allow future updates, namely for when the main dataset includes more recent values.

The GDP inclusion will serve as a complement when analyzing indicator “Value Added”, since its comparison with GDP is of the upmost relevance. The last official update made to this dataset was in February of 2021, being that the version in use.

Regarding transformations performed in the original “.csv” file, they were similar to the ones made in the first database, in order to normalize both files into the same structure, allowing establishment of relationships between both tables on the dashboard’s data model.

6.1.2.2.1. STRUCTURE

In that way, the structure of "Dataset_GDP" table was transformed to englobe GDP values, starting in 2008 until 2018, for each country, in a given year.

This dataset was collected directly from EUROSTAT, englobing all Member States and their aggregate, from 2008 to 2019. A filter on Power BI Query Editor was later applied on GDP's dataset (and other datasets), to consider the same time period of the main dataset – 2008 to 2018.

INDICATOR

As for the indicator considered in the original EUROSTAT database, the following was selected: "[B1GQ] Gross domestic product at market prices", which was given the name of "GDP".

UNIT

Since "Value Added" is measured at current prices, the unit of measure chosen for GDP was the same, in million euros. Therefore, GDP will be shown in "Million EUR", considering it is measured in current prices.

6.1.3. "Sustainability-oriented Indicators" Queries

The same logic as before was maintained for the "Sustainability-oriented Indicators" queries created, found on **Figure 9**. Dimensions for "Year", "Country" and "Sector" are equally considered and connected with these tables.

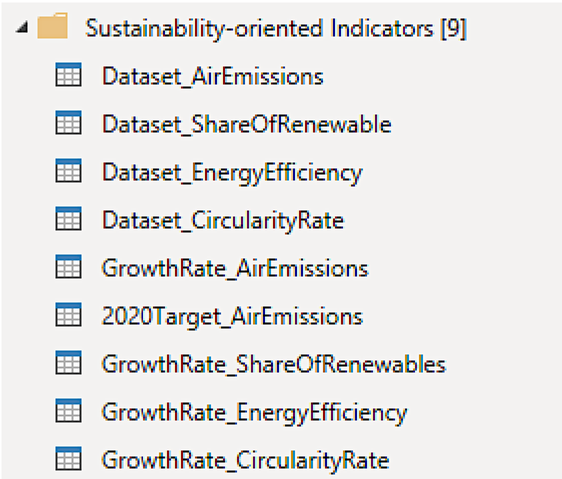


Figure 9. "Sustainability-oriented Indicators" Queries

6.1.3.1. Database "Air Emissions Accounts by NACE Rev. 2 Activity"

This database was collected with the objective of gathering information about the amount of greenhouse gases emitted to the atmosphere by every European country. This indicator will help the sustainability-oriented analysis intended to perform. The last update made to the original source database was in December of 2020, being this version the one in use.

6.1.3.1.1. Structure

The dataset was altered in Power BI Query Editor and can be found under the name "Dataset_AirEmissions".

INDICATOR

Regarding the choice for air pollutants and greenhouse gases, all greenhouse gases were considered, meaning that the filter on EUROSTAT's source database was "[GHG] Greenhouse gases (CO2, N2O in CO2 equivalent, CH4 in CO2 equivalent, HFC in CO2 equivalent, PFC in CO2 equivalent, SF6 in CO2 equivalent, NF3 in CO2 equivalent)". Therefore, the indicator in analysis will simply be named as "Greenhouse Gases".

SECTOR

The filter made on the original source when collecting data was set to include all NACE activities, under EUROSTAT's code name "Total – all NACE activities", resulting in a "Sector" column presenting a single value – "All Economy".

UNIT

The chosen unit to measure this indicator was "Kilograms (per capita)", filtering the original dataset on the source using "[KG_HAB] Kilograms per capita". Opting for a unit that measures emissions per capita, will allow for a better understanding of the country's ranking, preventing skewing the results.

6.1.3.2. DATABASE "GREENHOUSE GAS EMISSIONS, BASE YEAR 1990"

Unlike remaining databases, this dataset was used to perform only an additional calculation, to help analyze indicator "Greenhouse Gases".

Since the "2020 Target" project from EU specifies that the target for greenhouse gases emissions has to be at least 20% less, when compared to same values from 1990, this additional database had to be inserted in the analysis. This dataset includes values from air emissions with base year of 1990. In this way, a comparison between all years can be easily made, and additionally, a perception of evolution towards the target can be deduced. The original database was last updated in February of 2021, being this the version in use.

YEAR

This original database has values since 1990, unlike all remaining datasets. Additionally, the last year considered was 2018.

GROWTH COMPARED TO 1990

In this column a calculation was made on excel to allow representation of the comparison of a certain year value for a given country with the value from 1990, in order to perceive the distance from 2020 target, which is a reduction of at least 20%.

2020 TARGET

In this column, the target for 2020 was included, in order to posteriorly allow comparison of the previous column with this value, determining, therefore, country's performance towards EU target.

6.1.3.3. DATABASE "SHARE OF RENEWABLE ENERGY IN GROSS FINAL ENERGY CONSUMPTION"

This database was collected from the source considering the last update available, made in February 2021. The choice for this dataset pends, as explained, with it being included in the 2020 strategy implemented by EU. In this way, this database shows the share of renewable energy in gross final energy consumption, having target values for each country already included.

6.1.3.3.1. STRUCTURE

2020 TARGET

EU27's objective is to increase the share of renewables to 20% until 2020, although each country has its own individual target, included in the database, under the column "2020 Target".

6.1.3.4. DATABASE "ENERGY EFFICIENCY"

To have a complete analysis of the 2020 targets pursued by EU, there is only one objective-indicator left to consider – the energy efficiency. The original dataset was last updated in January of 2021, being this the version in use on the dashboard.

6.1.3.4.1. STRUCTURE

The final table with the original data can be found in the data model, under the name "Dataset_EnergyEfficiency".

INDICATOR

In the original database, the choice for the energy balance, to measure energy efficiency, was "[FEC2020-2030] Final energy consumption (Europe 2020-2030)". Therefore, the indicator chosen was "Final Energy Consumption", allowing comparisons between values on the dataset and the target for 2020 implemented by EU.

UNIT

The chosen unit was "Million tonnes of oil equivalent", under EUROSTAT's code name "[MTOE] Million tonnes of oil equivalent (TOE)". This choice was made in order to enable direct comparisons to the 2020 target.

2020 Target

Given that the 2020 target for final energy consumption is to represent no more than 1 086 million tonnes of oil equivalent, this column has the same value for all entries, in order to analyse how countries are contributing to reach this goal.

6.1.3.5. Database "Circular Material use rate"

The circularity rate[24] is a measure that indicates the share of materials recovered and reinserted back into economy. This process allows saving on primary raw materials, preventing further extraction. This indicator will allow to perceive which countries have higher circularity rates, and consequently, are reinventing their industrial processes in order to accommodate the world's needs of reducing use of materials in production, combining economic advances with a higher concern for the environment. In that way, this database will provide information about the circularity rate of materials in use within sectors, for a certain country or region. The last update was made in November of 2020, being this dataset the one in use.

6.1.3.5.1. Structure

Year

Although data was originally collected from EUROSTAT having in consideration the same time period as before, it should be noted that there is no data available for any country, in 2008 and 2009, with exception for EU27's aggregate.

[24] Ratio of circular use of materials to overall material use.

6.2. EXPLAINING THE DATA MODEL

After having the databases needed, created using the same structure, their relationships are now easier to perform and understand. These relationships, between the databases in use, i.e., all tables created and previously explained, achieved by formulating the data model in Power BI, allow for correlations between all variables, making analysis more dynamic and complete.

In this way, **Figure 10** represents the data model created in Power BI, with correlations between tables. Process of formulating connections between each table will not be exhausted here since it does not bring additional clarification. The important aspect to retain is that, by creating a data model with the right connections between tables will allow a smooth and interactive analysis in Power BI, while developing graphics, matrices, charts, and so forth.

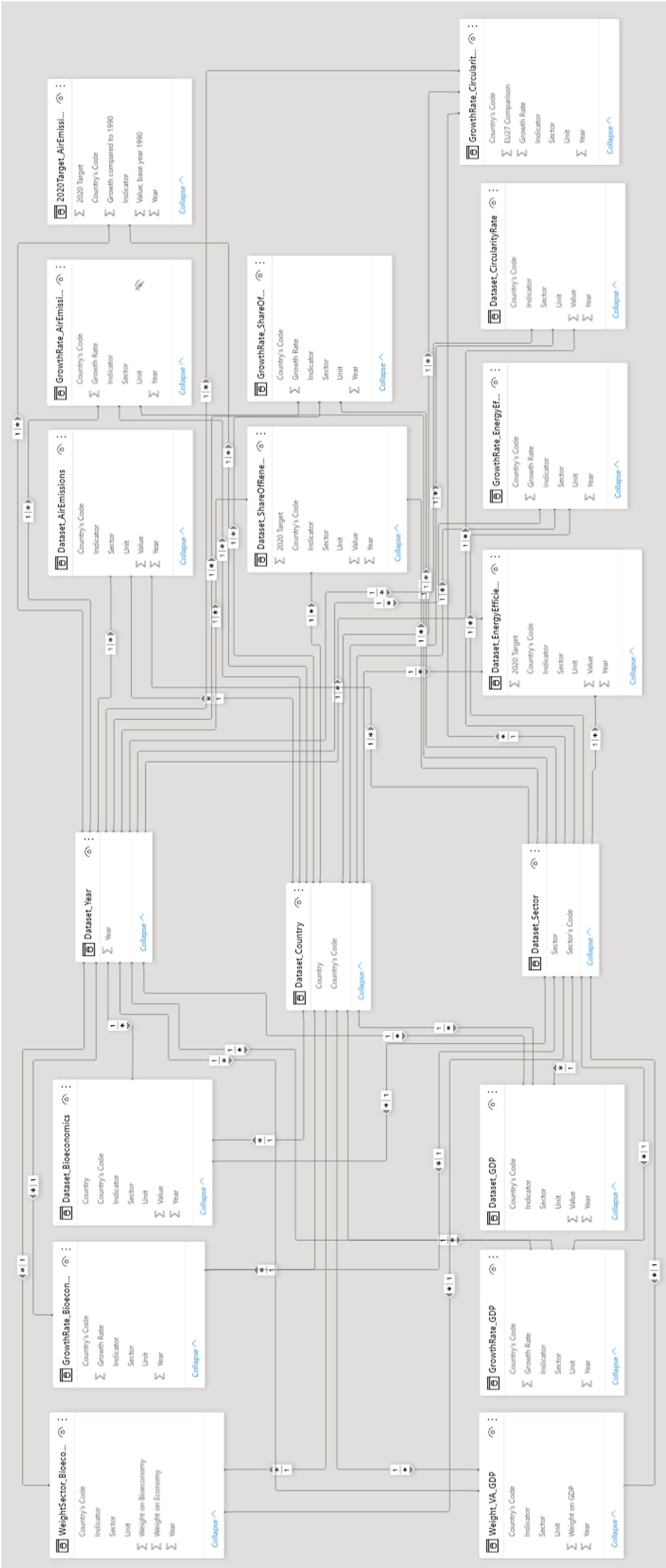


Figure 10. Preview of the Data Model

6.3. EXPLAINING THE DASHBOARD

Having a dataset adequate to the needs of the intended study, proceeding to constructing the dashboard was the following step. The program used to create and develop the dashboard, as already said, was **Power Bi Desktop** interface. This tool was selected because it allows for distinct simultaneous analysis and it is user-friendly, appealing and interactive.

The final dashboard is published online, and found HERE. Additionally, it can be accessed via QR Code (**Appendix B**), and the original file can be found through the following pathway, for anyone who wants to download it:

Origin Folder: Click HERE

Password: BIO2021

The dashboard's file is "Bioeconomy_Analysis.pbix", and the remaining folders contain original databases and excel files.

What will be explained in this current section is how the dashboard works and the logic implemented behind the construction of each page, in order to shed a light on what can be achieved by its use, trough the analysis of each indicator.

Every dashboard's page was created following a similar model structure, that should be understood correctly before starting with their analysis, preventing misinterpretation of numbers presented. Therefore, **Figure 11** enables to understand each page's basic framework logic.

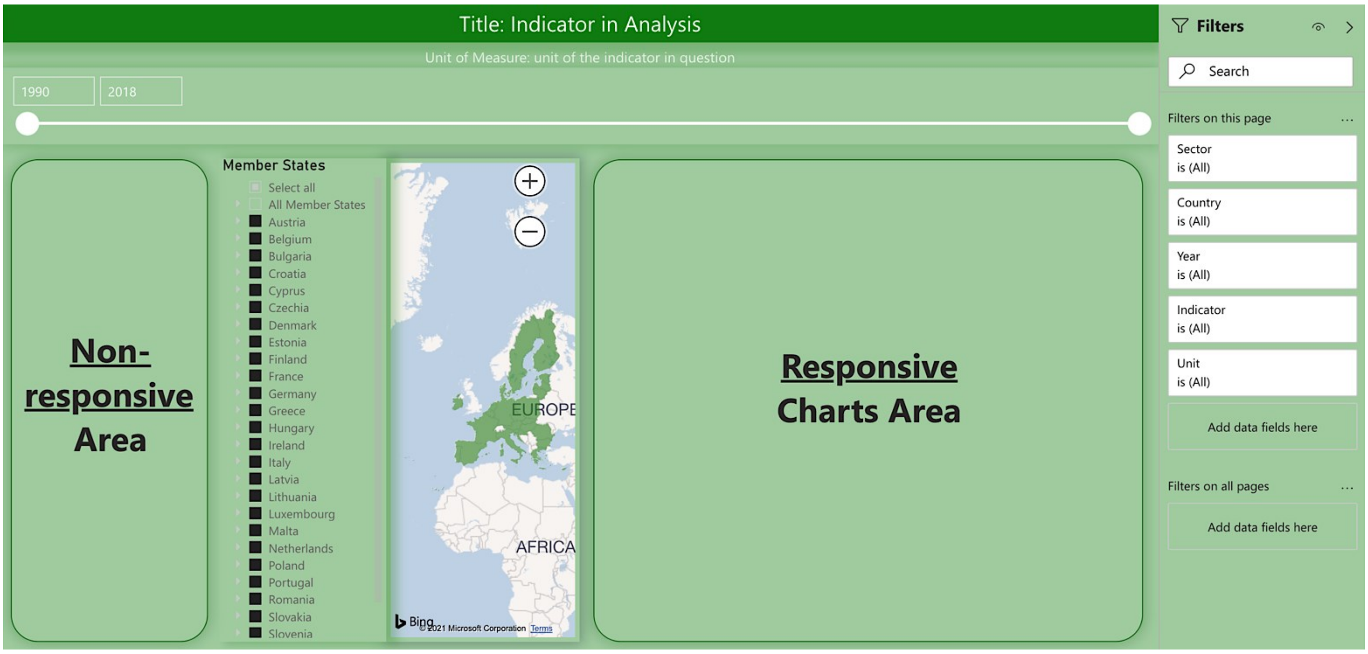


Figure 11. Preview of page's structure

As it is shown on **Figure 11**, organization of each page is simple and intuitive. Every indicator's analysis page is composed by the following sections:

– **Title:** allows to identify which indicator is being analyzed;

– **Unit of Measure:** identifies the unit of measure of the indicator in analysis;

– **Year Slicer:** allows to filter the period in analysis, enabling to shorten or increase it;

– **Non-responsive Area:** responds only to the "Year" slicer, and it is constituted by numerical cards or small charts, allowing immediate readings;

– **"Member States" Slicer:** allows to filter responsive charts by country, with option to select as many as wanted, enabling comparisons[25];

– **Filled Map:** represents the geographical observation of each country and its main numerical results (in form of tooltips), when a country is selected;

[25] By default, all countries are selected with exception for option "All Member States" since this will duplicate results. This option was inserted to allow comparisons between a specific country and the aggregate of EU27.

– **Responsive Charts Area:** area where various charts will be presented to analyze the indicator in question, responding to the year and country slicers.

Additionally, on the right side of the dashboard's view, filters can be found. Each visual can have specific filters, in order to show more detailed data. Moreover, a page can have filters that are affecting all visuals presented. Finally, filters can be applied to the entire dashboard, affecting all visuals of every page.

Having correctly understood the logic behind the construction of the dashboard, it is now easy to comprehend its different pages, allowing to take advantage of their full potential.

The dashboard was constructed following a simple principle – to allow an easy analysis of indicators in use, by anyone who wants to study such information, even if not having vast knowledge about bioeconomy or the program in use. In this way, analysis was divided into different pages, resulting in a dashboard with eight pages, each one corresponding to the analysis of one indicator. Therefore, the following pages are found on the final dashboard (Previews on **Appendix C**)

1. Value Added and GDP;
2. Turnover;
3. Employed People;
4. Labour Productivity;
5. Greenhouse Gases;
6. Share of Renewable Energy;
7. Final Energy Consumption;
8. Circularity Rate.

CHAPTER 7

BIOECONOMY IN NUMBERS

With full comprehension on the functioning of the dashboard, it is possible to analyze its numbers, in order to reach viable conclusions, that will help answering research questions proposed for this work. This chapter will be dedicated to analysis and interpretation of the constructed dashboard, supported by its numbers, graphics and charts.

The analysis will be divided into four parts. In the first part, "Bioeconomic Analysis" will be addressed, followed by "Sustainability Analysis", in the second part. Additionally, a summarized analysis, pondering both previous analyses will be made, to gather main conclusions. Finally, the chapter will end with a section dedicated to future recommendations, intending to address suggestions for further research that can complement this present work.

Therefore, the first two sections will be committed to a full analysis on each indicator previously addressed, in order to allow their understanding, over time and across EU's countries. Since a full country-by-country analysis is not on the scope of this work, an overall analysis will be made instead. This means that, for each indicator, three main conclusions will be persecuted: evolution over time; thriving countries; and countries that are not doing so well, when compared to EU27's aggregate.

Note that every figure presented on the current chapter was taken directly from the dashboard[26], showing its direct results, therefore being of own elaboration.

[26] For better readings, all graphics have higher resolution when analysed directly in the dashboard.

7.1. BIOECONOMIC ANALYSIS

The first analysis being made will focus on "Economic-oriented Indicators", listed before. This includes four pages of the dashboard constructed, each incident on a different indicator.

Firstly, ***"Bioeconomy's Value Added in Total Economy"*** analysis will provide a more generalized overlook on the composition of bioeconomy when compared to countries' economies, by looking to and comparing their "Value Added" and "GDP" indicators.

Moreover, the amount of sales in bioeconomy will be taken into account, trough analysis of ***"Turnover in Bioeconomy"***, focusing on the corresponding indicator "Turnover".

Additionally, ***"Employability in Bioeconomy"*** will be analyzed, with focus on indicator "Employed People", measuring the number of employed people in each sector that composes bioeconomy, and also comparing it with total economy.

Lastly, ***"Labour Productivity in Bioeconomy"*** will complement this analysis, incising on indicator "Labour Productivity", which provides a measure that indicates how productive employed people are in bioeconomy.

All four parts of the analysis will comprise the same time period – 2008 until 2018 - , gathering information about each indicator across these eleven years.

7.1.1. BIOECONOMY'S VALUE ADDED IN TOTAL ECONOMY[27]

Over time, there was a tendency of increase, both in value added and GDP. The value added increased about 18.01%, from 2008 until 2018, with GDP having similar growth, of approximately 20%. This means that, in average, while value added increased 1.64% yearly, GDP increased in 1.85%. **Figure 12** translates this increase over time. While in 2008, the sum of value added in bioeconomy, for all member states, was around 509K million euros, in 2018, this amount surpassed 600K million euros.

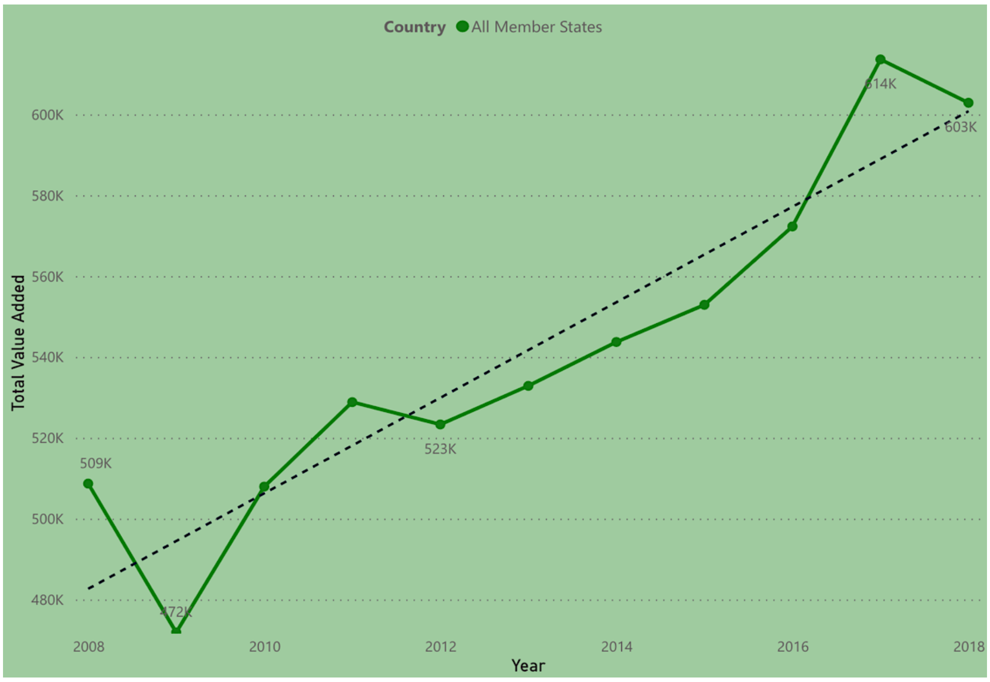


Figure 12. Evolution of Value Added in Bioeconomy in EU27

The same progression can be found in GDP, on **Figure 13**. In 2008, GDP was around 11M million euros, rising to 13.52M million euros until 2018.

Decrease in 2009 is evident, for both value added and GDP, due to 2008's crisis. Identically, countries' individual evolution of total value added and GDP was similar to EU27's aggregate.

[27] Figure's units for both indicators are expressed in Million Euros.

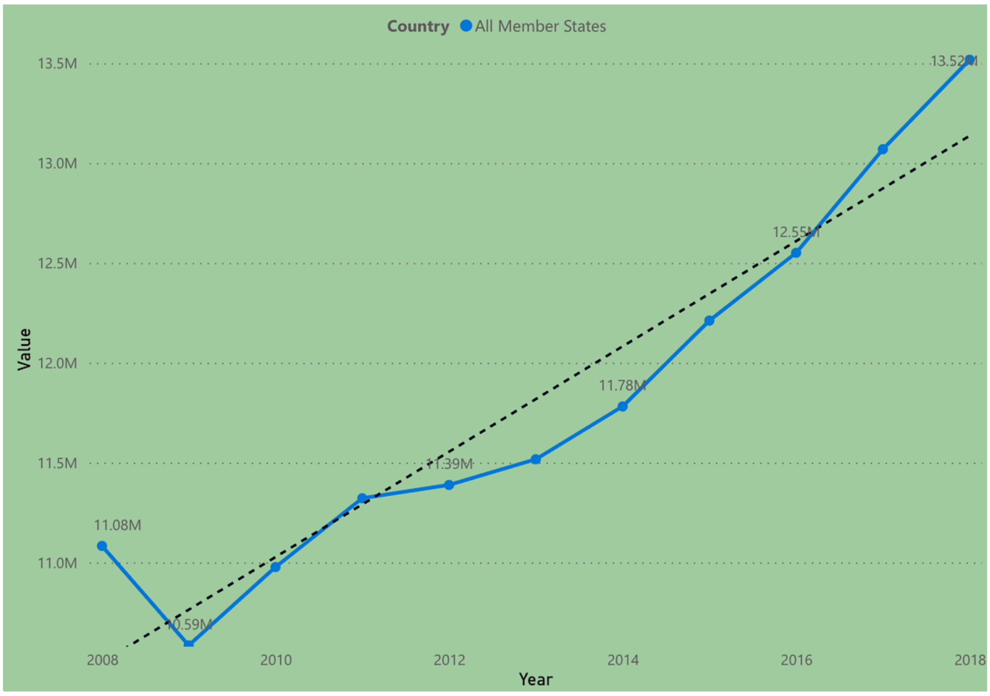


Figure 13. Evolution of total GDP in EU27

Figure 14 presents the evolution of bioeconomy's weight on GDP, demonstrating it has had slight oscillations along the period in analysis. The general tendency is for a decrease, since in 2008 the value was 4.59% while in 2018 it was 4.46%, with a significant drop in 2017, year when this percentage reached its peak (4.70%).

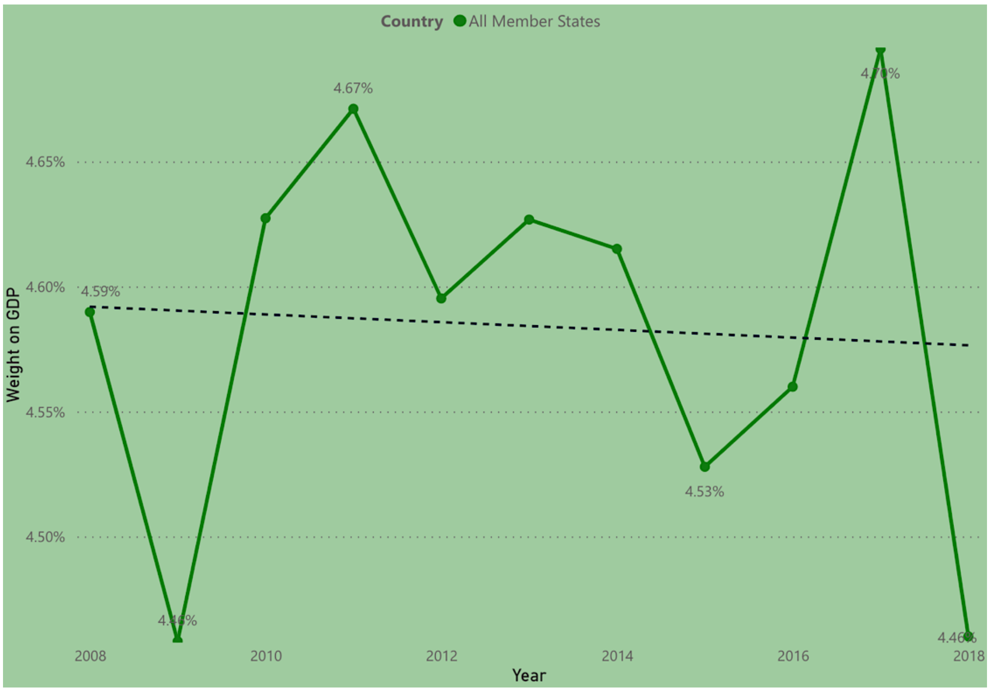


Figure 14. Evolution of Bioeconomy's Weight on GDP

Figure 15 allows to perceive time evolution of value added's growth. Tendency line indicates that in general there has been an increase in growth, although there are negative growth rates, indicating decreases in value added, such as in 2018.

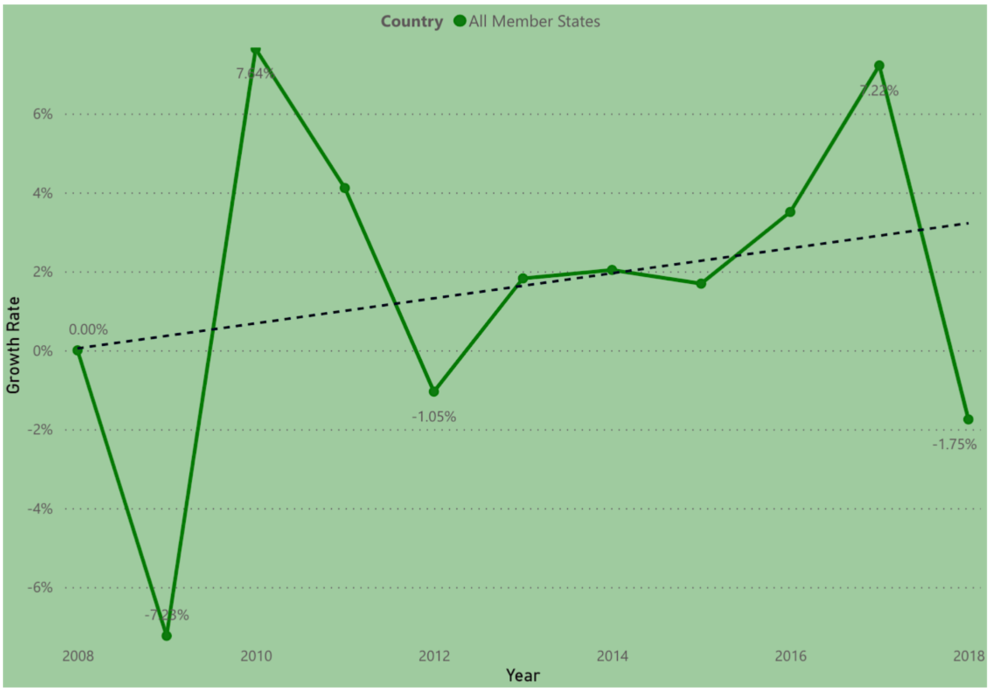


Figure 15. Value Added Growth Rate Evolution in EU27

Having a complete over time evolution, **the remaining analysis will be focused on 2018.** In the aggregate of all Member States, almost 603K million euros of value added were generated in 2018. Moreover, EU27 produced 13.5M million euros in GDP, as shown on **Figure 16**.

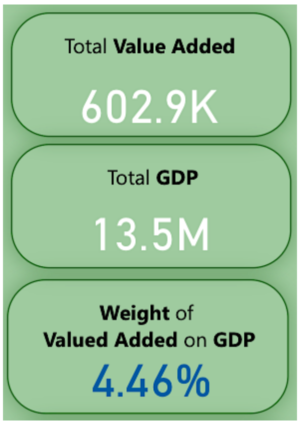


Figure 16. Value Added and GDP for EU27 in 2018

This corresponds to a weight of bioeconomy's value added on total GDP of almost 4.5%, as said before. This value comprises disparities between countries, where bioeconomy's weight can reach values close to 8%, while for other countries the percentage is only residual. Therefore, by analyzing the weight of bioeconomy's value added on GDP, results on **Figure 17** follow. This allows to rank countries, classifying them into Top and Bottom 3.

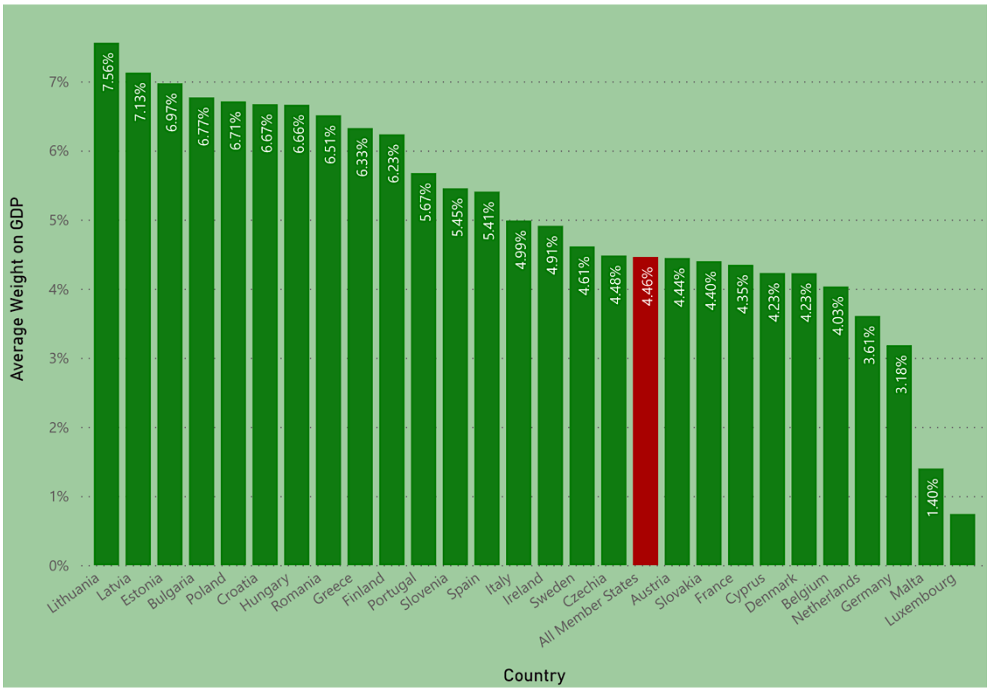


Figure 17. Weigh of Bioeconomy's Value Added on GDP in 2018

Lithuania, Latvia and Estonia are the Top 3 countries, having highest percentages of bioeconomy's value-added weight on GDP, in 2018. Conversely, Luxembourg, Malta and Germany are on the Bottom 3, meaning they have the lowest bioeconomy's weight on GDP.

Another interesting aspect can be identified on **Figure 18** and **Figure 19**. Although presenting the highest value added in the economy in absolute terms, Germany is at the Bottom 3, having its bioeconomy representing only around 3% on total GDP.

Lithuania	
7.56%	3440
Weight on GDP	Total Value Added
Latvia	
7.13%	2077
Weight on GDP	Total Value Added
Estonia	
6.97%	1809
Weight on GDP	Total Value Added

Figure 18. Value Added's Top 3 Countries in 2018

Luxembourg	
0.74%	445
Weight on GDP	Total Value Added
Malta	
1.40%	175
Weight on GDP	Total Value Added
Germany	
3.18%	106820
Weight on GDP	Total Value Added

Figure 19. Value Added's Bottom 3 Countries in 2018

Shifting the course of the analysis, let it stand on the **sectors of bioeconomy, for 2018**. On **Figure 20** it can be perceived each sector's share in total bioeconomy, regarding its value added.

"Food, beverage and tobacco" is the most relevant sector in the European bioeconomy with the highest value added amongst all sectors, adding 219K million euros in 2018. **"Agriculture" follows in the ranking**, with 185K million euros. **In third, there is "Bio-based chemicals, pharmaceuticals, plastics and rubber (excl. biofuels)"**, with 52K million euros in value added.

At the bottom, "Liquid biofuels" leads, with little above 2.8K million euros, followed by "Bio based electricity", with 3.2K million, approximately. Gathering a higher amount in value added, but still at the bottom, there is "Fishing and Aquaculture", with almost 7K million euros.

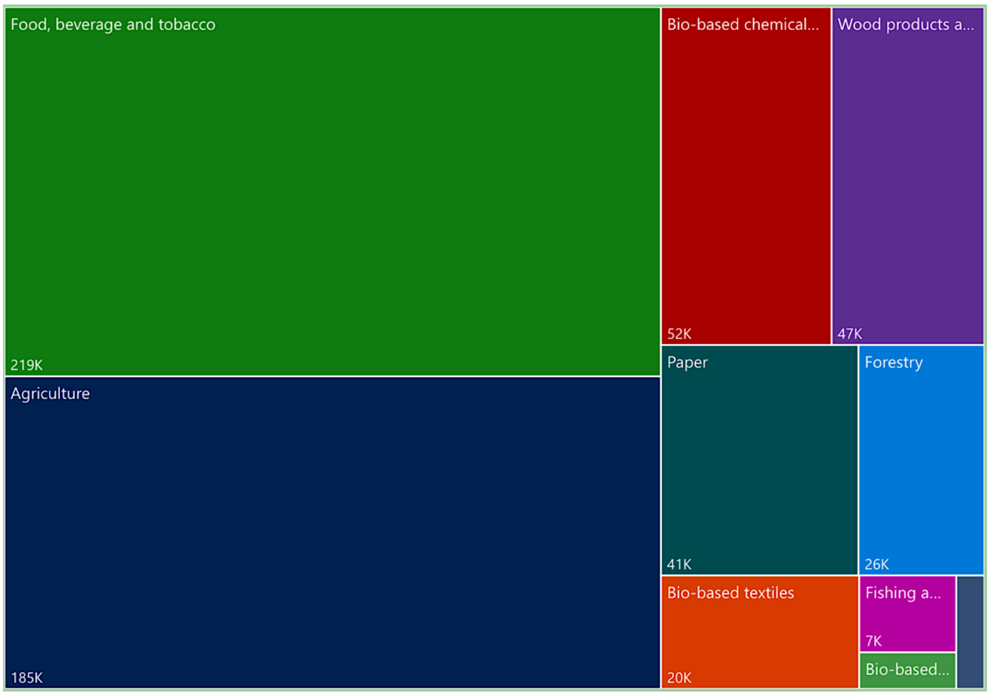


Figure 20. Value Added by Sector in EU27 for 2018

Considering 2018's weight for value added on GDP, **Figure 21** presents results by sector. Instantly, it can be perceived which sectors constitute the Top and Bottom 3.

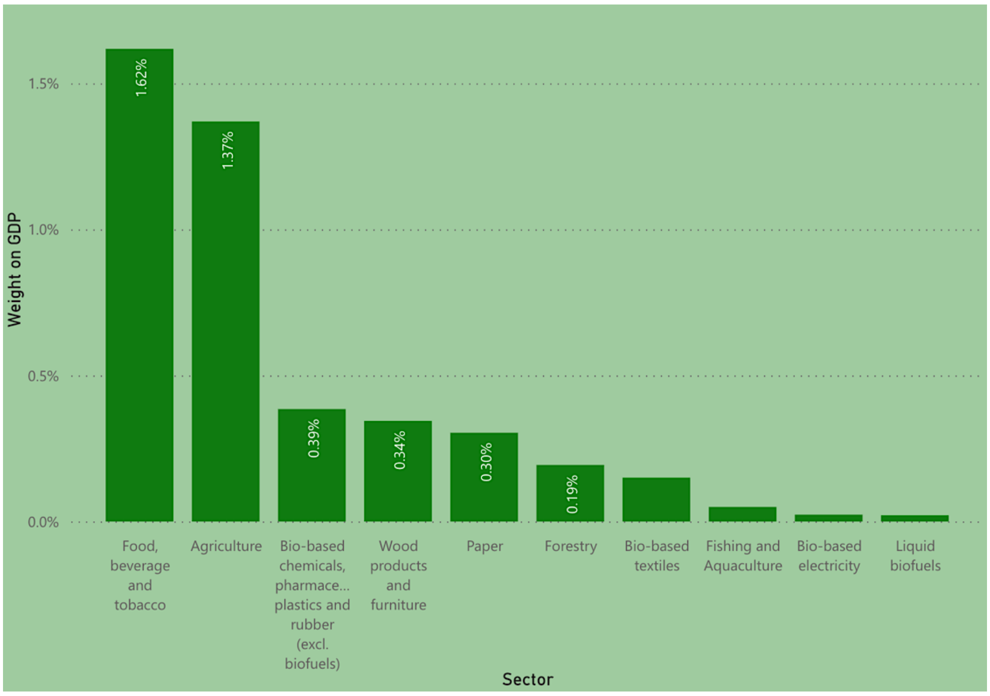


Figure 21. Value Added's Weight on GDP by Sector in EU27 for 2018

Figure 22 explicitly details percentages of **Figure 20** for the Top 3. "Food, beverage and tobacco" leads the top, followed by "Agriculture", having significantly higher percentages than the rest. "Bio-based chemicals, pharmaceuticals, plastics and rubber (excl. biofuels)" is in third, presenting a percentage of almost 0.40%.

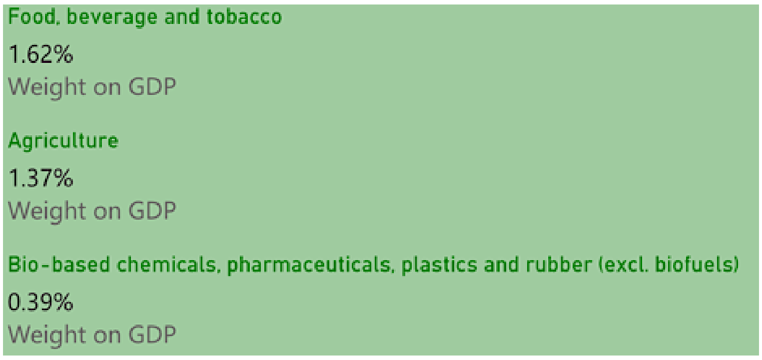


Figure 22. Value Added's Top 3 Sectors in 2018

Conversely, **Figure 23** discriminates values for the Bottom 3. "Liquid biofuels" and "Bio-based electricity" are in the bottom, with similar percentages of 0,02%, proceeded by "Fishing and Aquaculture".

Figure 23. Value Added's Bottom 3 Sectors in 2018

These results demonstrate that sectors "Food, beverage and tobacco" and "Agriculture" lead bioeconomy in terms of value added, by a significant difference, creating a huge gap between them and other sectors, especially the bio-based industry.

In terms of growth, **Figure 24** shows both growth rate for value added and sector's weight of value added in bioeconomy, for each sector of bioeconomy, for 2018.

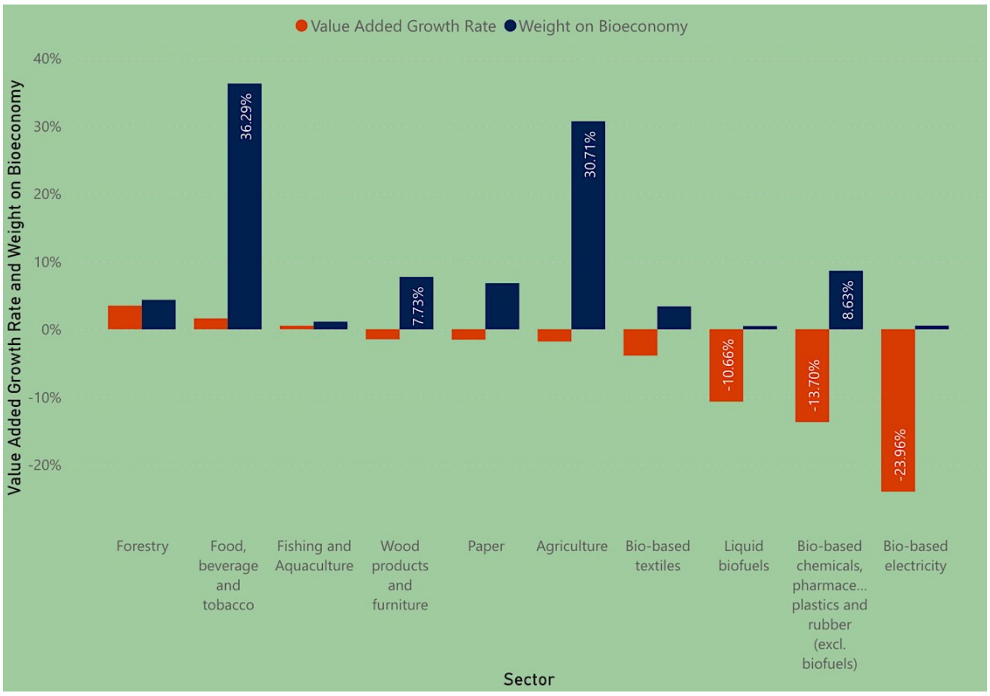


Figure 24. Value Added's Growth Rate and Weight in EU27 for 2018

The sectors who present higher growth rates, meaning they increased their value added in 2018, were "Forestry", "Food, beverage and tobacco" and "Fishing an Aquaculture". On the other side of the graphic, sectors "Liquid biofuels", "Bio-based chemicals, pharmaceuticals, plastics and rubber (excl. biofuels)" and "Bio-based electricity" present the lowest growth rates, with negative values, meaning their value added decreased in the year in analysis.

7.1.2. TURNOVER IN BIOECONOMY[28]

Tendency over time for turnover's behaviour is of an increase, as it can be seen on **Figure 25**. In 2008, total turnover in bioeconomy generated across EU27 was little below 2M million euros, increasing to 2.2M million euros until 2018. This represents an increase of almost 15%. In average, EU27 increased its turnover in 1.34% per year. The significant decrease between 2008 and 2009 can be explained by the crisis of 2008, which affected economy in a significant way, in its totality.

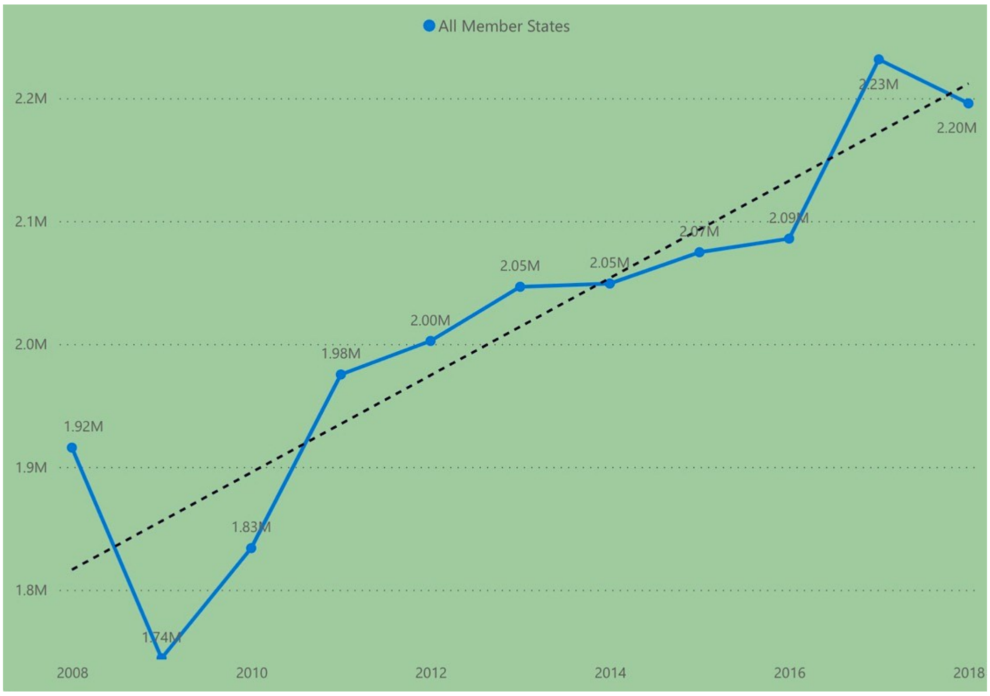


Figure 25. Evolution of Turnover in Bioeconomy in EU27

Additionally, in 2018 turnover's growth rate was negative, of -1.60%, corroborating its decrease seen on the graphic above.

When analysing the same evolution by country, a similar behaviour can be identified. In general, all countries suffered a decrease in 2009, having seen its turnover increased until more recent years. This is supported by **Figure 26**.

[28] Figure's units for this indicator are expressed in Million Euros.

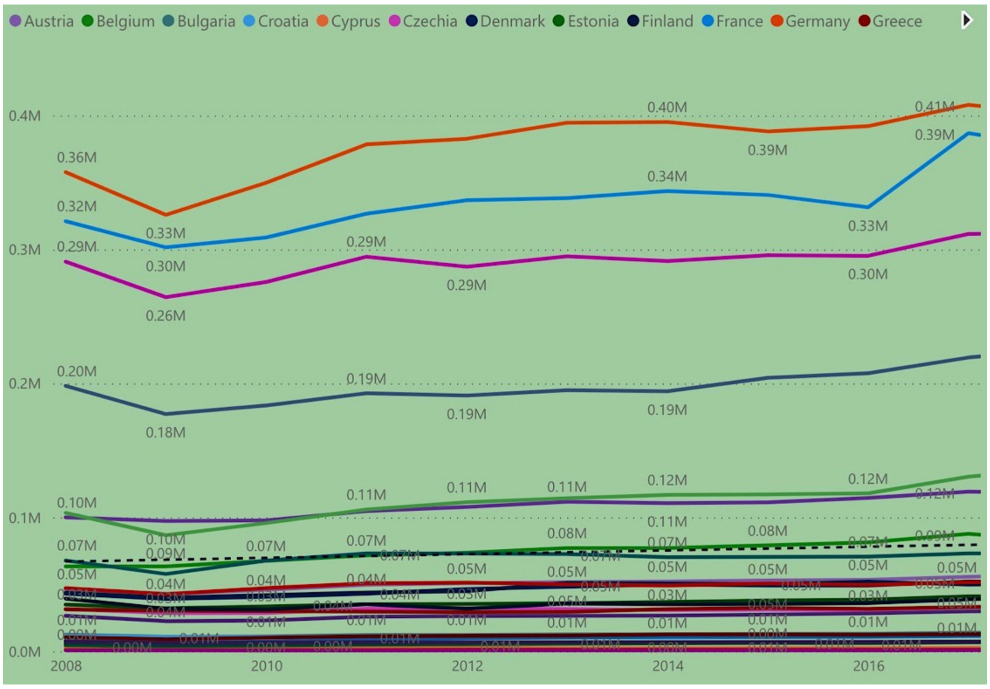


Figure 26. Evolution of Turnover in Bioeconomy by Country

Finally, looking at turnover's growth rate evolution on **Figure 27**, it is perceivable a positive evolution, meaning that in general, for EU27's bioeconomy, turnover has been increasing in time, although presenting a descent in the most recent year of 2018.

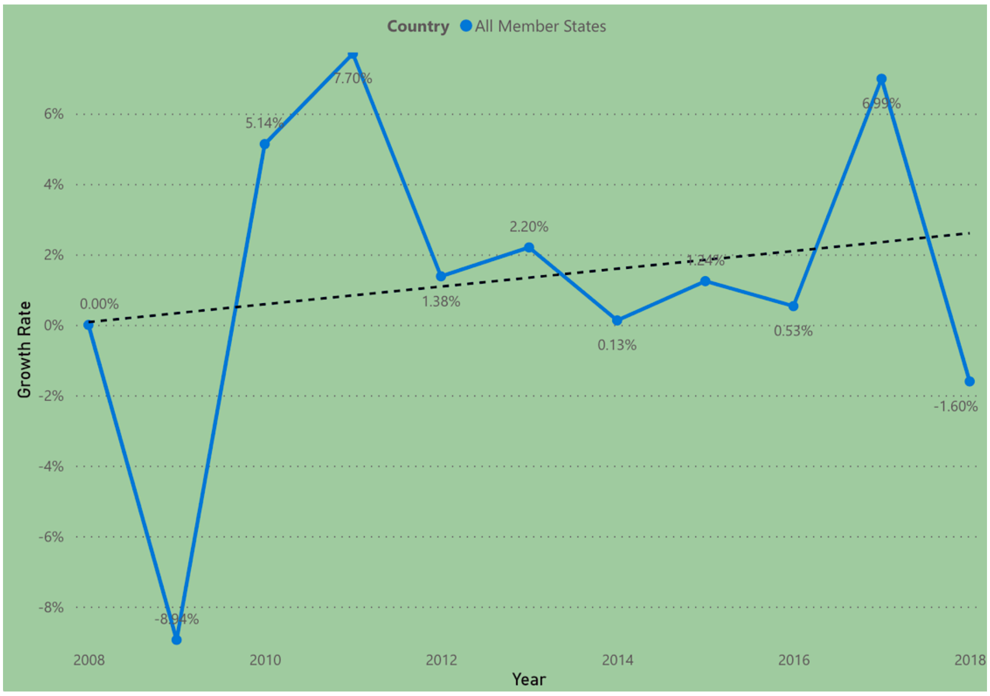


Figure 27. Turnover's Growth Rate Evolution in EU27

Focusing on the most recent year, in 2018 the totality of sectors that compose bioeconomy generated around 2.2M million euros of turnover, in EU27.

Starting with a country-related analysis, **Figure 28** ranks all countries in terms of their total turnover's contribution for EU27's aggregate, in 2018.

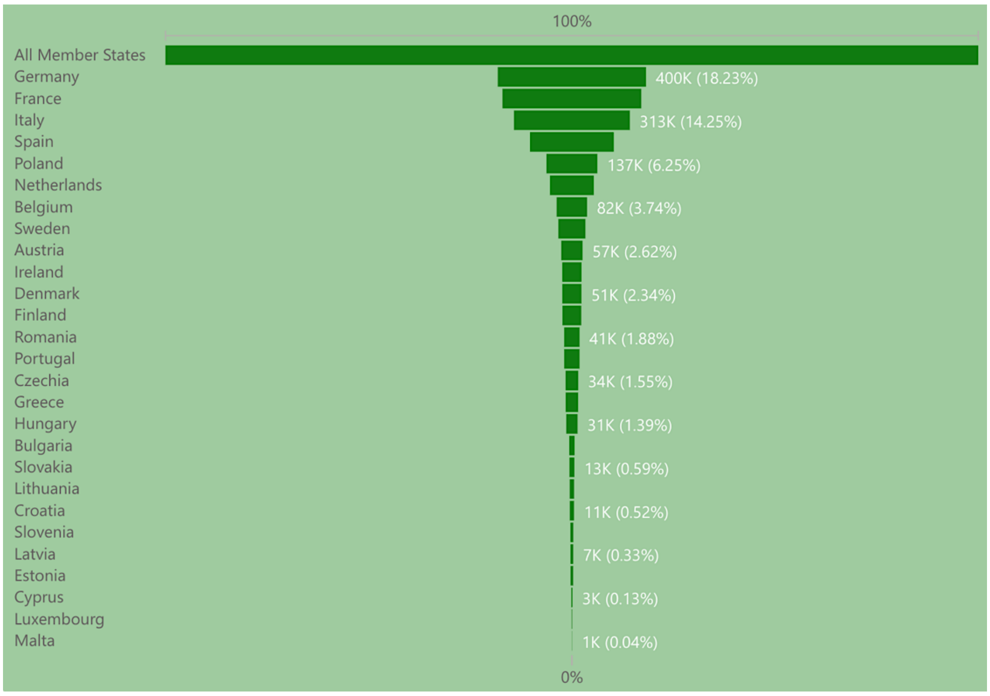


Figure 28. Bioeconomy's Turnover by Country in 2018

It starts to be clear which countries contribute more for the sum of total turnover in bioeconomy. **Top 3 by country is constituted by Germany, France and Italy**, being these the countries that generate more turnover. Conversely, Malta, Luxembourg and Cyprus are on the Bottom 3, with significantly lower turnover values.

When identifying the Top 3 countries for turnover in bioeconomy in 2018, **Figure 29** shows not only each country's exact absolute value, but also its growth rate. Although Italy is third on the Top 3, it is the only country presenting a positive turnover's growth rate, unlike the remaining two countries.

Germany	
400402	-1.87%
Total Turnover	Growth Rate
France	
374912	-3.11%
Total Turnover	Growth Rate
Italy	
313001	0.44%
Total Turnover	Growth Rate

Figure 29. Turnover's Top 3 Countries for 2018

On the other hand, when analysing the Bottom 3 countries for 2018, on **Figure 30** it can be seen that the country that sold less products and services in bioeconomy was Malta, with 828 million euros, followed by Luxembourg, with almost double the amount, and Cyprus, with almost 2.8K million euros. Luxembourg and Cyprus, being better ranked than Malta, also present positive growth rates, indicating turnover's increase in 2018. As for Malta, it shows a decrease, with a negative rate of almost 5%.

Malta	
828	-4.66%
Total Turnover	Growth Rate
Luxembourg	
1449	1.00%
Total Turnover	Growth Rate
Cyprus	
2791	2.89%
Total Turnover	Growth Rate

Figure 30. Turnover's Bottom 3 Countries for 2018

In fact, by analysing 2018's growth rates from all Member States, in **Figure 31**, it is perceived that both Germany and France, which are on turnover's Top 3, present the lowest growth rates, being amongst the few countries that have negative rates. Additionally, Malta can also be identified amongst lower ranked countries for growth rate, being surpassed only by Belgium.

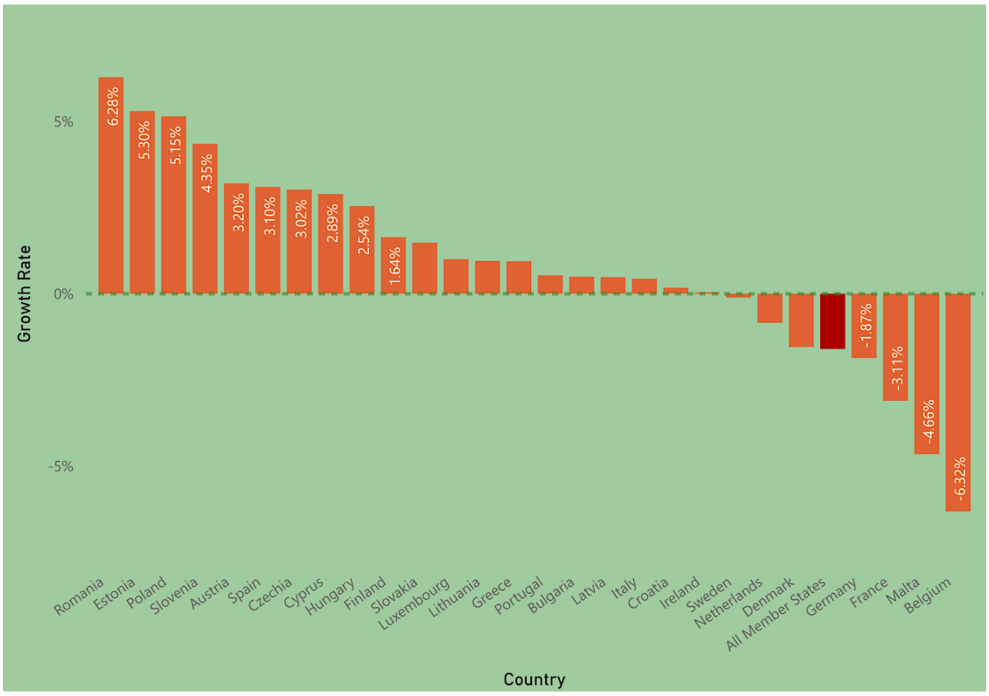


Figure 31. Growth Rates by Country in Bioeconomy for 2018

Shifting the focus from a country-related to a sector-related analysis, **Figure 32** analyses turnover for bioeconomy's sectors in 2018. Ranking sectors, constituting the **Top 3 there is "Food, beverage and tobacco"**, totalizing more than 50% of bioeconomy's turnover, followed by **"Agriculture"** and **"Paper"**. Conversely, on the Bottom 3 there is "Liquid biofuels", "Bio-based electricity" and "Fishing and Aquaculture".

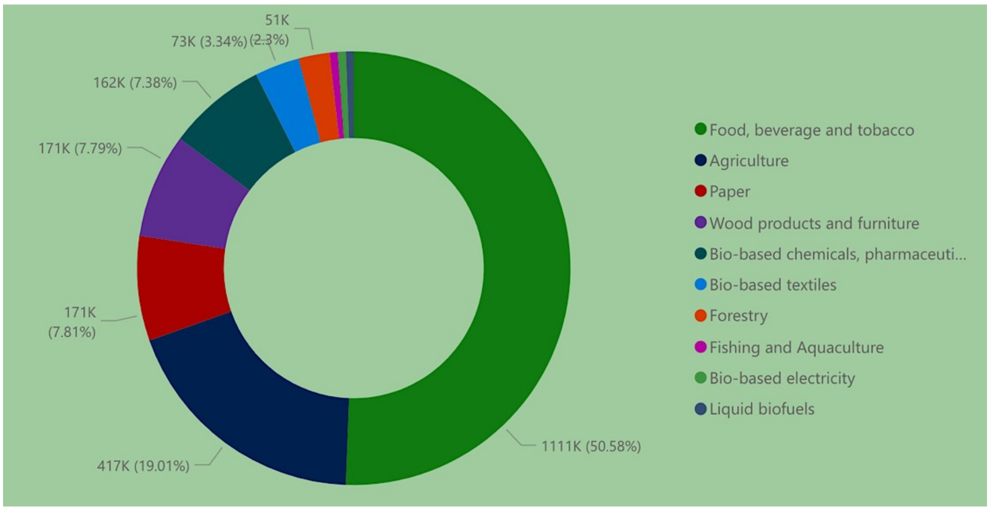


Figure 32. Turnover by Sector in EU27 for 2018

Looking closely to Top 3, additionally analysing their absolute values and growth rates for 2018 on **Figure 33**, the following can be concluded. In first of the Top 3, "Food, beverage and tobacco" generated more than 1M million euros in turnover, with a negative growth rate. As for "Agriculture", although having almost half amount for turnover, presented a positive growth rate, indicating its increase in 2018's turnover. Finally, "Paper" generated around 170K million euros, albeit presenting the worse growth rate of all sectors considered.

Food, beverage and tobacco		
50.58% Weight on Bioeconomy	1110680 Total Turnover	-0.40% Growth Rate
Agriculture		
19.01% Weight on Bioeconomy	417379 Total Turnover	0.06% Growth Rate
Paper		
7.81% Weight on Bioeconomy	171395 Total Turnover	-2.17% Growth Rate

Figure 33. Turnover's Top 3 Sectors in EU27 for 2018

It is equally important to perceive the evolution of each Top 3 sectors' weight on bioeconomy, presented on **Figure 34**.

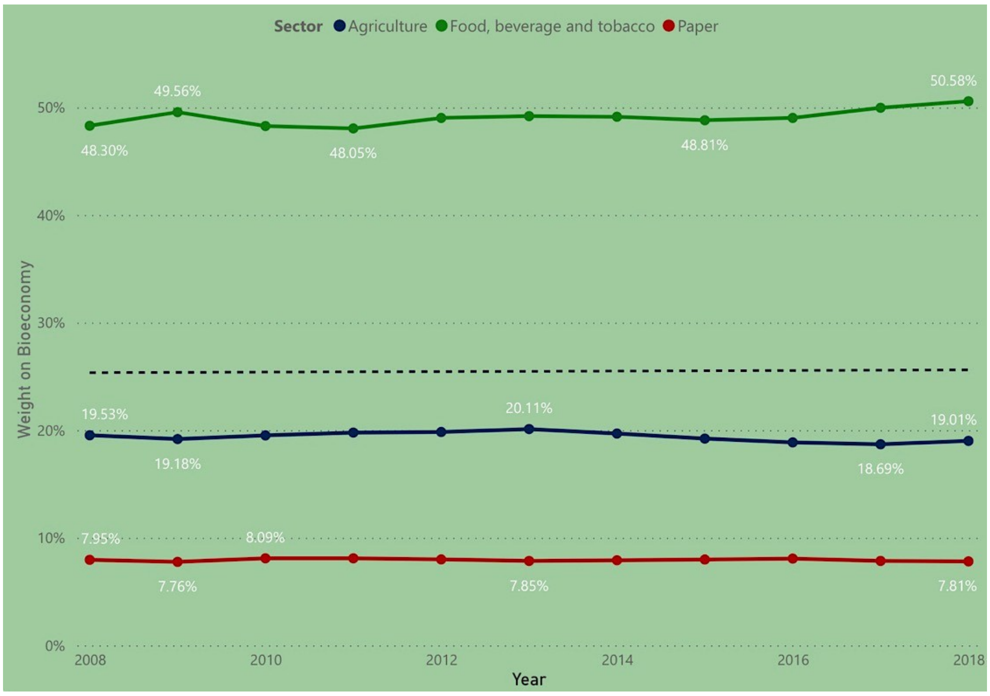


Figure 34. Top 3 Sectors Turnover's Weight on Bioeconomy in EU27

While "Agriculture" and "Paper" are decreasing their importance in total bioeconomy, "Food, beverage and tobacco" shows an increase, between 2008 and 2018.

Focusing on the Bottom 3, sectors where turnover represents a smaller sum in bioeconomy can be identified on **Figure 35**, together with their corresponding absolute turnover values and growth rates. "Liquid biofuels", "Bio-based electricity" and "Fishing and Aquaculture" all present significantly lower weights on bioeconomy when compared to Top 3. Moreover, the two worse ranked countries also present the lowest growth rates, showing a negative tendency in 2018.

Liquid biofuels		
0.58%	12762	-6.96%
Weight on Bioeconomy	Total Turnover	Growth Rate
Bio-based electricity		
0.60%	13194	-29.14%
Weight on Bioeconomy	Total Turnover	Growth Rate
Fishing and Aquaculture		
0.61%	13417	1.79%
Weight on Bioeconomy	Total Turnover	Growth Rate

Figure 35. Turnover's Bottom 3 Sectors in EU27 for 2018

In terms of weight evolution, **Figure 36** shows that from the Bottom 3 sectors, the only one with a positive evolution is "Bio-based electricity", indicating this sector is increasing its turnover in totality of bioeconomy, while remaining two are decreasing.

Moreover, in order to contextualize the growth rates beforementioned for Top and Bottom 3, **Figure 37** shows turnover's growth rate between 2008 and 2018, for each sector in EU27. Coincidently to previous conclusions, sector "Bio-based electricity" is the one showing higher increase for turnover, distancing from "Forestry" in almost 8 percentage points. "Bio-based textiles" is the only sector presenting a negative average growth, indicating decrease in its turnover over the years.

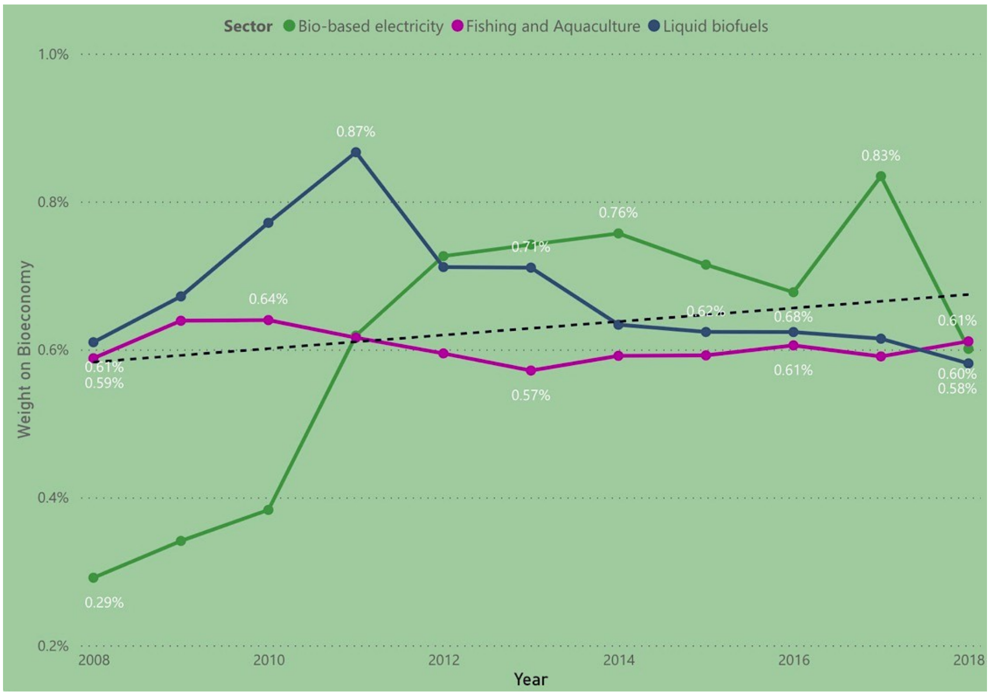


Figure 36. Bottom 3 Sectors Turnover's Weight on Bioeconomy in EU27

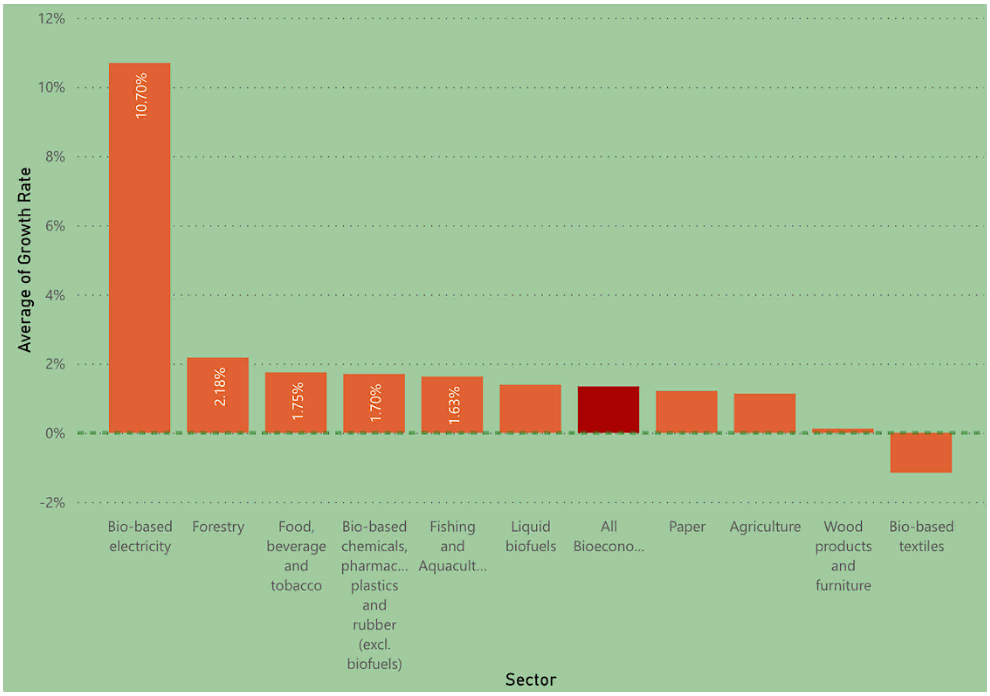


Figure 37. Average Turnover Growth Rate by Sector in EU27

7.1.3. EMPLOYABILITY IN BIOECONOMY[29]

When analysing the evolution over time of the number of employed people in bioeconomy, there is noticeably a decrease. Although there was a slight increase in 2017, the total amount of people employed in 2008 was about 20 million, decreasing 13.58% until 2018, totalizing 17.39 million. This decrease is shown on **Figure 38**.

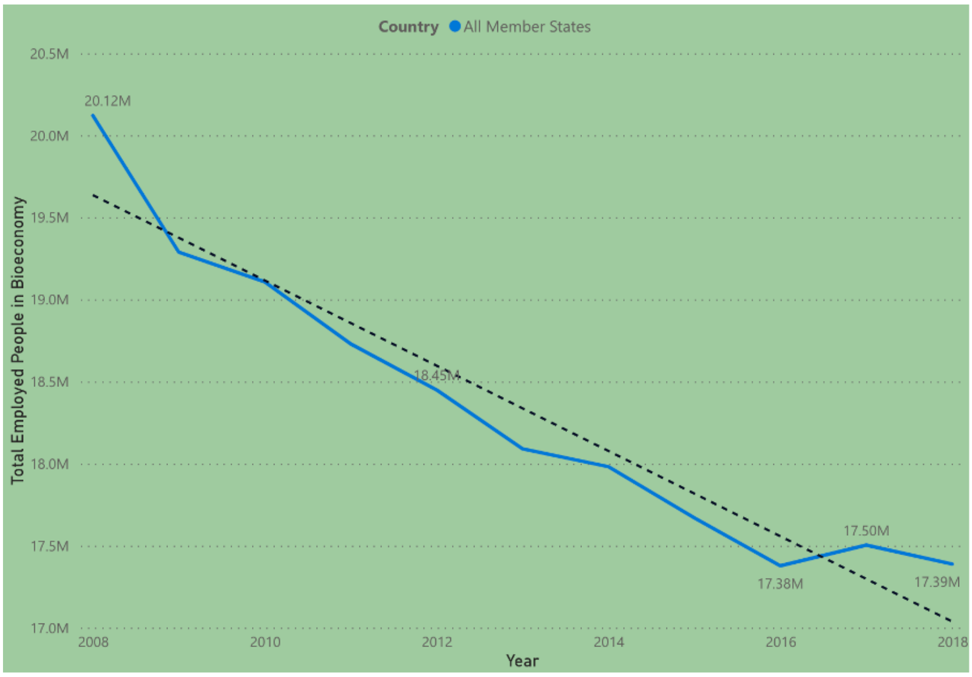


Figure 38. Evolution of Employed People in Bioeconomy in EU27

If the same analysis is made in the context of total economy, it is perceived that the amount of people employed is in fact increasing, since 2013, as seen on **Figure 39.** Therefore, considering that the total of employed people in all economy is increasing, that cannot be the reason why the total amount of people employed in bioeconomy is decreasing.

[29] Figure's units for this indicator are expressed in Number of Employed People.

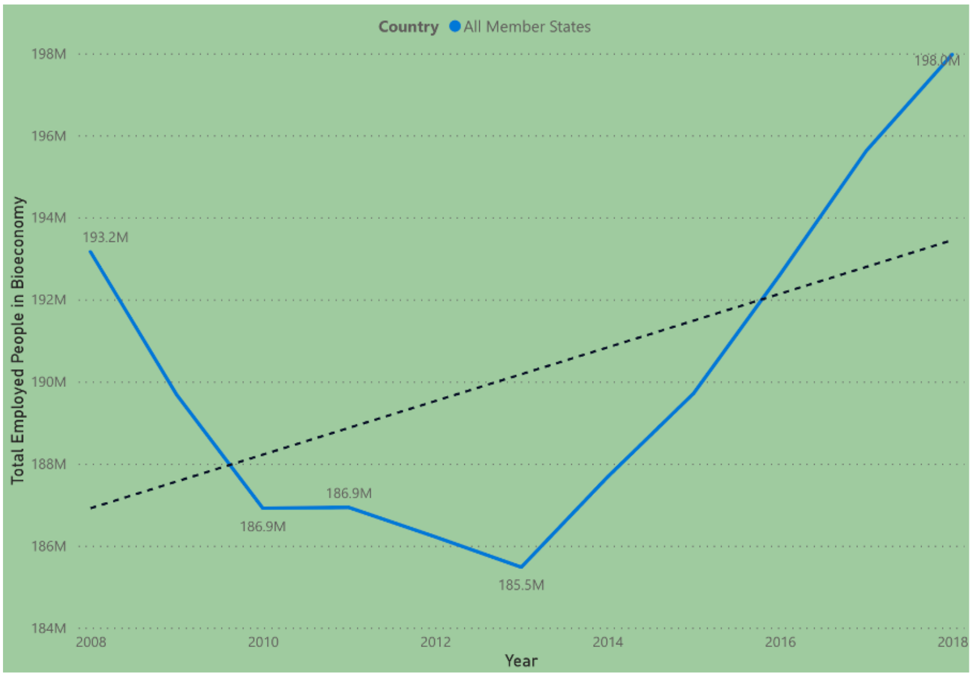


Figure 39. Evolution of Employed People in Economy in EU27

In this way, let it be analysed the evolution of the total number of employed people in EU27, by sector. The results of this analysis can be seen on **Figure 40**. In fact, by this graphic, while all other sectors maintained a plain evolution, between 2008 and 2018, "Agriculture" seemed to have had a significant decrease in its total amount of jobs. This decrease was almost 20%, justifying the drop in the totality of bioeconomy.

Conversely, although it could not compensate "Agriculture's" decrease, it can be perceived that sector "Food, beverage and tobacco" had an increase of about 4%, in this period.

These results are also consistent with **Figure 41**, which shows the average growth rates for each sector, along the years in analysis. For "Agriculture's" sector, the growth rate is consistently negative, showing its decline.

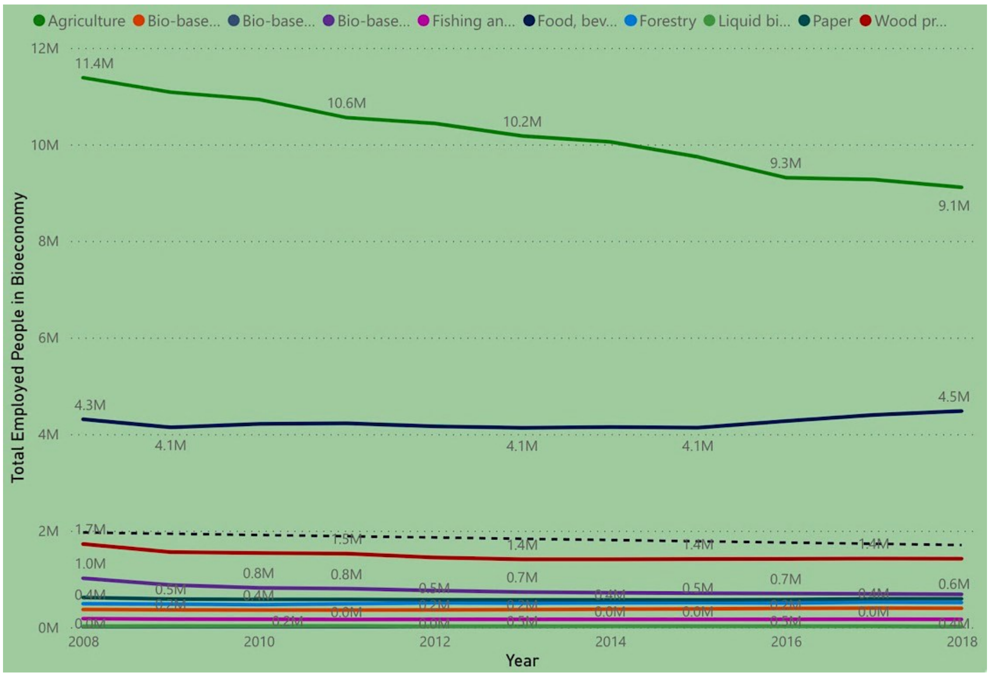


Figure 40. Evolution of Total Employed People in EU27 by sector

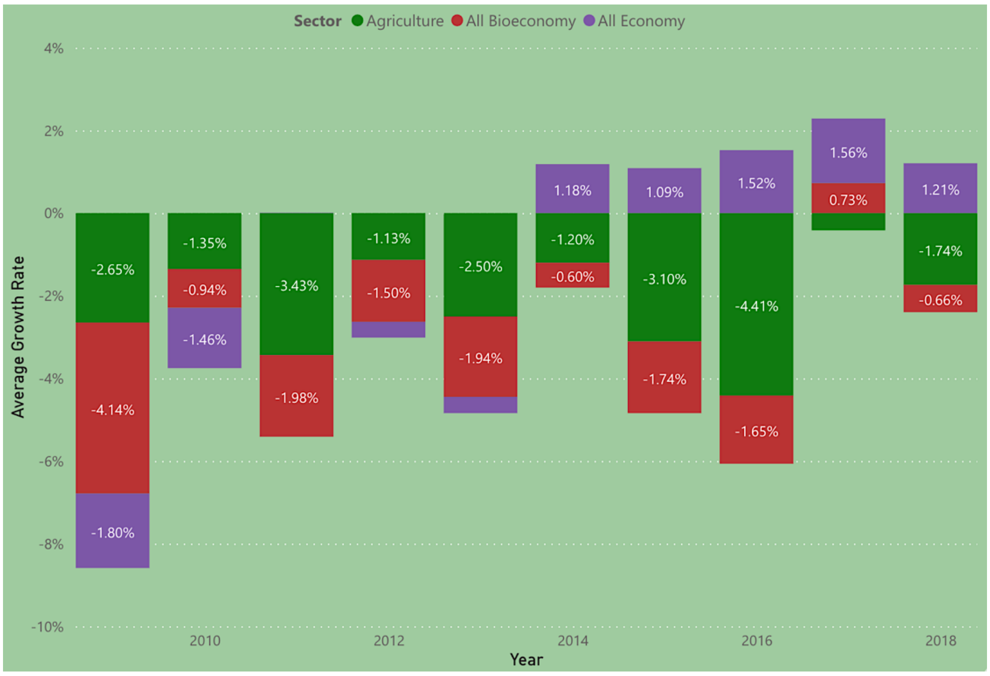


Figure 41. Growth Rates by sector, for EU27

Additionally, if the evolution over time of the weight that the totality of bioeconomy has on total economy is analyzed, it can be perceived that it is diminishing. In 2008, the weight of the total amount of employed people of bioeconomy over economy was around 10.40%, while in 2018 it corresponded to only

8.78%. This can be analyzed in **Figure 42**. This decrease corresponds to 15%, and it can be linked to the decrease of the same weight of "Agriculture" on "All Bioeconomy", which was more than 20%, between the same period. All other sectors had their weights on bioeconomy maintained or with slight alterations, across time – **Figure 43**.

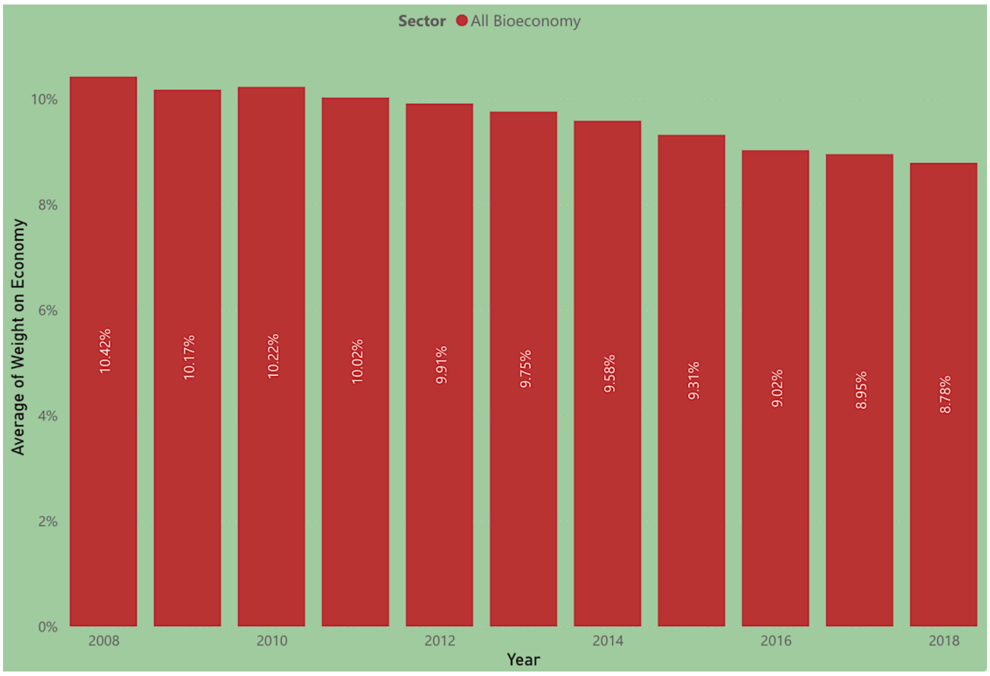


Figure 42. Bioeconomy over Economy Weight Evolution in EU27

Figure 43. Sectors over Economy Weight Evolution in EU27

In 2018 the totality of EU27's bioeconomy, generated approximately 17 million jobs – **Figure 44**. As for people employed in total economy, that number rises to approximately 198 million – **Figure 45**.

Figure 44. Total Employed People in Bioeconomy in EU27 for 2018

Figure 45. Total Employed People in Economy in EU27 for 2018

In order to obtain Top and Bottom 3 rankings by country, the weight of employment in bioeconomy over total economy was analysed – **Figure 46**.

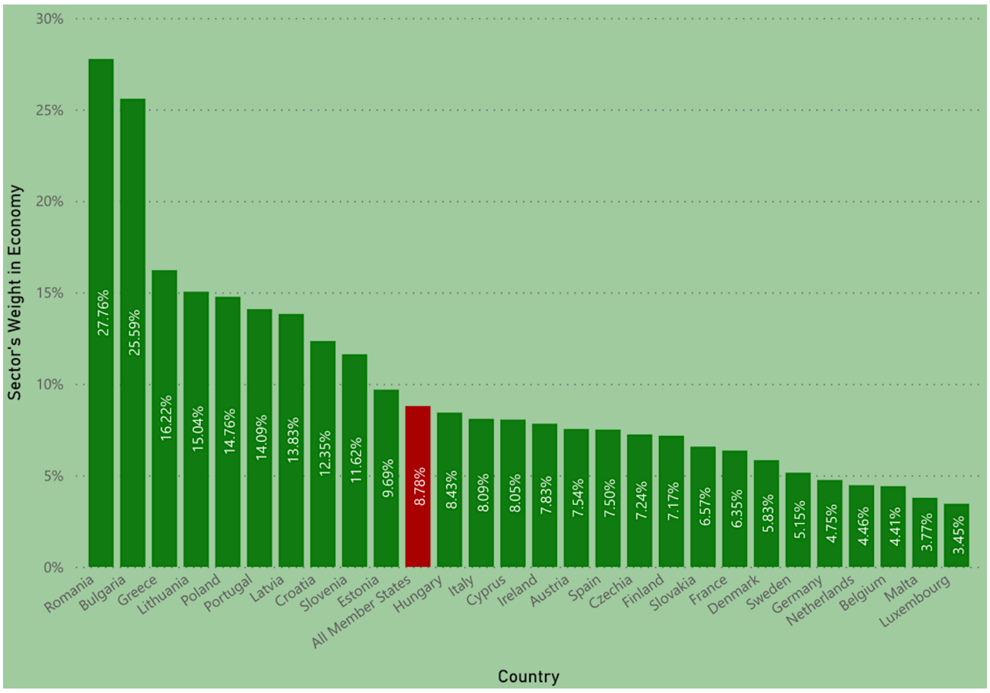


Figure 46. Bioeconomy over Economy Weight in EU27 for 2018

In this graphic, it is perceivable that for EU27's aggregate, employment on bioeconomy represents more than 8% of total employment.

Focusing on the **Top 3 countries, Romania, Bulgaria and Greece** present higher rates for employment in bioeconomy. Inclusively, Romania and Bulgaria present values approximately 10 percentage points higher than next ranked countries. Although Romania and Greece present positive growth rates, they are low, indicating that employability in bioeconomy did not present significant increase in 2018, compared to 2017. Contrarily, Bulgaria has a negative growth rate, implying that the number of employed people in bioeconomy suffered a decrease compared to year before – **Figure 47**.

Romania		
27.76% Weight on Economy	2412076 Total People Employed	0.09% Growth Rate
Bulgaria		
25.59% Weight on Economy	806852 Total People Employed	-4.83% Growth Rate
Greece		
16.22% Weight on Economy	620829 Total People Employed	0.19% Growth Rate

Figure 47. Employability in Top 3 Countries for 2018

Trying to understand which sectors have higher impact on these results, graphic on **Figure 48** was constructed. For all countries on Top 3, the sector who contributes more for employability's higher weight on total economy is "Agriculture", representing more than 70% of employability in total bioeconomy, in each country. To note that sector "Food, beverage and tobacco" also presents a significant impact on bioeconomy's employability.

Figure 48. Sector's Weight on Bioeconomy in Top 3 Countries for 2018

Focusing on Bottom 3, constituted by Luxembourg, Malta and Belgium, the same analysis was made. Although all have similar weights of their employability on economy, Belgium has a significantly higher absolute number of people employed in bioeconomy, albeit presenting the lowest growth rate. Contrarily to Top 3, all countries on Bottom 3 present positive growth rates, indicating they all saw their total number of employed people increase, between 2017 and 2018, as shown on **Figure 49**.

Luxembourg		
3.45% Weight on Economy	9656 Total People Employed	0.47% Growth Rate
Malta		
3.77% Weight on Economy	8995 Total People Employed	1.75% Growth Rate
Belgium		
4.41% Weight on Economy	209738 Total People Employed	0.05% Growth Rate

Figure 49. Employability in Bottom 3 Countries for 2018

Similarly to Top 3, sectors with higher employability representation on bioeconomy are "Agriculture" and "Food, beverage and tobacco", although on the Bottom 3 the latest sector has higher weight percentage than the first – **Figure 50.**

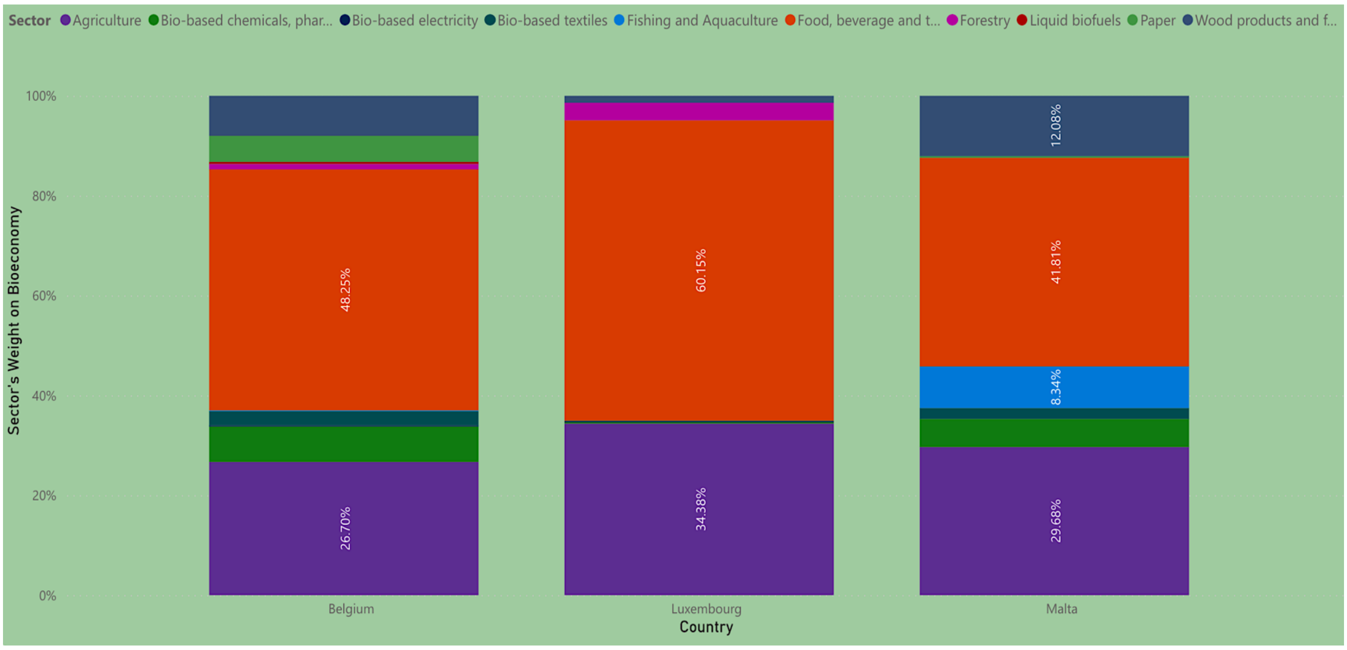


Figure 50. Sector's Weight on Bioeconomy in Top 3 Countries for 2018

Shifting to a sectorial analysis, in order to obtain Top and Bottom 3 rankings by sector, the sectors' weight of employment on total economy was analysed – **Figure 51**. In 2018, bioeconomy's employment represents almost 9% of total employment, although having a degrowth of almost 1% in total employment in bioeconomy, compared to 2017.

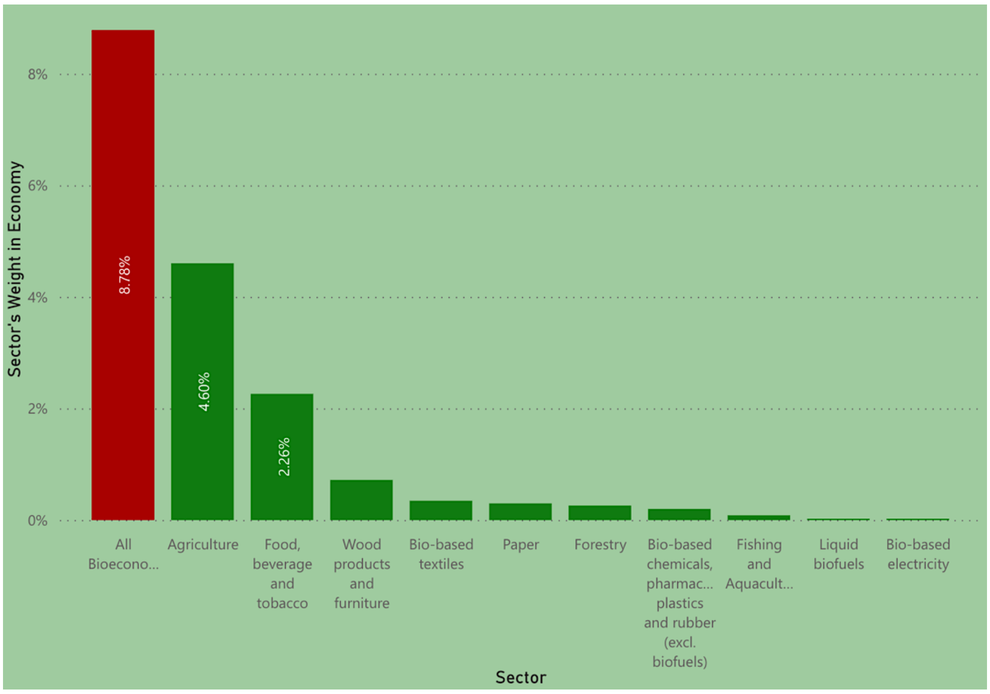


Figure 51. Sector's Weight on Economy in EU27 for 2018

Focusing on bioeconomy only, **Figure 52** presents each sectors weight on bioeconomy, for employment in 2018. **Top 3 Sectors**, which had more people employed in 2018, were "**Agriculture", "Food, beverage and tobacco" and "Wood products and furniture"**. Contrarily, Bottom 3 is constituted by "Bio-based electricity" Liquid biofuels" and "Fishing and Aquaculture".

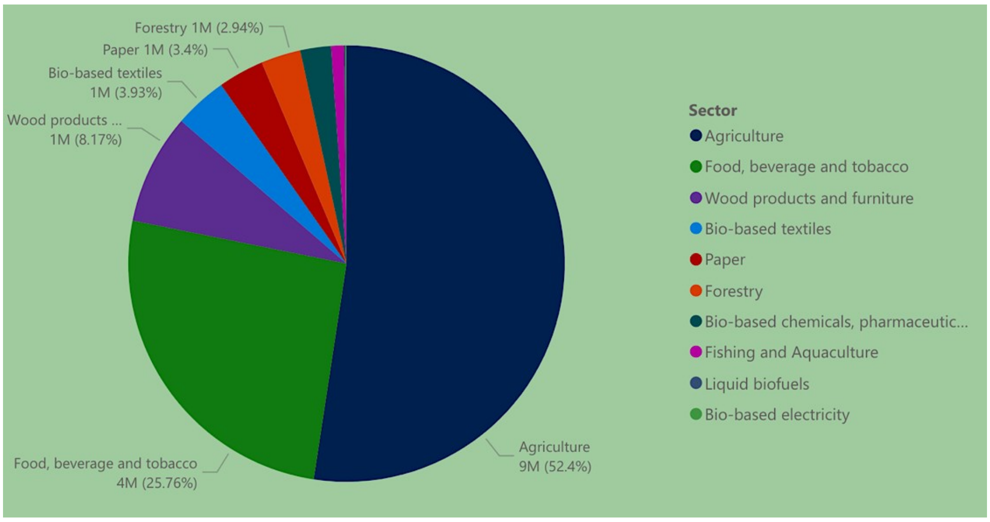


Figure 52. Bioeconomy's Employment by Sector in EU27 for 2018

Having such high percentage of contribution in bioeconomy's employment, of more than 50%, "Agriculture's" negative influence over time's evolution of total employment in bioeconomy is also here justified. Considering that in 2018 the totality of employed people in bioeconomy represents close to 9% of the total amount of people employed in all economy, "Agriculture" represents half of the weight on total economy, meaning around 4.5%. That is evident on **Figure 53**.

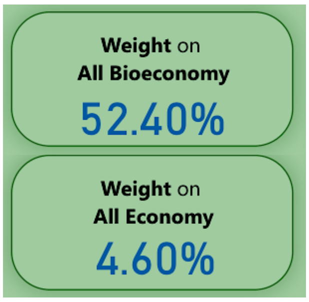


Figure 53. Agriculture's Weight on Bioeconomy and Economy in EU27 for 2018

Looking closely to the Top 3, on **Figure 54**, although being the more impactful sector, representing more than 50% of total bioeconomy's employment, the total number of employed people in "Agriculture" decreased in 2018. Contrarily, "Food, beverage and tobacco" had an increase of almost 2%, having an already high weight percentage that surpasses 25%.

Agriculture		
52.40%	9112420	-1.74%
Weight on Bioeconomy	Value	Growth Rate
Food, beverage and tobacco		
25.76%	4479397	1.83%
Weight on Bioeconomy	Value	Growth Rate
Wood products and furniture		
8.17%	1420211	-0.30%
Weight on Bioeconomy	Value	Growth Rate

Figure 54. Employability in Top 3 Sectors in EU27 for 2018

On the other hand, **Figure 55** shows that sectors who employ the smaller number of people are "Bio-based electricity", "Liquid biofuels" and "Fishing and Aquaculture", totalizing all together around 2%. To aggravate, all sectors have negative growth rates in 2018, demonstrating that besides their employment values being low, they also decreased.

Bio-based electricity		
0.07%	12349	-45.24%
Weight on Bioeconomy	Total People Employed	Growth Rate
Liquid biofuels		
0.11%	19812	-3.39%
Weight on Bioeconomy	Total People Employed	Growth Rate
Fishing and Aquaculture		
0.95%	165610	-0.60%
Weight on Bioeconomy	Total People Employed	Growth Rate

Figure 55. Employability in Bottom 3 Sectors in EU27 for 2018

7.1.4. Labour Productivity In Bioeconomy[30]

The tendency for labour productivity in EU27, over the years, is for an increase, with an average growth rate of almost 3%, between 2008 and 2018. In **Figure 56** this increasing tendency can be identified, with labour productivity having a value of 25 thousand euros per person in 2008, while in 2018 that value was 35 thousand euros.

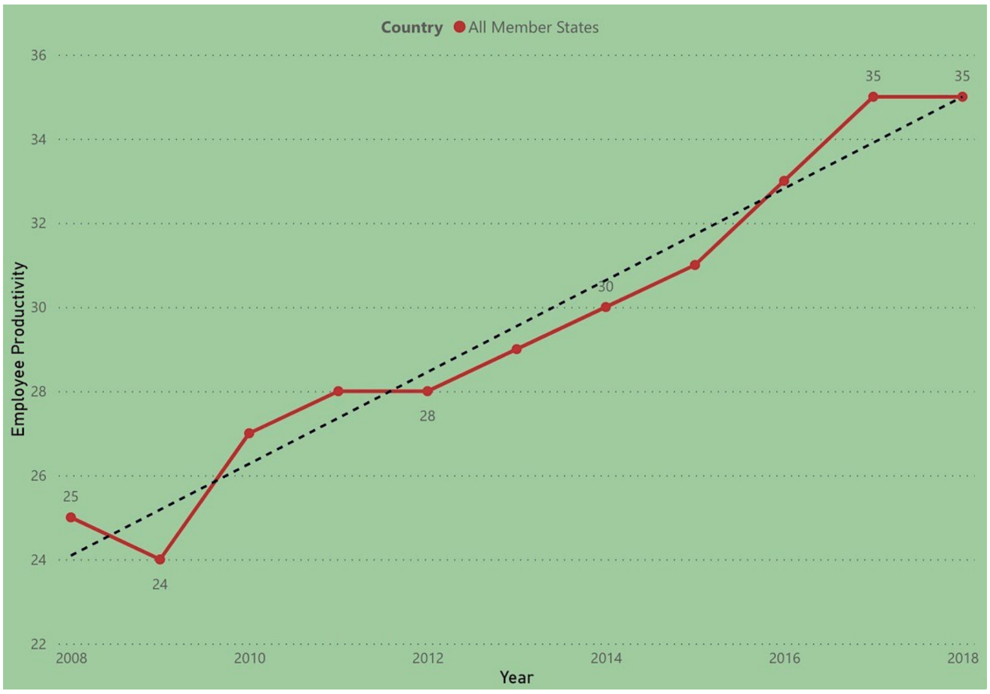


Figure 56. Evolution of Labour Productivity in Bioeconomy in EU27

In fact, when analyzing the evolution of the labour productivity's growth rate, it is visible, through **Figure 57**, that growth rates were mostly positive, not surpassing 9%, but there was a decrease in 2018 for employee productivity.

[30] Figure's units for this indicator are expressed in 1000 Euros per Person.

Figure 57. Growth Rate Evolution in EU27 for Bioeconomy

Having perceived how this indicator evolved in time, the **analysis can be focused on the latest year**, similarly to what was previously made. Bioeconomy's employee productivity for **2018** was 35 thousand euros, in EU27.

Starting with a cross-section analysis focusing on countries, **Figure 58** ranks all countries by total employee productivity for 2018. Immediately, it can be identified that **Ireland, Belgium and Sweden lead Top 3** and, conversely, Bulgaria, Romania and Poland constitute the Bottom 3, having lowest values for 2018's labour productivities.

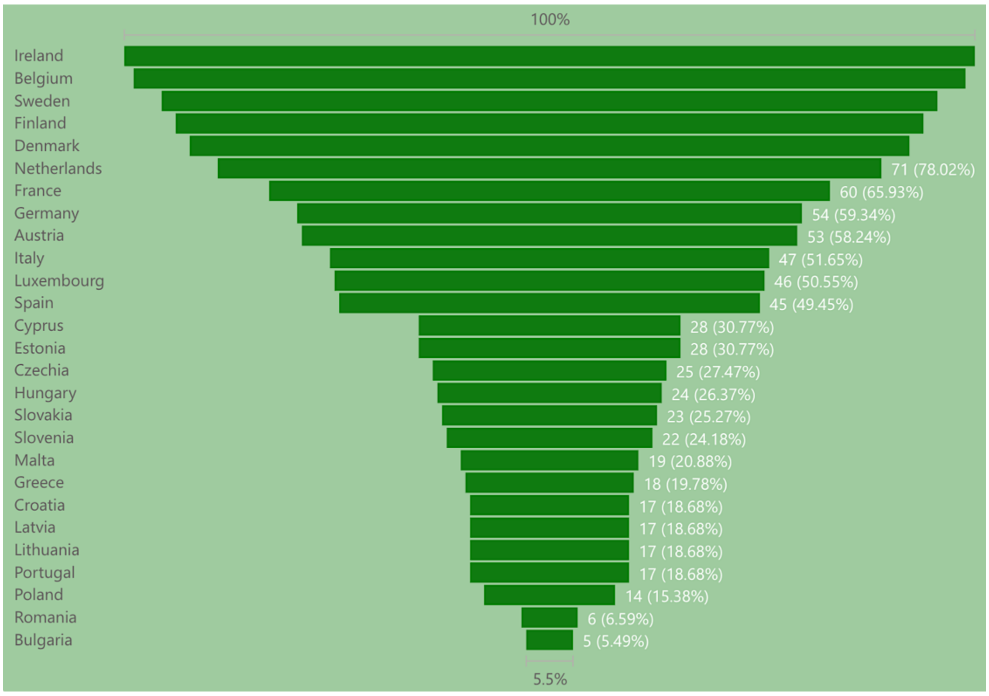


Figure 58. Employee Productivity by Country in Bioeconomy for 2018

In **Figure 59**, as part of Top 3 countries, Ireland, Belgium and Sweden can be found, each presenting similar percentages for labour productivity. Employed People in Ireland, in all bioeconomy, each produced 91 thousand euros in 2018. In Belgium, this amount is almost 90 thousand euros, and in Sweden 83 thousand euros. All countries of the Top 3 present negative growth rates for labour productivity in 2018, indicating decrease for this variable.

Ireland	
91 Employee Productivity	-1.75% Growth Rate
Belgium	
89 Employee Productivity	-0.59% Growth Rate
Sweden	
83 Employee Productivity	-0.33% Growth Rate

Figure 59. Labour Productivity's Top 3 Countries in Bioeconomy for 2018

Contrarily, the Bottom 3 countries, shown on **Figure 60**, constituted by Bulgaria, Romania and Poland, present much lower values for their labour productivities.

Employees in Bulgaria's bioeconomy produced only 5 thousand euros in 2018, being this value similar to Romania's. In Poland, this sums up to 14 thousand euros, per worker, in the same year. Additionally to being the country with lowest employee productivity, Bulgaria has the lowest growth rate amongst countries of Bottom 3 for 2018.

Country	Employee Productivity	Growth Rate
Bulgaria	5	0.02%
Romania	6	6.55%
Poland	14	2.42%

Figure 60. Labour Productivity's Bottom 3 Countries in Bioeconomy for 2018

In order to better understand growth rate values for Top and Bottom 3 countries, **Figure 61** shows all countries' growth rates for 2018, including EU27's aggregate, allowing for comparisons.

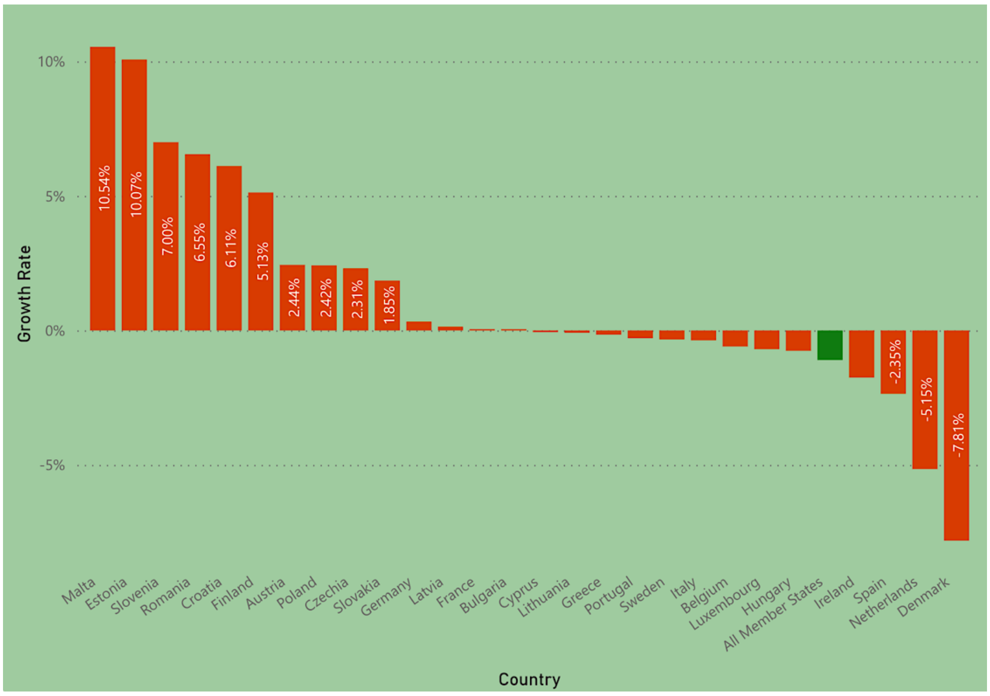


Figure 61. Growth Rates by Country in Bioeconomy for 2018

Changing the focus, a sectorial analysis will be made, identically to what was done for countries, ranking them into Top and Bottom 3.

Figure 62 allows to perceive which countries rank highest and lowest in terms of bioeconomy's labour productivity, in 2018.

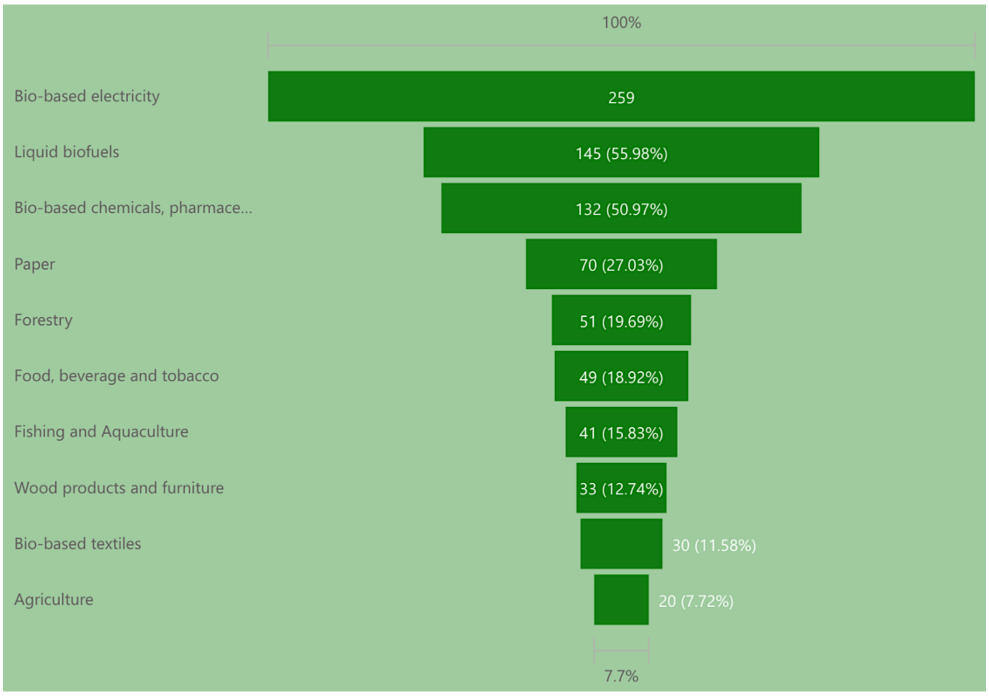


Figure 62. Labour Productivity by Sector in EU27 for 2018

In the **Top 3,** sector **"Bio-based electricity" leads the way, followed** by **"Liquid biofuels",** and **finally "Bio-based chemicals, pharmaceuticals, plastics and rubber (excl. biofuels)"** – **Figure 63**. This ranking, unlike all others, presents only sectors that are bio-based, indicating that these sectors are indeed the ones that represent higher labour productivity amongst bioeconomy's sectors.

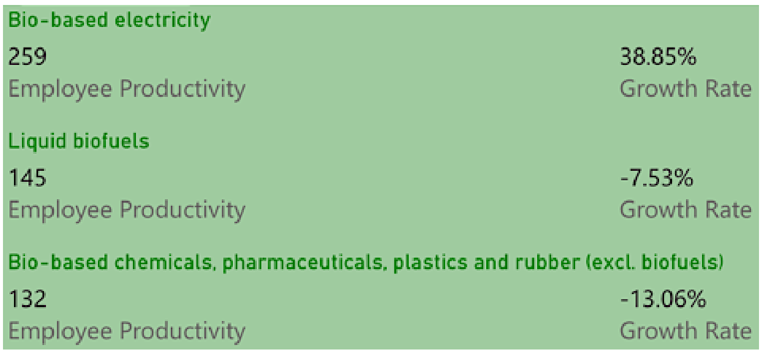


Figure 63. Labour Productivity's Top 3 Countries for 2018

Additionally, first ranked sector presents the highest growth rate percentage, indicating its growth in 2018, marking a positive tendency for this indicator.

In order to understand labour productivity weight's behaviour over time, **Figure 64** shows values for the Top 3 Sectors. Once again, "Bio-based electricity", although presenting negative rates for some years, presents a positive general tendency, indicating that its weight on bioeconomy is increasing. Contrarily, remaining two sectors see their weights diminishing in 2018, decreasing their labour productivity importance in bioeconomy.

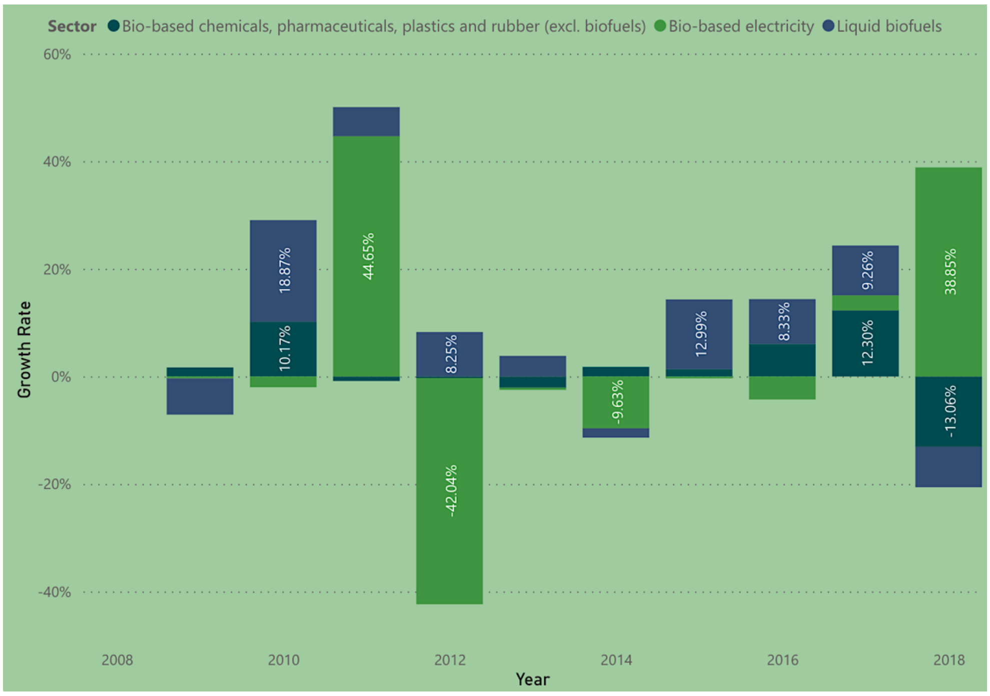


Figure 64. Labour Productivity Weigh on Bioeconomy for Top 3 Sectors in 2018

Conversely, when looking at the Bottom 3, on **Figure 65**, two of the sectors that appear are not bio-based. "Agriculture" presents as the sector where labour productivity is lower, with a value of 20 thousand euros per worker in 2018. "Bio-based textiles" follows, with 30 thousand, and lastly, "Wood products and furniture" ranks even better, with 33 thousand euros. Adding to their lowest labour productivity values, all sectors show a decrease in labour productivity in 2018.

Figure 65. Labour Productivity's Bottom 3 Countries for 2018

In the same way as it was made for Top 3, **Figure 66** shows sector's labour productivity weight on bioeconomy over time. In general, all sectors present positive growth in most years, although decreasing in the most recent year, with "Agriculture" having the lowest decrease, when presenting the highest increase for previous year.

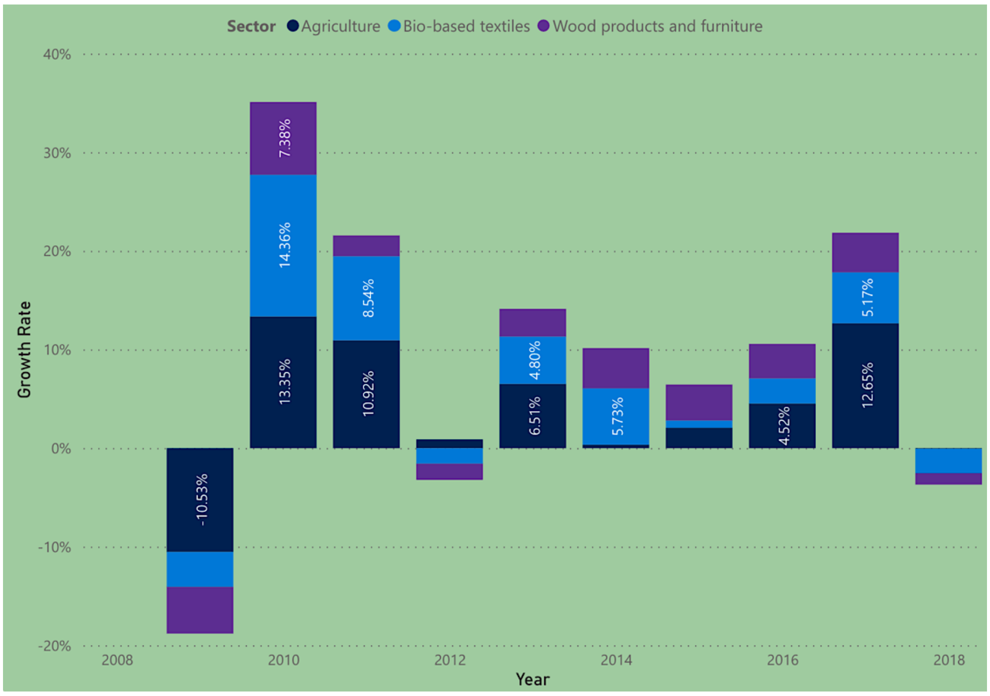


Figure 66. Labour Productivity Weigh on Bioeconomy for Bottom 3 Sectors in 2018

Additionally, and to compare this values to the ones showed for Top and Bottom 3 sectors, when analyzing the growth rate of labour productivity by sector, results on **Figure 67** follow. It can be perceived that the sector who saw its labour productivity more increased, amongst all sectors, was "Bio-based electricity", confirming that this sector, which ranked first, is evolving in a positive way.

The lowest labour productivity growth rate belongs to "Bio-based chemicals, pharmaceuticals, plastics and rubber (excl. biofuels)", with a negative rate of -13.06%, event thought being on the Top 3.

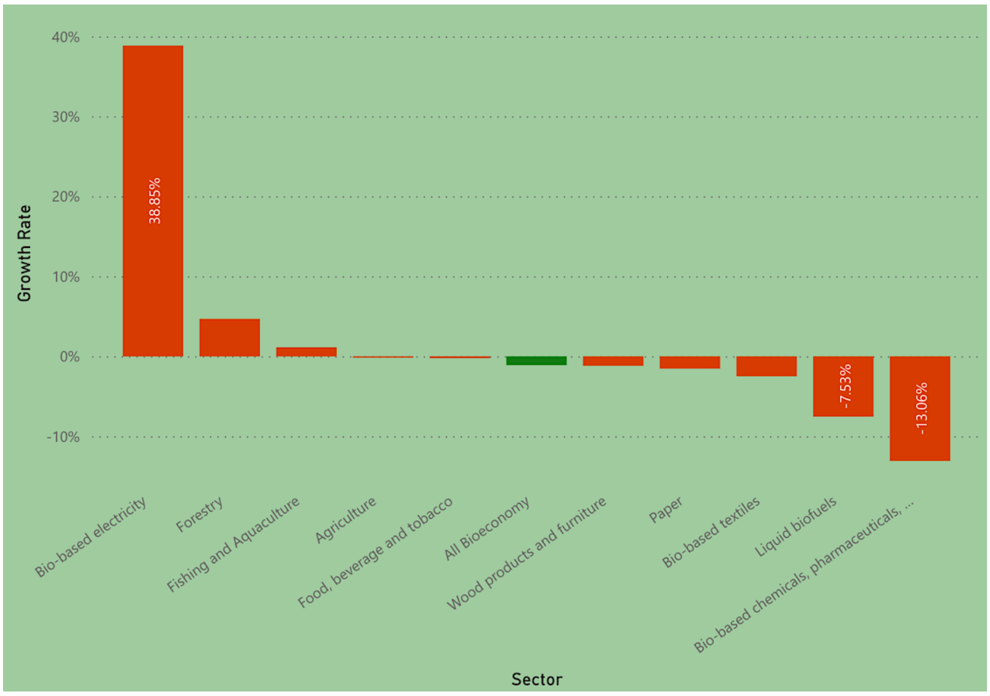


Figure 67. Growth Rates by Sector in EU27 for 2018

7.2. Sustainability Analysis

Having analyzed the "Economic-oriented Indicators", the following analysis will focus on the remaining set of indicators, the "Sustainability-oriented Indicators". As it happened in the previous section, analysis will be divided by indicator, individually.

The first analysis will have as focus ***"Air Emissions"***, which provides information about amount of emissions thrown into atmosphere by EU member states, focusing on indicator "Greenhouse Gases".

Additionally, a closer look will be taken into ***"Share of Renewables"***, which analyzes indicator "Share of Renewable Energy in Gross Final energy consumption", providing an overlook on the share of renewable energy, in gross final consumption, on each country.

Moreover, to complement the previous analysis, ***"Energy Efficiency"*** will be analyzed. This comprises knowledge about how efficient countries are, in the indicator in analysis, i.e., in their final energy consumption, allowing comparisons with EU27's aggregate.

Lastly, ***"Circularity of the Economy"*** will conclude the sustainability analysis. Overview on this indicator will provide a notion into countries' circularity, incising on indicator "Circularity Rate".

In the first three analysis, a comparison to the "2020 Target" will be made, in order to understand how far countries, and EU27's aggregate, are of achieving their corresponding goals.

Apart from "Air Emissions" analysis, all of them will be conducted in the same period as before – 2008 and 2018. Since the goal for 2020 of the "Air Emissions" is compared to values of 1990, this analysis, for some graphics and charts, will be enlarged, starting in 1990, although always ending in 2018. Additionally, all analysis will be made for global economy, not considering specific sectors, as before.

7.2.1. AIR EMISSIONS[31]

So far, in the previous analysis made, a good tendency of evolution was pointed as of increasing. However, in this case, a good evolution for this indicator is of decreasing, characterizing its positive progress.

Between 2008 and 2018, EU27's aggregate, emitted to the atmosphere, on average, 7.6K kilograms of greenhouse gases per capita. There has been a degrowth of emissions in this period, represented by a -1.6% growth rate, on average, in EU27. This information can be found on **Figure 68**.

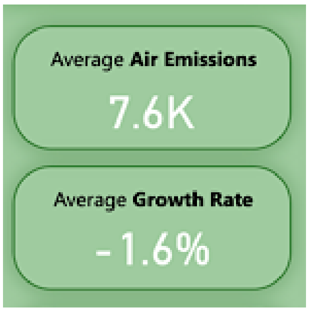


Figure 68. Average Air Emissions and Growth Rate in EU27

This decrease can also be identified on **Figure 69**. While in 2008, 8567 kilograms of greenhouse gases per capita were emitted, in 2018 this number decreased to 7132 kilograms, corresponding to a total decrease of more than 17%. In this period, the totality of Member States emitted around 83.5 thousand kilograms per capita.

[31] Figure's units for this indicator are expressed in Kilograms per Capita.

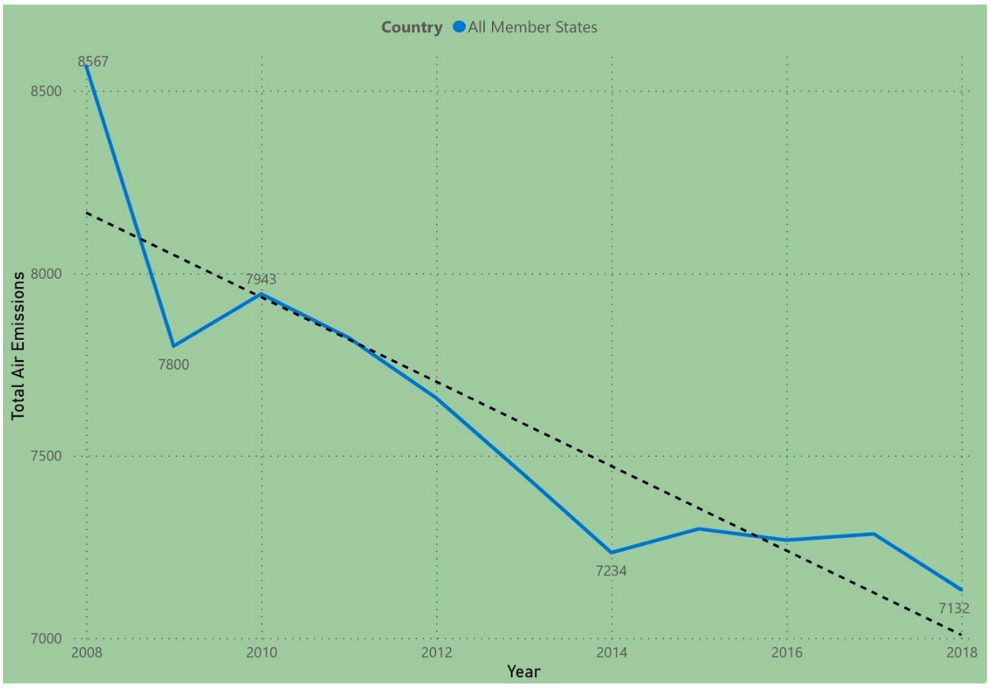


Figure 69. Evolution of Total Air Emissions on EU27

Moreover, **Figure 70** shows the same absolute results, comparing total amount of air emissions per capita and its growth rate, by country, between 2008 and 2018.

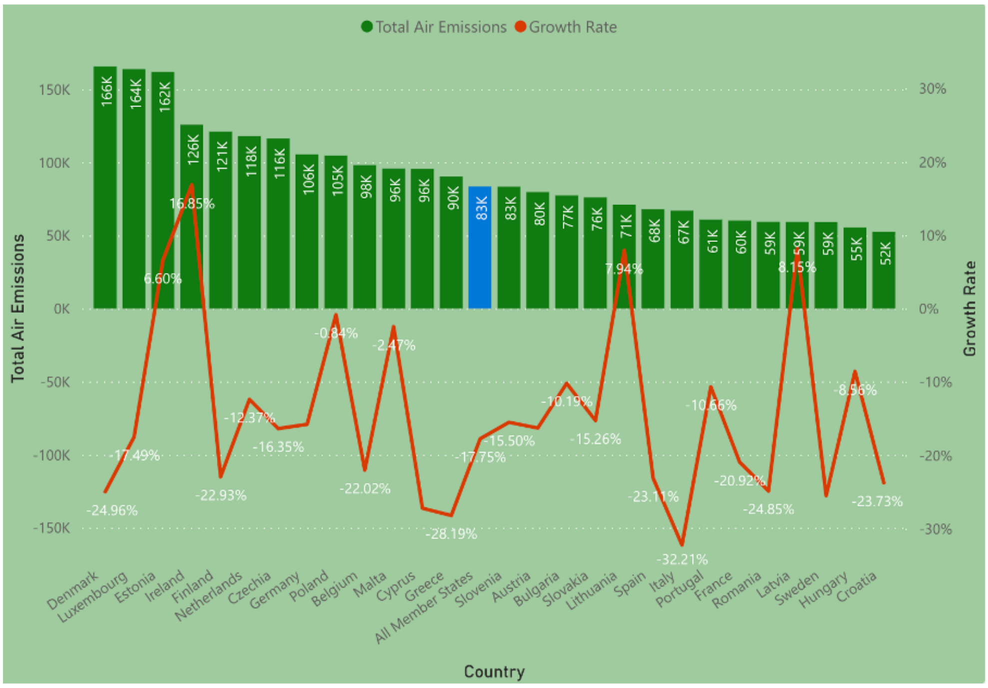


Figure 70. Total Air Emissions and Growth Rate by Country (2008-2018)

The lowest growth rates belong to Italy, Greece and Cyprus, meaning these countries had their emissions reduced more than remaining countries, presenting negative rates of more than 27%. Contrarily, Ireland, Latvia, Lithuania and Estonia increased their emissions, in the same period, being the only countries that present positive rates.

Turning the focus to analysing values in the base year of 1990, for the aggregate of EU27, results on **Figure 71** follow.

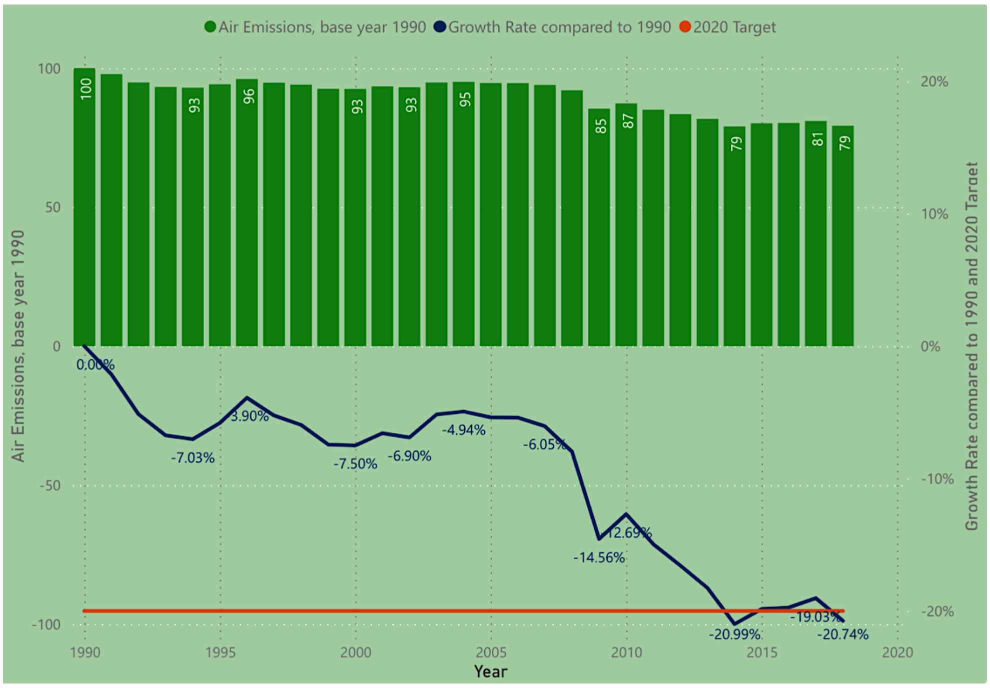


Figure 71. Evolution of Air Emissions, base year 1990, in EU27

Although general tendency is for decreasing, the total air emissions suffered increases in some years. Moreover, the first year where the "2020 Target" was fulfilled, of decreasing air emissions in 20% compared to 1990, was 2014, where growth rate reached its maximum, of -20.99%. In 2018, the last year of analysis, EU27 presented a decrease of 20.74%, achieving the goal for 2020. This can additionally be supported by **Figure 72**.

Figure 72. Distance to 2020 Target in EU27, in 2018

All things considered, this means that, unless tendency of increase alters until then, in 2020 EU27 will be able to consider one of its "2020 Targets" fulfilled.

As for the Member States, **Figure 73** shows air emissions, their growth rates and distance to target, by country. Countries that are, in 2018, below and above the "2020 Target" can quickly be identified. Additionally, countries that present higher amounts for air emissions are the ones that have higher positive growth rates (meaning they showed an increase in emissions in 2018), and are, therefore, further from reaching the target goal.

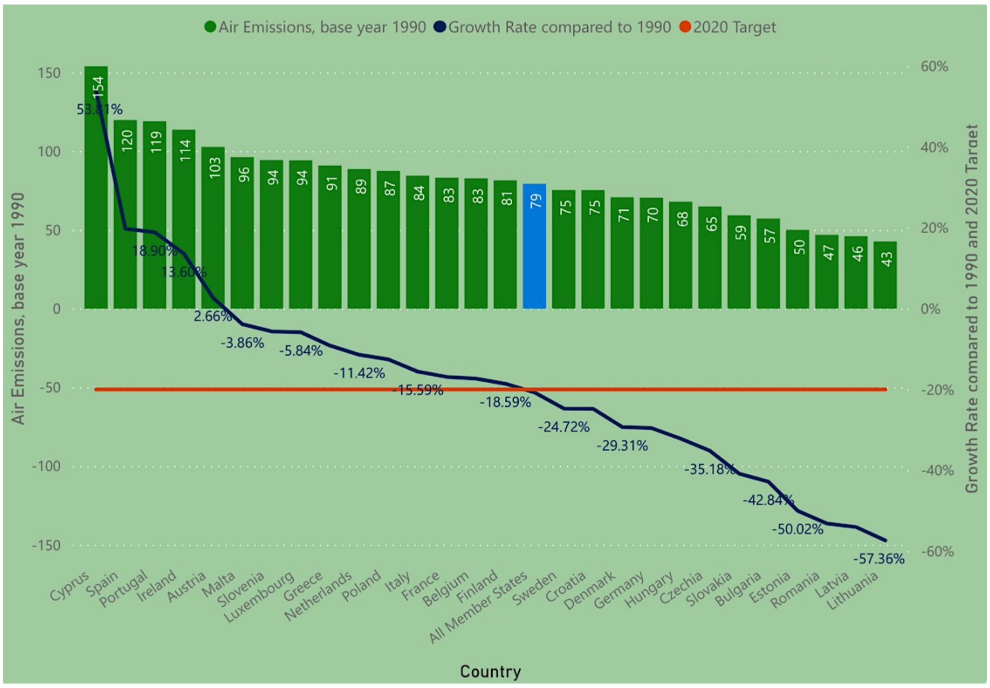


Figure 73. Evolution of Air Emissions, base year 1990, by country, in 2018

Having understood time evolution for this indicator, analysis can be **focused only on the most recent year (2018)**, in order to determine Top and Bottom countries, as it has been done so far.

Refocusing on the countries' analysis, let Top and Bottom 3 countries in terms of total air emissions in 2018, be analysed.

The Top 3 for this indicator, will represent countries who emit more greenhouse gases into the atmosphere. Information about the Top 3 countries can be found on **Figure 74**, which identifies their corresponding absolute values and growth rates for 2018, **Figure 75**, which presents their evolution over time, and **Figure 76**, that indicates their distance to the "2020 Target".

Estonia is the country who has more air emissions per capita, with a total surpassing 14.5K kilograms per capita, followed by Denmark, with approximately 14K kilograms, which is similar to Luxembourg, presenting in third, for 2018.

Even so, Denmark has the highest growth rate when compared to its pears, constituting a negative evolution on the last year, meaning that its air emissions were increased between 2017 and 2018. On the other hand, Estonia being in first on the Top 3 seems to have improved between 2017 and 2018, considering that its growth rate is negative and higher than 5%, which means that it was able to decrease its air emissions per capita.

Estonia	14531 Total Air Emissions	-5.08% Growth Rate
Denmark	14053 Total Air Emissions	2.53% Growth Rate
Luxembourg	14043 Total Air Emissions	0.46% Growth Rate

Figure 74. Air Emissions Top 3 Countries for 2018

Although the three countries present a general decrease in their emissions, Estonia had more fluctuances, between 2008 and 2018, nevertheless being at the top of Top 3.

Luxembourg, even though still presenting an increase in air emissions between 2017 and 2018, finishes in 2018 with almost as many absolute air emissions per capita as Denmark, which in 2017 was below Luxembourg in air emissions.

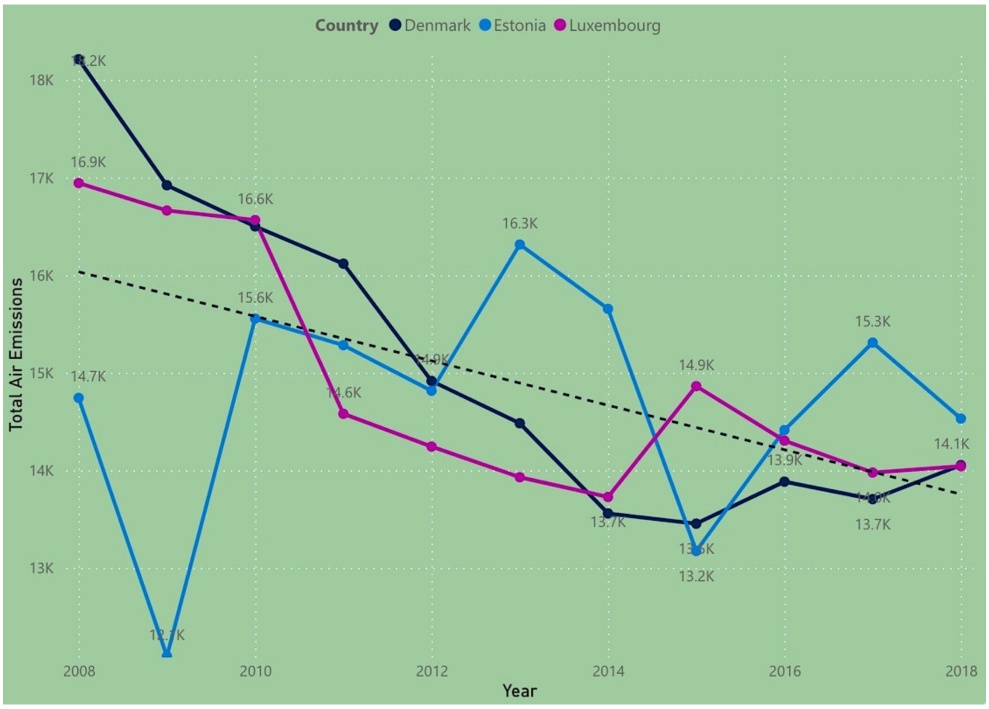


Figure 75. Evolution of Air Emissions on Top 3 countries

Additionally, taking in consideration indicators shown on **Figure 76**, 2018's distance to the 2020 goal for air emissions can be perceived, for our Top 3 countries.

With a positive evolution between 2008 and 2018, shown on **Figure 75**, Estonia presents in 2018 a decrease higher than 50% when compared to values from 1990, surpassing greatly EU's target goal of 20% reduction, as seen on **Figure 76**. Denmark, yet again, seems to be evolving positively, since it has surpassed 2020's target goal in 2018, with a decrease of almost 30% compared to values of 1990.

On the other hand, Luxembourg is far from reaching the goal, having decreased its air emissions in only 5.84%, needing to catch up on this evolution by almost 15 percentage points until 2020, in order to reach the goal.

Figure 76. Distance to 2020 Target, for EE, DK and LU (in 2018)

The Bottom 3 countries, which present lowest air emissions, are **Croatia, Sweden** and **France – Figure 77**.

Figure 77. Air Emissions Bottom 3 Countries for 2018

Croatia has the lowest value for greenhouse emissions per capita, totalizing almost 4.5K kilograms in 2018. Sweden follows with approximately 4.7K kilograms, and finally, France has almost 5K kilograms per capita of emissions. They all present negative growth rates, meaning that their air emissions between 2017 and 2018 decreased, improving even more in terms of less GHG emitted.

As it can be seen on **Figure 78**, all countries have a general tendency of decrease, between 2008 and 2018. Additionally, Croatia was persistently below the remaining two countries during the time period in question, indicating that it would be the country that emits less greenhouses into the atmosphere in any other past year of analysis.

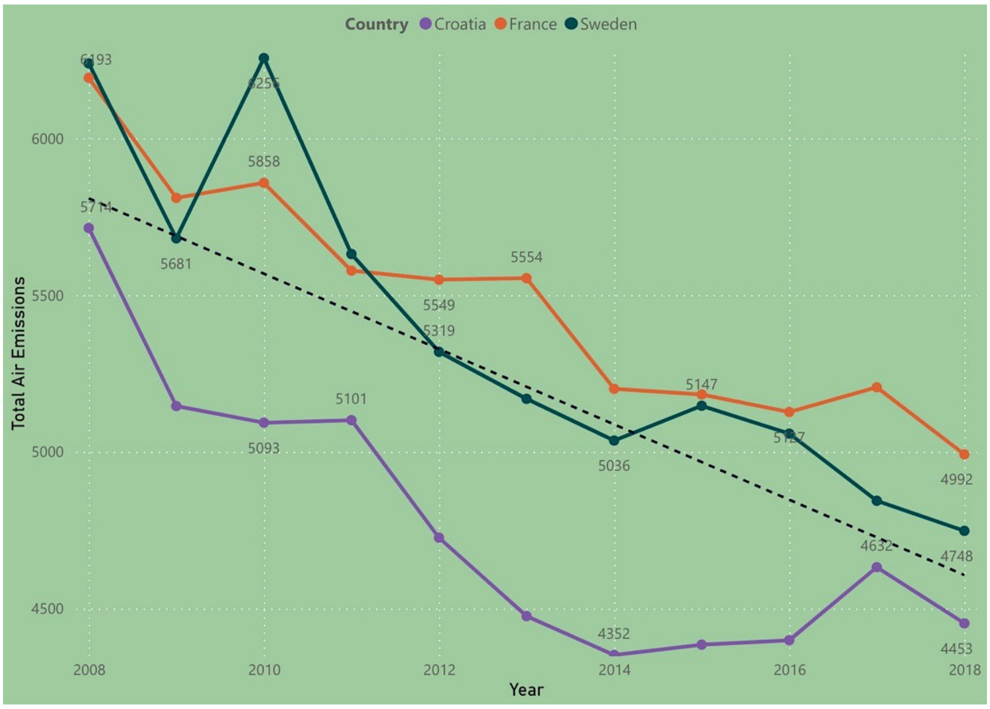


Figure 78. Evolution of Air Emissions on Bottom 3 countries

Figure 79 shows countries' distances to the "2020 Target". Croatia and Sweden are, in 2018, achieving EU's goal of at least 20% reduction. Moreover, Croatia and Sweden present the highest reductions when compared to 1990 values, surpassing the target in almost 5 percentage points, while France is approximately 3 percentage points far away from the 20% reduction. Nevertheless, considering that between 2017 and 2018 France presented a reduction of its air emissions close to 2%, indicates that by 2020, it is likely to at least reach the goal, if maintaining degrowth, contributing even more for the general decrease of greenhouse gas emissions per capita, in EU.

Figure 79. Distance to 2020 Target, for HR, SE and FR (in 2018)

7.2.2. SHARE OF RENEWABLES[32]

Indicator in analysis is "share of renewable energy in gross final energy consumption", however, for simplification reasons, in this section it will be mentioned only as "share of renewable energy".

The average share of renewable energy in EU27, between 2008 and 2018, was of 16.3% per year. As it can be seen on **Figure 80**, tendency for its evolution is of an increase, corresponding to an augment of approximately 42%. While in 2008, share of renewables in the aggregate of all Member States was 12.56%, in 2018 it was almost 19%. Moreover, in average, the yearly increase was 3.8%.

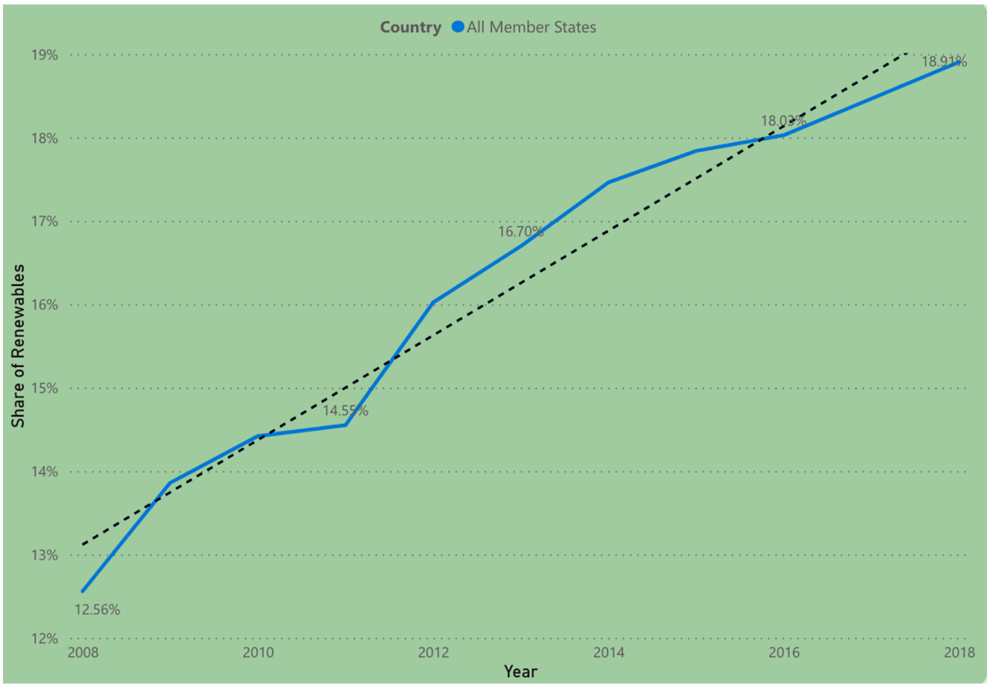


Figure 80. Evolution of Share of Renewable Energy in EU27

The stablished target to be reached by 2020, for this indicator, was to increase the share of renewable energy in at least 20%. Although tendency is to increase, in 2018, the target in not yet fulfilled, as it can be seen on **Figure 81**.

[32] Figures' units for this indicator are expressed in Percentages.

However, if the yearly growth rate for EU27 maintains, it is predictable that by 2020 the goal can be surpassed.

Figure 81. Distance to 2020 Target for EU27

As in previous analysis, **focus will be made on the most recent year, therefore 2018**. Turning attention to all country members, **Figure 82** shows growth rates and corresponding "2020 targets", for each country, in 2018.

It can be perceived that countries with higher of share of renewables, although having corresponding higher targets for 2020, are surpassing or closer to reaching their goals.

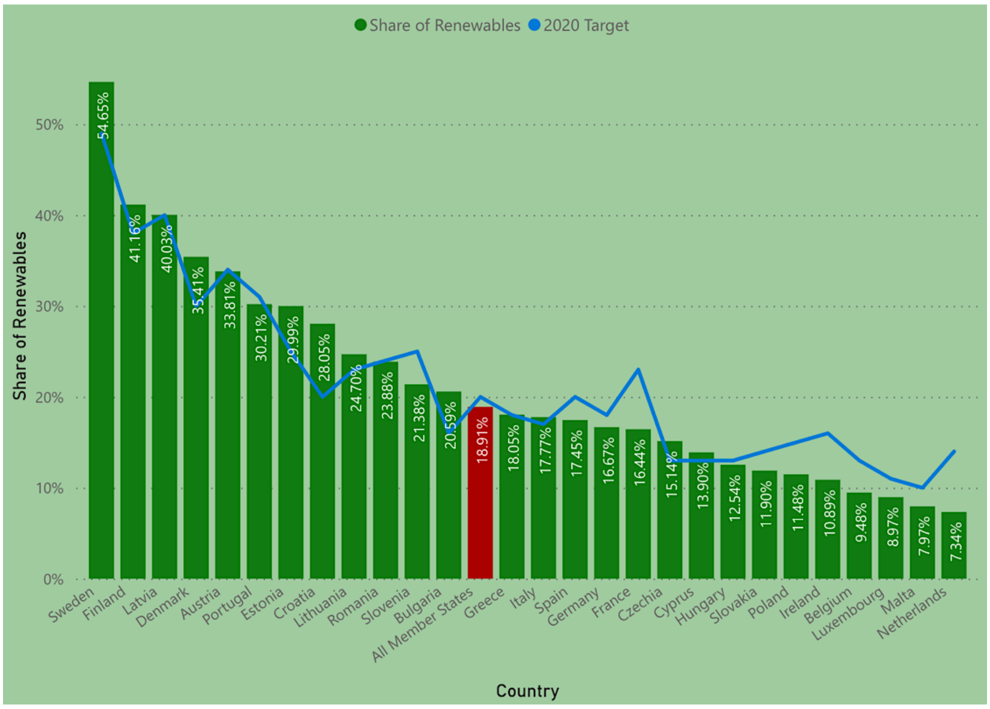


Figure 82. Share of Renewable Energy and 2020 Target by Country for 2018

For countries situated on the right spectrum of the graphic, distances between their growth rates and target percentages are, in general, higher, meaning they are further away from meeting their goals.

It is now crucial to analyze countries on the Top and Bottom 3 and understand their behaviour in terms of renewable energy.

As it is shown on **Figure 83**, **Sweden, Finland and Latvia are part of the Top 3** countries, presenting the highest percentages of renewable energy.

Sweden is leading, with a share of almost 55%, and a 2018's growth rate of almost 1%. Following, there is Finland, with a share of 41.16%, and a growth rate of 0.59%. Finally, Latvia, presents a share of renewables similar to Finland, of 40.03%, and an average growth rate surpassing 2.50%, the highest of the three.

Figure 83. Share of Renewables Top 3 Countries for 2018

By interpretation of **Figure 84** is it also notable that all countries present a positive evolution for this indicator between 2008 and 2018, meaning they all saw their share of renewable energy increase, during this period.

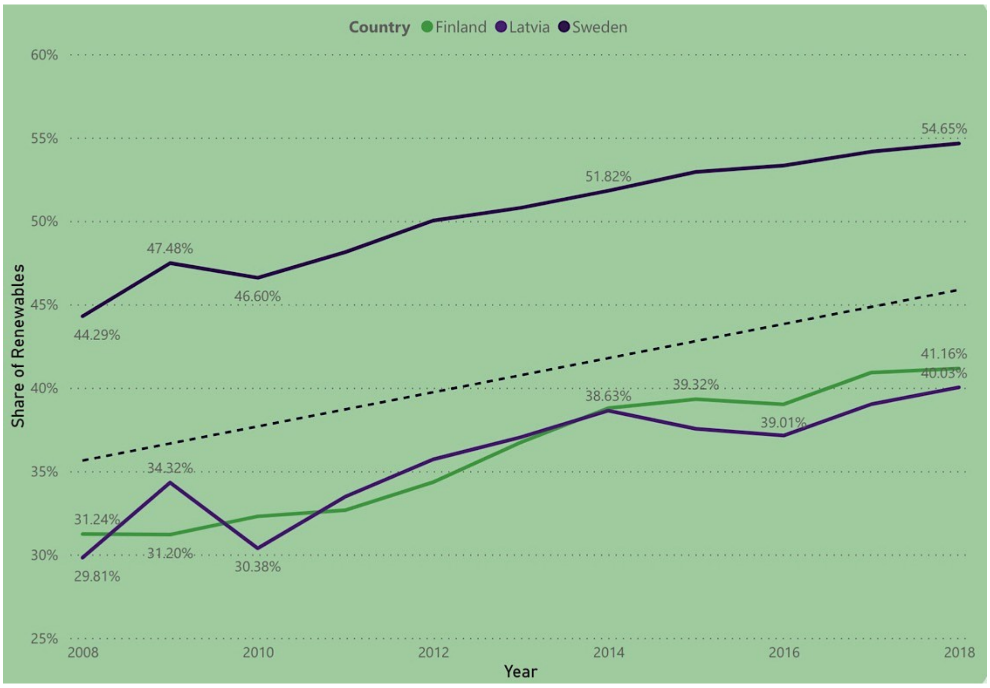


Figure 84. Evolution of Share of Renewable Energy on Top 3 countries

A summary of the Top 3 can be also found on **Figure 85**. This matrix presents percentages for renewables, growth rates and targets, for each country of the Top 3, on an annual basis. It is notable that, by 2018, all three countries already surpass their goals for 2020, having a higher "Share of Renewables" value than their "2020 Target".

Country	Finland			Latvia			Sweden		
Year	Share of Renewables	Growth Rate	2020 Target	Share of Renewables	Growth Rate	2020 Target	Share of Renewables	Growth Rate	2020 Target
2008	31.24%	0.00%	38.00%	29.81%	0.00%	40.00%	44.29%	0.00%	49.00%
2009	31.20%	-0.12%	38.00%	34.32%	15.12%	40.00%	47.48%	7.20%	49.00%
2010	32.29%	3.51%	38.00%	30.38%	-11.49%	40.00%	46.60%	-1.86%	49.00%
2011	32.66%	1.15%	38.00%	33.48%	10.22%	40.00%	48.14%	3.31%	49.00%
2012	34.34%	5.13%	38.00%	35.71%	6.66%	40.00%	50.03%	3.93%	49.00%
2013	36.73%	6.95%	38.00%	37.04%	3.72%	40.00%	50.79%	1.53%	49.00%
2014	38.78%	5.59%	38.00%	38.63%	4.30%	40.00%	51.82%	2.02%	49.00%
2015	39.32%	1.40%	38.00%	37.54%	-2.82%	40.00%	52.95%	2.18%	49.00%
2016	39.01%	-0.78%	38.00%	37.14%	-1.07%	40.00%	53.33%	0.72%	49.00%
2017	40.92%	4.88%	38.00%	39.02%	5.06%	40.00%	54.16%	1.55%	49.00%
2018	41.16%	0.59%	38.00%	40.03%	2.59%	40.00%	54.65%	0.91%	49.00%

Figure 85. Evolutionary information about Top 3 Countries

Focusing on the Bottom 3 countries, they can be found on **Figure 86**. While the Top 3 fluctuated, on average, between shares of 40% and 55%, on the Bottom 3 shares don't surpass the 10%. Even though their general tendency, over time, is of a positive evolution, their values are well below than top countries, for this indicator.

The Bottom 3 is constituted, in ascending order, by Netherlands, Malta and Luxembourg. In terms of shares of renewables, Netherlands has a value of 7.34%, followed by Malta, with almost 8%, and finally, Luxembourg, with a rate close to 9%, for 2018. Additionally, all three countries from the Bottom 3 present high growth rate between 2017 and 2018, indicating they are improving their share of renewable energy values.

Netherlands	
7.34% Share of Renewables	13.69% Growth Rate
Malta	
7.97% Share of Renewables	10.38% Growth Rate
Luxembourg	
8.97% Share of Renewables	44.77% Growth Rate

Figure 86. Share of Renewables Bottom 3 Countries for 2018

When looking to Bottom 3 countries' evolution regarding share of renewable energy, all countries saw it increasing, indicating a positive evolution, between 2008 and 2018, as it happened with Top 3 – **Figure 87.**

Although Malta started, in 2008, with the lowest percentage of renewables, it finished, in 2018, above Netherlands, which was the country who started 2008 with a higher value. That justifies the highest average growth rate of Malta, and the lowest being from Netherlands.

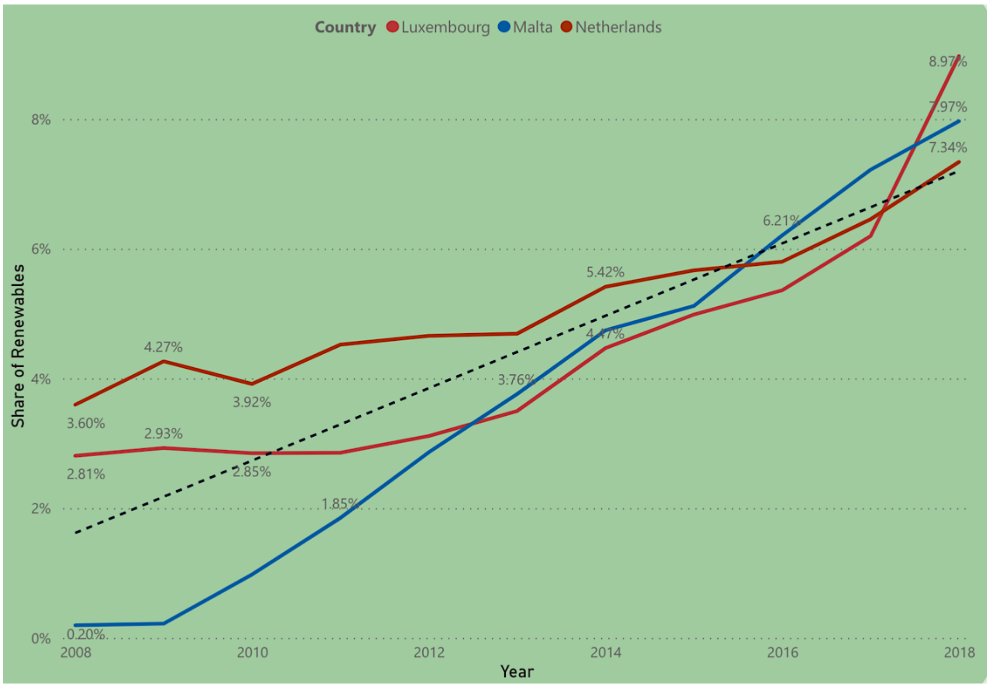


Figure 87. Evolution of Share of Renewable Energy on the Bottom 3 countries

Lastly, analyzing **Figure 88**, and contrarily to what happened in the Top 3, it can be perceived that all countries belonging to Bottom 3 have not reached their 2020 target by 2018. Nevertheless, as it happened for EU27, if each country maintains their annual growth rates, it is predictable that their goals can be achieved until 2020.

Country	Luxembourg			Malta			Netherlands		
Year	Share of Renewables	Growth Rate	2020 Target	Share of Renewables	Growth Rate	2020 Target	Share of Renewables	Growth Rate	2020 Target
2008	2.81%	0.00%	11.00%	0.20%	0.00%	10.00%	3.60%	0.00%	14.00%
2009	2.93%	4.27%	11.00%	0.22%	13.33%	10.00%	4.27%	18.63%	14.00%
2010	2.85%	-2.70%	11.00%	0.98%	342.99%	10.00%	3.92%	-8.18%	14.00%
2011	2.86%	0.21%	11.00%	1.85%	88.97%	10.00%	4.52%	15.50%	14.00%
2012	3.11%	9.03%	11.00%	2.86%	54.70%	10.00%	4.66%	2.98%	14.00%
2013	3.50%	12.36%	11.00%	3.76%	31.38%	10.00%	4.69%	0.69%	14.00%
2014	4.47%	27.72%	11.00%	4.74%	26.17%	10.00%	5.42%	15.43%	14.00%
2015	4.99%	11.59%	11.00%	5.12%	7.90%	10.00%	5.67%	4.67%	14.00%
2016	5.36%	7.50%	11.00%	6.21%	21.27%	10.00%	5.80%	2.36%	14.00%
2017	6.20%	15.61%	11.00%	7.22%	16.29%	10.00%	6.46%	11.27%	14.00%
2018	8.97%	44.77%	11.00%	7.97%	10.38%	10.00%	7.34%	13.69%	14.00%

Figure 88. General information about the Bottom 3 countries

7.2.3. ENERGY EFFICIENCY[33]

As it happened with "Air Emissions" analysis, the positive evolution of indicator "Final Energy Consumption" is characterized by its decrease.

Between 2008 and 2018, in EU27, there was a general decrease of the total amount of energy consumption, as perceived on **Figure 89**. However, there has been an increase of more than 5%, since 2014 until 2018. Nevertheless, the growth of final energy consumption on EU27 was -4.15%, in the eleven years analysed, showing a general positive tendency.

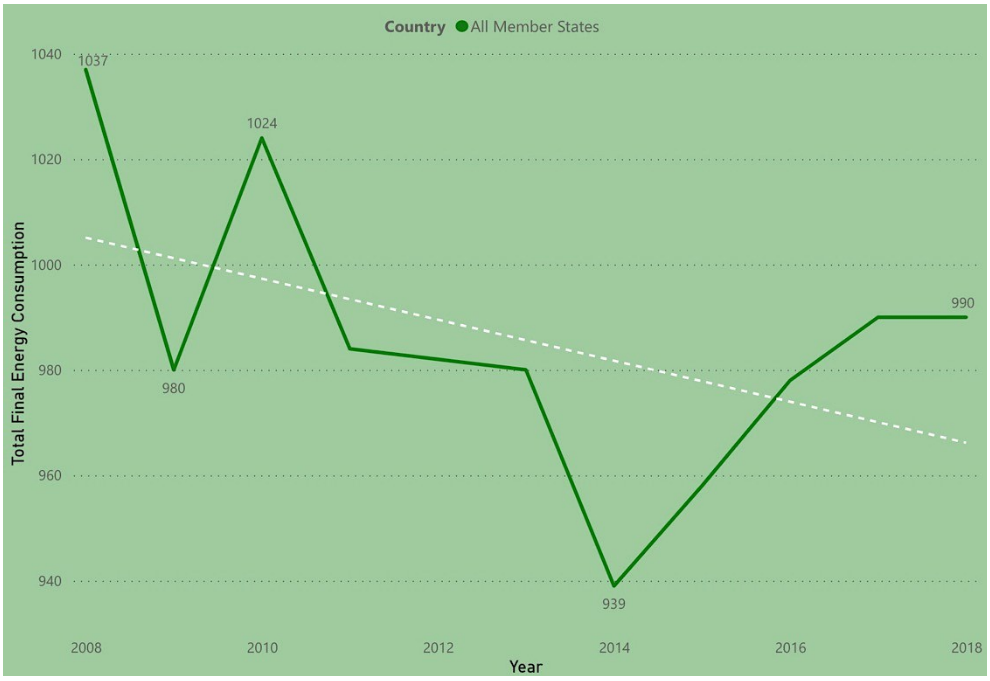


Figure 89. Evolution of Final Energy Consumption in EU27

Considering **Figure 90** and **Figure 91**, distance to "2020 Target" for EU27 can be identified, for 2018 and the totality of the period in analysis, correspondently.

[33] Figure's units for this indicator are measured in Million Tonnes of Oil Equivalent.

As already pointed on Chapter 5, EU's goal for this indicator is to have a final energy consumption not higher than 1 086 million tonnes of oil equivalent, in 2020. The fact that, in 2018, the goal is being achieved is not promising, taking in consideration that the final energy consumption in EU27 is, from 2014 until 2018, increasing.

Figure 90. Distance to 2020 Target in EU27

However, looking back to 2008, the total final consumption was little more than 1000 million tonnes, remaining bellow 2020's goal, indicating that, until 2020, there is no reason for this value to surpass the target.

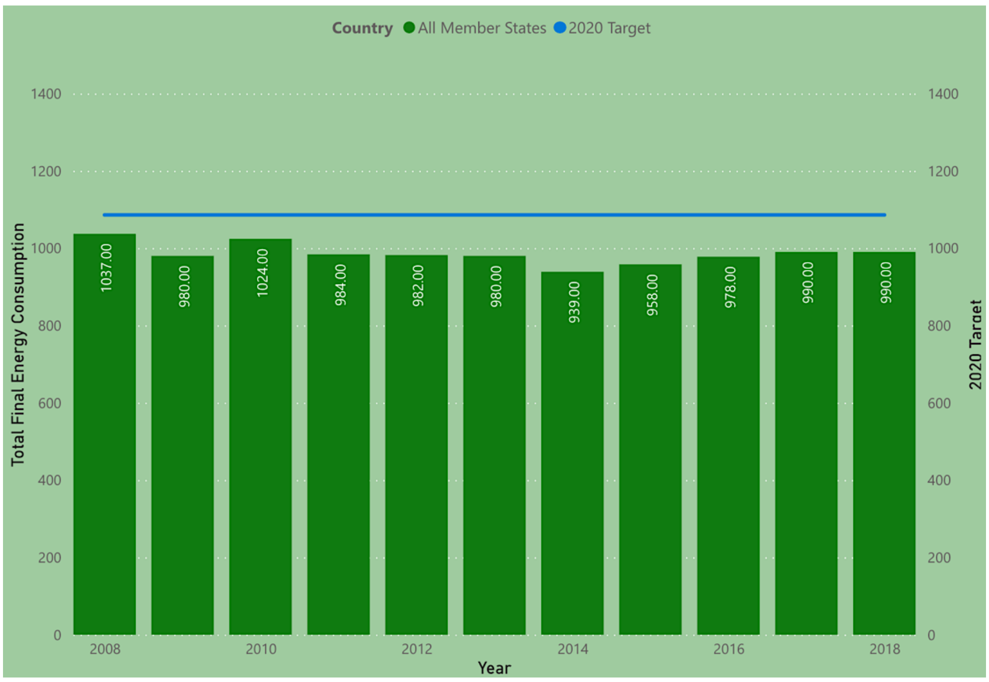


Figure 91. Evolution of Total Final Energy Consumption and 2020 Target in EU27

Additionally, values for final consumption maintained between 2017 and 2018, which can indicate that additional measures were taken or accountability for this increase is in place, by policy makers and intervenients. Alternatively, this can indicate that EU stablished a target not sufficiently ambitious, and perhaps it should have set a higher goal.

Focusing on 2018, in the totality of EU, approximately 990 million tonnes of oil equivalent were consumed, with a positive growth rate of 0.01%.

Turning the focus to all country members, **Figure 92** ranks them in terms of final energy consumption's growth rate by 2018. It can be seen that there are a lot of countries who present positive growth rates, some even high, meaning that these countries are not reducing their final energy consumption, but contrarily, increased it between 2017 and 2018.

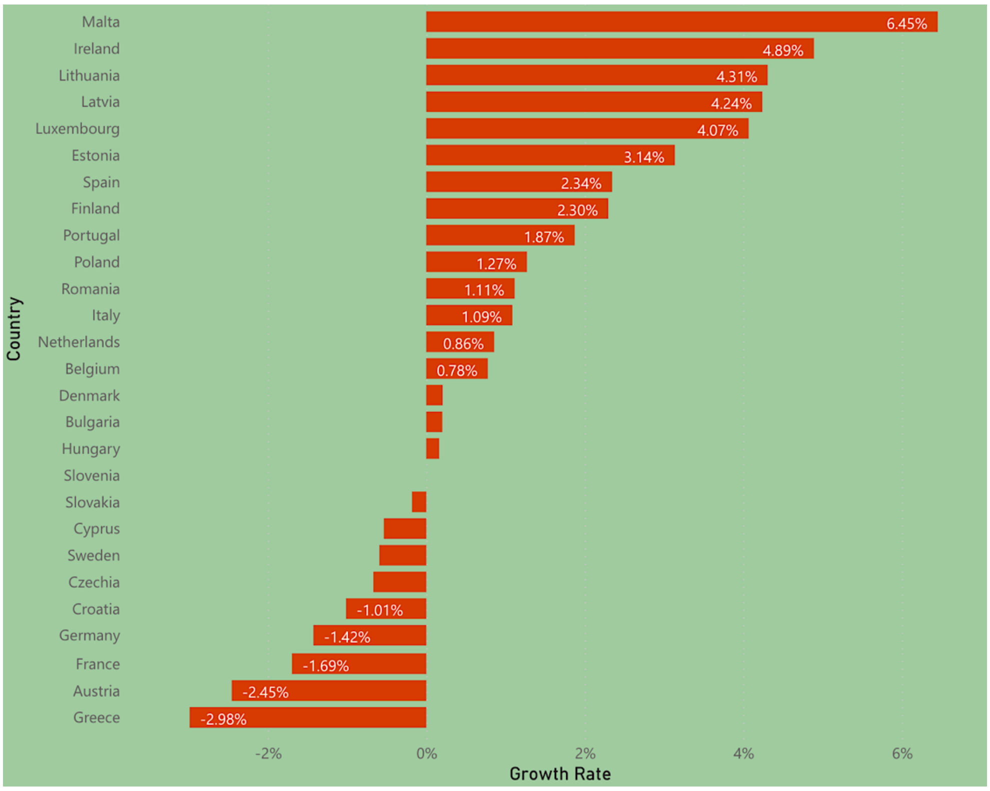


Figure 92. Final Energy Consumption Growth Rate by Country for 2018

Conversely, countries presenting negative growth rates, which are below Slovakia[34] on the graphic above, are investing their efforts in decreasing their consumption of final energy.

Figure 93 shows the Top 3 countries, by total final energy consumption for 2018. Germany, France and Italy constitute the Top 3, with respectively, 215, 147 and 116 million tonnes of oil equivalent of energy consumption. Even if on the Top 3, which is not a good indicator in this case, Germany and France saw their consumption decrease between 2017 and 2018, although Italy showed a slight increase.

Germany	215 Total Final Energy Consumption	-1.42% Growth Rate
France	147 Total Final Energy Consumption	-1.69% Growth Rate
Italy	116 Total Final Energy Consumption	1.09% Growth Rate

Figure 93. Energy Efficiency's Top 3 Countries for 2018

[34] Slovakia shows for 2018 a growth rate of zero percentage points.

Additionally, as perceived on **Figure 94**, although presenting significantly high absolute values, countries on the Top 3 seem to be improving their position, with a positive evolution over time, by decreasing their consumption.

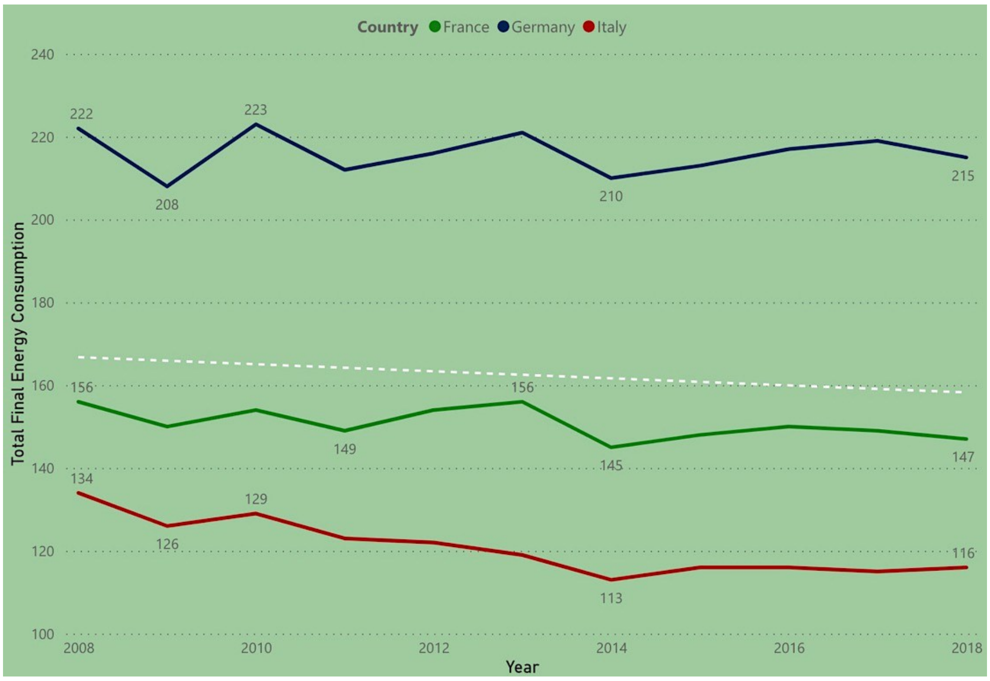


Figure 94. Evolution of Final Energy Consumption in the Top 3 countries

On the other hand, the **Bottom 3, formed by Malta, Cyprus and Estonia**, present much lower values – **Figure 95**. While Malta has a total of 1 million tonnes, Cyprus has double, with 2 million tonnes, followed by Estonia, with 3 million tonnes of oil equivalent, in 2018. However, excepting Cyprus, they all present a growth between 2017 and 2018, indication of an increase in their consumptions.

Malta	
1 Total Final Energy Consumption	6.45% Growth Rate
Cyprus	
2 Total Final Energy Consumption	-0.53% Growth Rate
Estonia	
3 Total Final Energy Consumption	3.14% Growth Rate

Figure 95. Energy Efficiency's Bottom 3 Countries for 2018

Additionally, when seeing their absolute values over time, a constant evolution can be perceived, indicating that these were the countries that were always responsible for less consumption of final energy.

Nevertheless, it should be taken in consideration that these values are absolute, and not per unit of output, meaning that bigger economies will inevitably present higher energy consumption values. Ideally, the energy efficiency measure should consider the final energy consumption per unit of GDP. However, Eurostat, assumes final energy consumption as a measure of energy efficiency. Since this was our main source of data regarding the sustainability analysis and since Eurostat does not provide a better measure, the final energy consumption was considered, for consistency purposes.

7.2.4. Circularity of the Economy[35]

Average circularity rate for EU27, between 2008 and 2018, was approximately 11%, with a total growth rate of 9%. In average, circularity rate in EU27 increased approximately 1%, in the same period.

Figure 96 shows the evolution of circularity rate in EU27, between 2008 and 2018. As it is notable, there has been a general increase, marking a positive tendency of evolution.

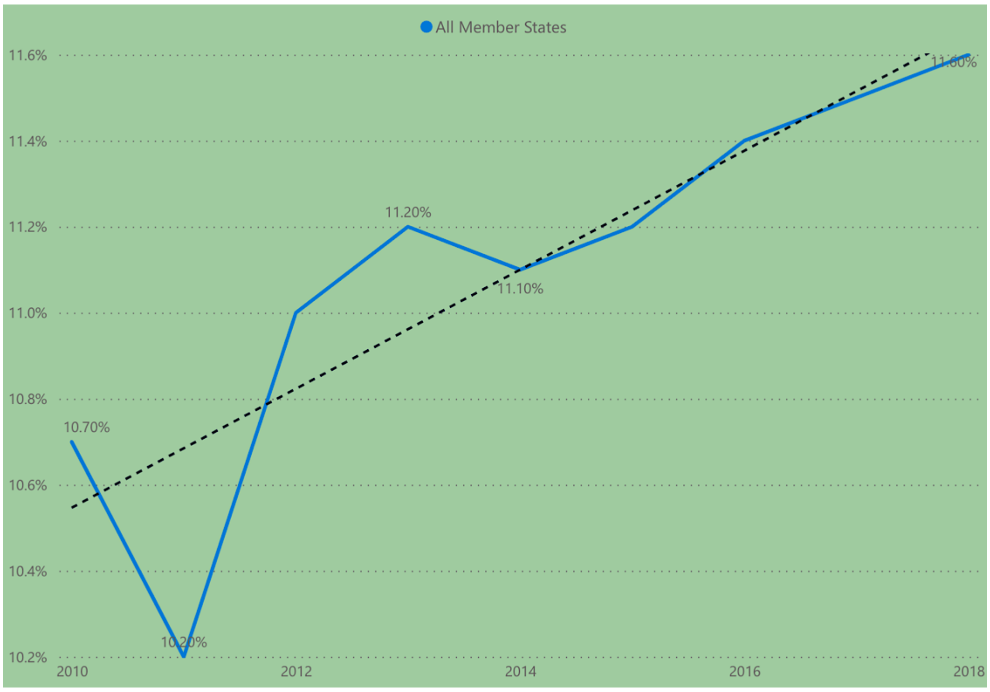


Figure 96. Evolution of Circularity in EU27

For year 2018, considering the Member States individually, **Figure 97** shows circularity and growth rate for each country.

On the left side of the graphic, countries with higher circularity can be found. **The Top 3 countries are Netherlands, Belgium and France**, with rates surpassing 19%. Looking at their growth, Belgium and France present positive rates, indicating that

[35] Figure's units for this indicator are expressed in Percentages.

between 2017 and 2018 occurred an increase in their circularity. However, Netherlands presents a negative growth rate for the same period.

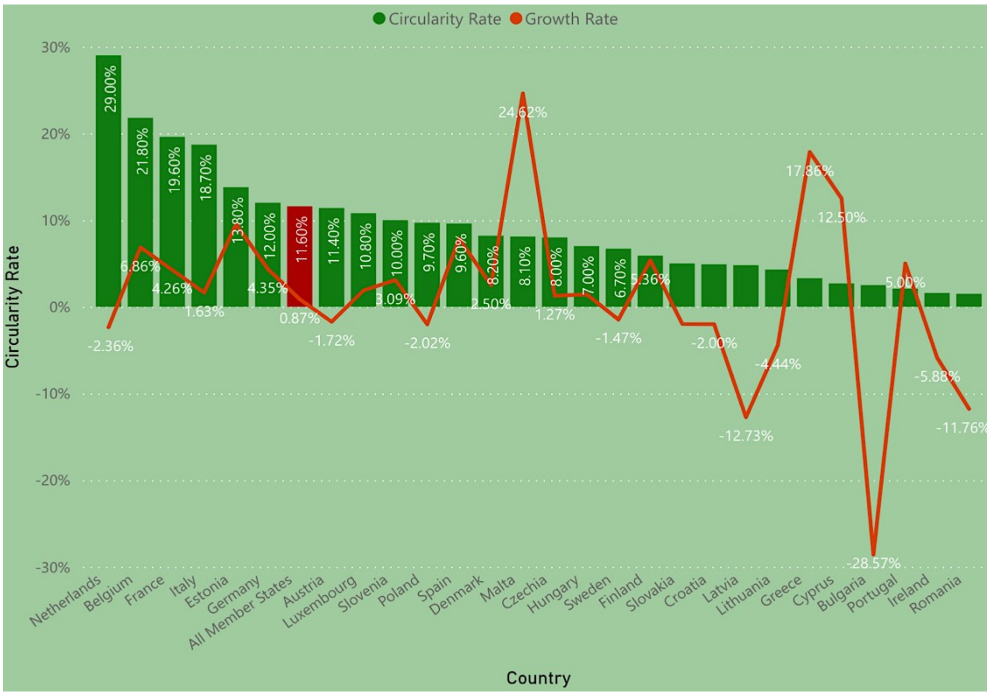


Figure 97. Circularity and Growth Rates by Country for 2018

Analysing closely circularity's evolution for Top 3 countries, results on **Figure 98** follow.

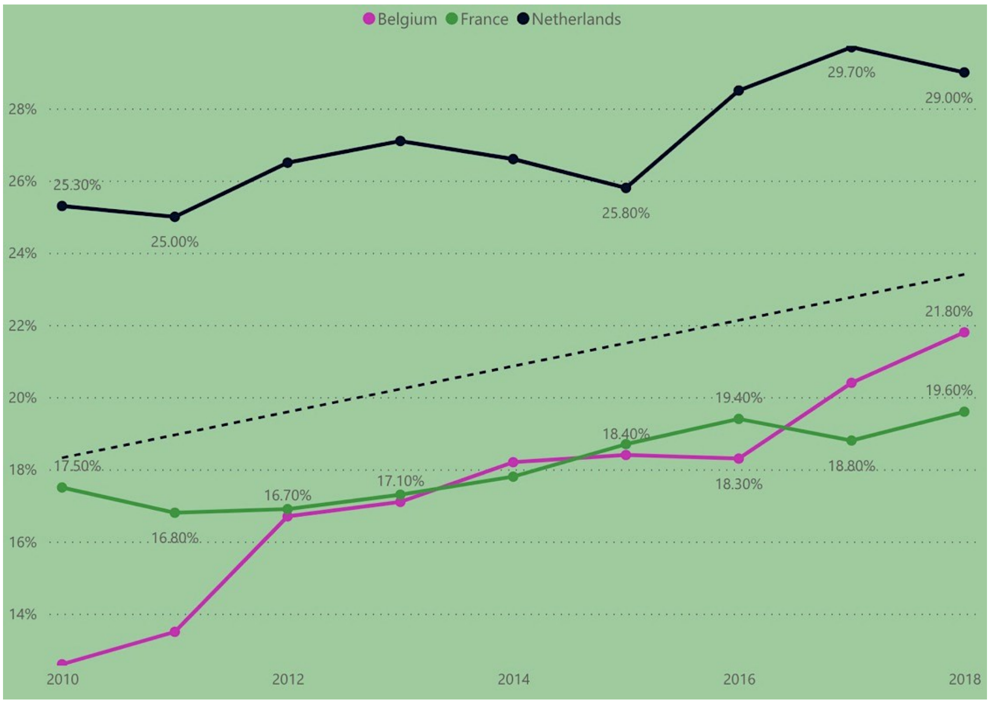


Figure 98. Circularity's Evolution for Top 3 Countries

The general tendency is for an increase in all countries, demonstrating this indicator's positive evolution, between 2008 and 2018.

Although a target is not yet stablished for EU's circularity, in order to understand how countries are performing in terms of circularity a comparison between EU27's aggregate average and countries' averages can be made. **Figure 99**, **Figure** 100 and **Figure** 101 provide that comparison for Top 3 countries.

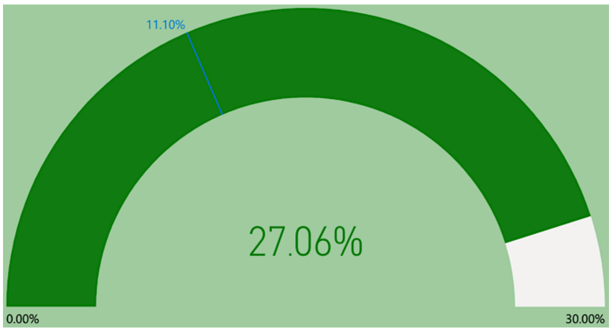


Figure 99. Netherland's Comparison to EU27 Average Circularity

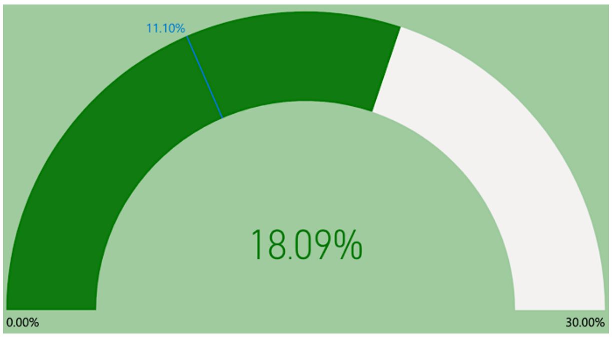


Figure 100. France's Comparison to EU27 Average Circularity

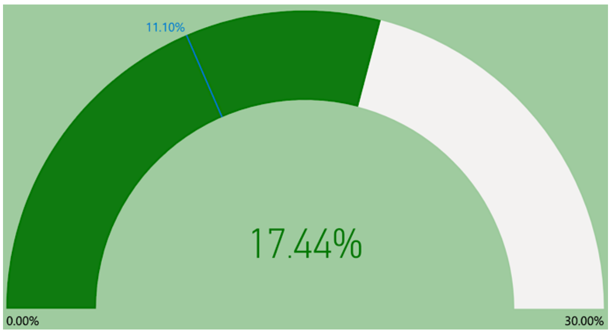


Figure 101. Belgium's Comparison to EU27 Average Circularity

Contrarily, on the right end of the graphic presented on **Figure 97**, countries with lower circularity rates are identified as Romania, Ireland and Portugal. Although Portugal presents a positive growth rate, the remaining two countries have negative rates, meaning they had a decrease in their circularity.

Moreover, when analysing their evolution in time, between 2008 and 2018, in terms of circularity rate, results are an shown on **Figure 102.**

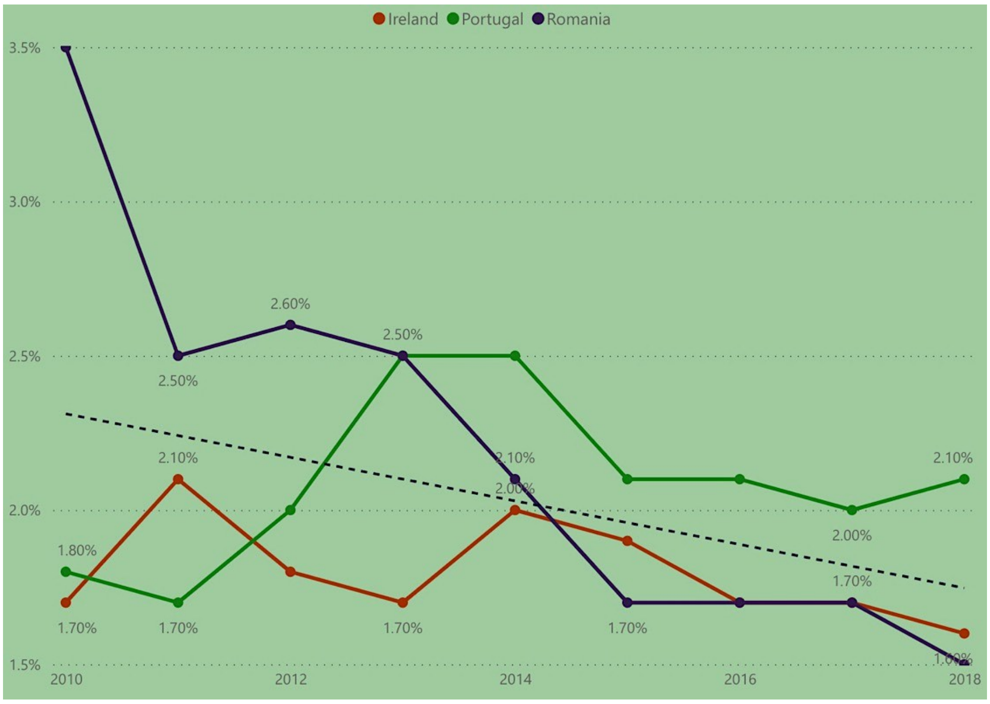


Figure 102. Circularity's Evolution for Bottom 3 Countries

Although Portugal is showing a general increase, from 2015 on it started to decrease its circularity, showing a slight improvement only between 2017 and 2018. As for the remaining two countries, the decrease is aggravated since it is notable for the entire period in question.

In fact, when looking at **Figure 103**, **Figure** 104 and **Figure** 105, where average circularity rates of Romania, Portugal and Ireland, correspondently, are being compared with EU27's circularity rate, it can be perceived that all three countries are far away from the 11% value presented by the aggregate of all member states, meaning there is a lot to conquer in terms of circularity in their economies.

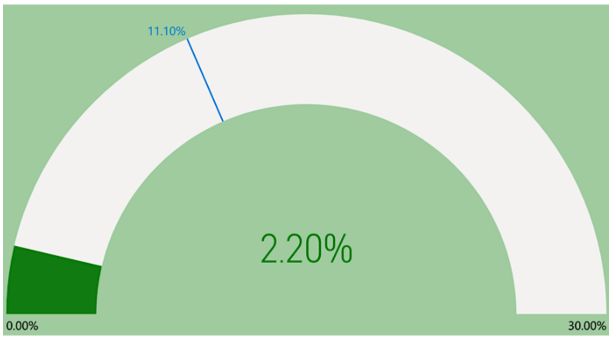


Figure 103. Romania's Comparison to EU27 Average Circularity

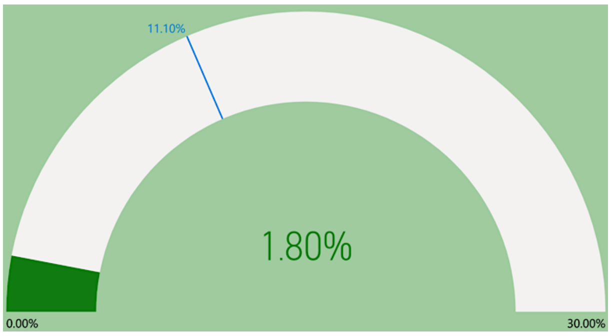


Figure 104. Ireland's Comparison to EU27 Average Circularity

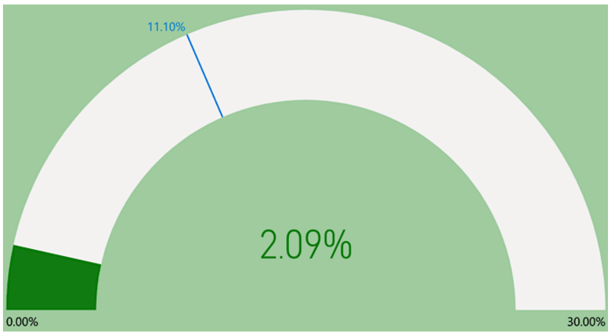


Figure 105. Portugal's Comparison to EU27 Average Circularity

7.3. WAVING IT ALL TOGETHER

Having concluded both analyses, it is crucial to gather the main conclusions. Consequently, in order to better understand and simplify results, an overall analysis was made, including the general outcome for bioeconomic and sustainability-oriented data analysis.

Since the main goal is to determine bioeconomy's performance in EU27, which translates in ultimately identifying leading countries and sectors (if applicable), a graphic was constructed in order to easily answer this question.

In that way, **Figure 106** allows to identify **2018's leading countries and sectors**, amongst economic-oriented indicators analysis, extracting its main results. Additionally, **Figure 107** has the same resuming feature, although relative to "Sustainability-oriented Analysis", enlisting **2018's leading countries**.

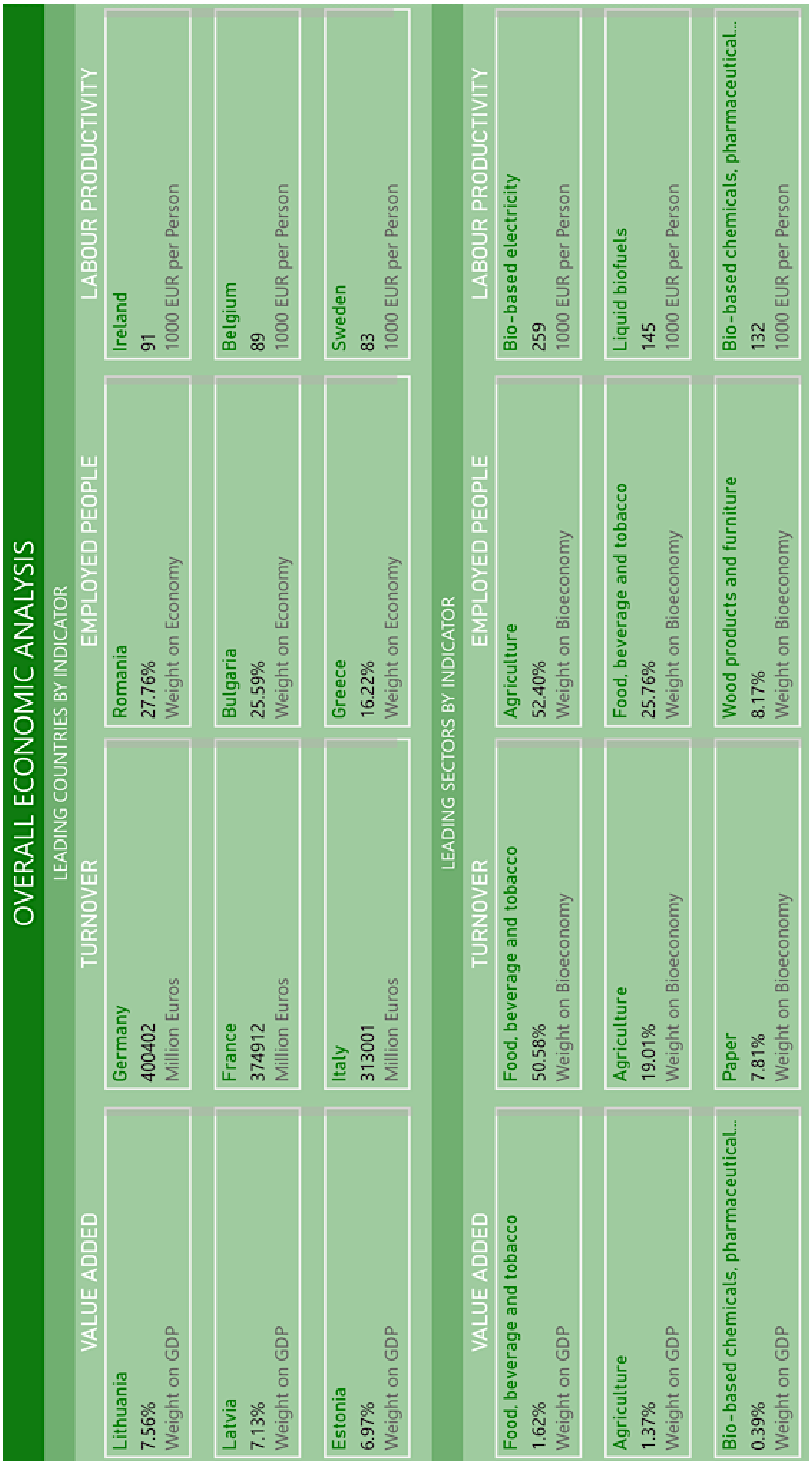


Figure 106. Overall Economic-oriented Analysis

Results on **Figure 106** were already discussed in detail along Chapter 7, specifically on section 7.1., since mentions on Top 3 countries/sectors were present on every analysis made.

Regarding leading countries, and by quickly analyzing **Figure 106**, it can be seen that leading countries for **added value** are **Lithuania, Latvia and Estonia**, being these countries creating more value in bioeconomy.

Addressing bioeconomy's **turnover**, **Germany**, **France** and **Italy** are the countries who invoiced highest monetary values.

As for **employability** in bioeconomy, **Romania**, followed by **Bulgaria** and **Greece**, are the leading countries, meaning they employ the highest number of people in bioeconomy, creating more jobs.

Finally, for **labour productivity**, **Ireland** is leading, followed by **Belgium** and **Sweden**, reflecting that, in these countries, people who are employed in bioeconomy are more productive than when compared to people who work in bioeconomies from remaining countries.

Moreover, if a basic system point is applied to rankings shown on **Figure 106**, it can be easily obtained a conclusion regarding which country is leading, in general, i.e., considering all indicators at once, on bioeconomy. The system point works in the following manner: counting per category, 3 points will be given to countries in first place, 2 points will be given for second place and, finally, 1 point will be given to countries in third place. Results can be identified on **Table** 4.

Reading these results, it can be perceived that Germany, Ireland, Lithuania and Romania are leading the way. Following, there is Belgium, Bulgaria, France and Latvia, which come in second place in the general ranking. In third place, there are Estonia, Greece, Italy and Sweden.

ECONOMIC RANKING	COUNTRIES
1^{st}	Germany
	Ireland
	Lithuania
	Romania
2^{nd}	Belgium
	Bulgaria
	France
	Latvia
3^{rd}	Estonia
	Greece
	Italy
	Sweden

Table 4. Point System Results for Countries in Economic-oriented analysis

Regarding leading sectors, moving forward with this review, **Figure 106** provides the following conclusions.

In terms of **value added**, the leading sectors are "**Food, beverages and tobacco**", "**Agriculture**" and "**Bio-based chemicals, pharmaceuticals, plastics and rubber (excl. biofuels)**".

On the other hand, sectors who presented the highest invoiced amount, i.e., highest **turnover** values, were "**Food, beverage and tobacco**", "**Agriculture**" and "**Paper**".

In terms of **employability**, sectors that employed the higher number of people in bioeconomy were "**Agriculture**", "**Food, beverage and tobacco**" and "**Wood products and furniture**".

Moreover, in terms of productivity, sectors that present higher **labour productivity** are "**Bio-based Electricity**", "**Liquid biofuels**" and "**Bio-based chemicals, pharmaceuticals, plastics and rubber (excl. biofuels)**".

Additionally, applying the same system point as before, results on **Table 5** will follow. A general ranking can be stablished in order to obtain a hierarchy between leading sectors.

ECONOMIC RANKING	SECTORS
1^{st}	Food, beverages and tobacco
2^{nd}	Agriculture
3^{rd}	Bio-based electricity
4^{th}	Bio-based chemicals, pharmaceuticals, plastics and rubber (excl. biofuels)
	Liquid biofuels
5^{th}	Paper
	Wood products and furniture

Table 5. Point System Results for Sectors in Economic-oriented analysis

Analyzing these results, it becomes clear that sector "Food, beverage and tobacco" is leading the ranking for economic-oriented analysis. Following in second place in the general ranking, there is "Agriculture". In third and fourth places in the ranking, the first bio-based sectors appear, correspondently "Bio-based electricity" and "Bio-based chemicals, pharmaceuticals, plastics and rubber (excl. biofuels)". Tied with last-mentioned sector, also in fourth place, there is "Liquid biofuels". In fifth place, there is "Paper" and "Wood products and furniture".

Proceeding to the sustainability-oriented analysis, on **Figure 107**, results in terms of leading countries can be identified, for each indicator.

Figure 107. Overall Sustainability-oriented Analysis

Considering the amount of greenhouse gases emitted to the atmosphere, the countries who are leading with **<u>less air emissions</u>**[36], i.e., the ones that emit lowest amounts per capita, are **Croatia**, **Sweden** and **France**.

In terms of **<u>share of renewable energy</u>** in gross final energy consumption, countries identified as having higher shares are **Sweden**, **Finland** and **Latvia**.

On the other hand, considering **<u>energy efficiency</u>**, which counts total tonnes of final energy consumed, countries who present **<u>lower values</u>**[37] are considered the ones leading, being them **Malta**, **Cyprus** and **Estonia**, in ascending order.

Finally, in terms of **<u>circularity</u>**, **Netherlands**, **Belgium** and **France**, have the highest circularity rates amongst all country members.

Applying the same point system, it can be identified which countries are leading in terms of sustainability, on Erro! A origem da referência não foi encontrada..

As it can be seen, Sweden is leading the ranking, in terms of sustainability. In second place, there is a tie between Croatia, Malta and Netherlands, all having three points, related to one first place on different categories. The third place is occupied by Cyprus, Finland and Belgium, each having two points. Finally, Latvia, Estonia and France are in last place, with only one point.

Additionally, regarding **2020 targets analysis**, it is concluded that, by 2018, EU27's aggregate was:

i) surpassing "Air Emissions" goal by 0.74 percentage points;

ii) 1.09 percentage points from reaching "Share of Renewables" goal;

iii) surpassing in 8.84 percentage points the "Energy Efficiency" goal;

iv) and, presenting an average circularity rate of 11%.

[36] Corresponds to the Bottom 3.
[37] Corresponds to the Bottom 3.

SUSTAINABILITY RANKING	COUNTRIES
1^{st}	Sweden
2^{nd}	Croatia
	Malta
	Netherlands
3^{rd}	Cyprus
	Finland
	Belgium
4^{th}	Latvia
	Estonia
	France

Table 6. Point System Results for Sectors in Sustainability-oriented analysis

In an overall results analysis, the final conclusion is that the Top countries in terms of **economic performance** are **Germany, Ireland, Lithuania and Romania**, and the Top country in terms of **sustainability performance** is **Sweden.**

Although Sweden is leading in sustainability, it does not appear on the top of the overall economic analysis, and none of the countries that has better economic performance is additionally leading on the sustainability front. For example, Germany, who leads the economic analysis cannot be found on the final overall sustainability analysis ranking.

Moreover, by looking to the sustainability's final ranking, it can be perceived that it is mainly constituted by smaller countries, i.e., that have less population, like Croatia, Malta, Cyprus, Latvia and Estonia, or by countries from Northern Europe, as

Sweden and Finland. There are only three countries – Netherlands, Belgium and France – who are more economically developed and situated in Central Europe.

In the same way, the final economic ranking can be grouped by different types of countries. Germany, Belgium, France and Italy belong to more developed economic regions, from Central/Southern Europe. Ireland and Sweden fit into Northern European countries, and finally, Greece, Lithuania, Romania, Bulgaria, Latvia and Estonia constitute smaller countries.

In terms of sectorial economic ranking, primary sectors are leading, such as "Food, beverage and tobacco" and "Agriculture", having more representativeness in the final outcome. Conversely, only three bio-based sectors are represented in the final ranking.

CONCLUSION

Bioeconomy is rapidly growing, demanding attention for its principles' implementation, especially since last decade. It is now, more than ever, a field that starts to gain momentum, since it promotes a better balance between society's growing needs and environmental conservation. Being an economic, social and political project, bioeconomy opens the possibility to guide economy towards a more efficiently sustainable field.

Although consensus on its definition and vision is far from being reached, it is evident that bioeconomy has common economic and sustainability goals with other related fields, such as bio-based economy, circular or green economy. Moreover, its multifaced characteristic provides it with a special property: to adapt to each country's needs, allowing for them to adjust bioeconomic goals to respond to their more urgent problems.

EU has a dedicated bioeconomic strategy and policy, including various programs to fight climate change. Although, and from what it was deduced by development of this work, it seems that those targets and goals for climate action are undervalued, meaning that it is not promising for the environment, and therefore, society, that EU is, by 2018, doing so well in the majority of their goals. What this actually means is that these goals are not as ambitious as they could be, even though EU is a leading region when it comes to promoting economic and environmental balance.

From the results achieved through interpretation of the dashboard constructed, it can be concluded that primary sectors still have high impact on bioeconomic results, considering, for example, that "Agriculture" is present in most indicators' Top 3. Consequently, this impacts the economic analysis, since more primary-industryintense countries will present better results in most economic indicators, as the case for employment.

Therefore, finishing this study, one should be able to point further improvements to the work developed, enhancing future results. There are three main recommendations which can be applied in the future, to improve analysis made.

Although current work was developed including all bioeconomy's sectors, nowadays it would prove equally important if a closer look to the bio-based share of bioeconomy was considered. As an example, Romania was at the top of employability analysis, albeit this result derived from agriculture's high relevance in this country's jobs. Even if important, improvements on bioeconomy's performance won't be enhanced or achieved by developments in primary sectors. Therefore, it would be beneficial if additional analysis was conducted and set out to focus on bio-based sectors. This can be achieved by modifying the dashboard's report, which with the help of filters or filtering directly the "Sector" dimension on the data model, could be instantly made. Additionally, as perceived by the analysis, weight of bio-based sectors over bioeconomy is starting to increase over time, proving necessity to reduce sectorial scope, limiting it to bio-based sectors.

Another future remark would be to improve the model made on Power BI, including prediction models that estimate future values, especially for all sustainability indicators. Since original data is available, in most cases, until 2019, due to delays in its treatment and publication, prediction models would enable to assess EU's sustainability performance by 2020. Moreover, this would allow to perceive if current pace is enough to reach more distant goals in time, such as 2030 targets. By doing this, politic and economic actors can foresee results and adapt their course of action in case of need, allowing adjustments in policy and strategy beforehand.

Finally, as a complement on the theoretical side, a deeper focus on top countries' strategies and policies should be made, understanding what distinguishes these countries and why they are thriving when compared to others, trying to perceive important key factors that make them leading Member States in European bioeconomy.

Technological advances, economic growth and development are, at this point of humanity, impossible to stop. The problem society is facing should not be one concerned with how to prevent further growth, but yet how to take advantage of technological/economical advances in order from society benefiting most from it, applying and putting these innovations at humanity's service. Therefore, the greater challenge should be in how society, namely politicians, leaders and organizations, perceive growth. A better combination between unprecedent growth and finite resources has mandatorily to be a priority, in order to restore world's balance. As Christian Patermann affirms in the initial transcription of this work, let us, all together, surpass the difficulties that today's world faces, leaving aside criticism and unconstructive discussion, in order to rapidly improve society's position in major economic and environmental challenges, with the help of bioeconomy.

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APPENDIX

APPENDIX A. TABLES' PREVIEWS FROM POWER BI

	Year	Country	Country's Code	Indicator	Sector	Unit	Value
1	2008	Austria	AT	Labour Productivity	Agriculture	1000 EUR per person	16.1534584150098
2	2008	Austria	AT	Labour Productivity	Bio-based chemicals, pharma...	1000 EUR per person	122.54473763230766
3	2008	Austria	AT	Labour Productivity	Bio-based electricity	1000 EUR per person	254.09120663320965
4	2008	Austria	AT	Labour Productivity	Bio-based textiles	1000 EUR per person	42.10433008147793
5	2008	Austria	AT	Labour Productivity	All Bioeconomy	1000 EUR per person	38.00027561301475
6	2008	Austria	AT	Labour Productivity	Fishing and Aquaculture	1000 EUR per person	33.333333333333336
7	2008	Austria	AT	Labour Productivity	Food, beverage and tobacco	1000 EUR per person	55.40858734672346
8	2008	Austria	AT	Labour Productivity	Forestry	1000 EUR per person	40.97379741885022
9	2008	Austria	AT	Labour Productivity	Liquid biofuels	1000 EUR per person	105.95720069404278
10	2008	Austria	AT	Labour Productivity	Paper	1000 EUR per person	86.65735952886003
11	2008	Austria	AT	Labour Productivity	Wood products and furniture	1000 EUR per person	51.68881606310774
12	2008	Austria	AT	Employed People	Agriculture	Number of people employed	178550
13	2008	Austria	AT	Employed People	Bio-based chemicals, pharma...	Number of people employed	8213.516076338303
14	2008	Austria	AT	Employed People	Bio-based electricity	Number of people employed	570.295946429519
15	2008	Austria	AT	Employed People	Bio-based textiles	Number of people employed	10088.136515372391
16	2008	Austria	AT	Employed People	All Bioeconomy	Number of people employed	368647.1776793231
17	2008	Austria	AT	Employed People	Fishing and Aquaculture	Number of people employed	330
18	2008	Austria	AT	Employed People	Food, beverage and tobacco	Number of people employed	77719
19	2008	Austria	AT	Employed People	Forestry	Number of people employed	25570
20	2008	Austria	AT	Employed People	Liquid biofuels	Number of people employed	807.8765329273007
21	2008	Austria	AT	Employed People	Paper	Number of people employed	18444.625
22	2008	Austria	AT	Employed People	All Economy	Number of people employed	3994100

Figure 108. Preview of table "Dataset_Bioeconomics"

	Year	Country	Country's Code	Indicator	Sector	Unit	Growth Rate
1	2018	Austria	AT	Labour Productivity	Agriculture	Percentage	0,056949224
2	2018	Austria	AT	Labour Productivity	Bio-based chemicals, pharma...	Percentage	-0,001073021
3	2018	Austria	AT	Labour Productivity	Bio-based electricity	Percentage	0
4	2018	Austria	AT	Labour Productivity	Bio-based textiles	Percentage	0,005312364
5	2018	Austria	AT	Labour Productivity	All Bioeconomy	Percentage	0,024374013
6	2018	Austria	AT	Labour Productivity	Fishing and Aquaculture	Percentage	-0,063116371
7	2018	Austria	AT	Labour Productivity	Food, beverage and tobacco	Percentage	-0,024913612
8	2018	Austria	AT	Labour Productivity	Forestry	Percentage	0,049844381
9	2018	Austria	AT	Labour Productivity	Liquid biofuels	Percentage	0
10	2018	Austria	AT	Labour Productivity	Paper	Percentage	0
11	2018	Austria	AT	Labour Productivity	Wood products and furniture	Percentage	0,001644442
12	2018	Austria	AT	Employed People	Agriculture	Percentage	-0,067608546
13	2018	Austria	AT	Employed People	Bio-based chemicals, pharma...	Percentage	-0,003118052
14	2018	Austria	AT	Employed People	Bio-based electricity	Percentage	0,041666401
15	2018	Austria	AT	Employed People	Bio-based textiles	Percentage	0,014834728
16	2018	Austria	AT	Employed People	All Bioeconomy	Percentage	-0,02560098
17	2018	Austria	AT	Employed People	Fishing and Aquaculture	Percentage	0,114285714
18	2018	Austria	AT	Employed People	Food, beverage and tobacco	Percentage	0,025550159
19	2018	Austria	AT	Employed People	Forestry	Percentage	-0,037660611
20	2018	Austria	AT	Employed People	Liquid biofuels	Percentage	0,066193457
21	2018	Austria	AT	Employed People	Paper	Percentage	0
22	2018	Austria	AT	Employed People	All Economy	Percentage	0,013754577

Figure 109. Preview of the final outlook of table "GrowthRate_Bioeconomics"

	Year	Country	Country's Code	Indicator	Sector	Unit	Weight on Bioecono...	Weight on Economy
1	2008	Austria	AT	Labour Productivity	Agriculture	Percentage	0,425087928	null
2	2008	Austria	AT	Labour Productivity	Bio-based chemicals, pharma...	Percentage	3,224838127	null
3	2008	Austria	AT	Labour Productivity	Bio-based electricity	Percentage	6,686562203	null
4	2008	Austria	AT	Labour Productivity	Bio-based textiles	Percentage	1,10800065	null
5	2008	Austria	AT	Labour Productivity	All Bioeconomy	Percentage	1	null
6	2008	Austria	AT	Labour Productivity	Fishing and Aquaculture	Percentage	0,87718662	null
7	2008	Austria	AT	Labour Productivity	Food, beverage and tobacco	Percentage	1,458110144	null
8	2008	Austria	AT	Labour Productivity	Forestry	Percentage	1,078250006	null
9	2008	Austria	AT	Labour Productivity	Liquid biofuels	Percentage	2,788327163	null
10	2008	Austria	AT	Labour Productivity	Paper	Percentage	2,28044029	null
11	2008	Austria	AT	Labour Productivity	Wood products and furniture	Percentage	1,360222136	null
12	2008	Austria	AT	Employed People	Agriculture	Percentage	0,484338443	0,044703438
13	2008	Austria	AT	Employed People	Bio-based chemicals, pharma...	Percentage	0,022280155	0,002056412
14	2008	Austria	AT	Employed People	Bio-based electricity	Percentage	0,001546997	0,000142785
15	2008	Austria	AT	Employed People	Bio-based textiles	Percentage	0,027365289	0,00252576
16	2008	Austria	AT	Employed People	All Bioeconomy	Percentage	1	0,092297934
17	2008	Austria	AT	Employed People	Fishing and Aquaculture	Percentage	0,000895165	8,26219E-05
18	2008	Austria	AT	Employed People	Food, beverage and tobacco	Percentage	0,210822176	0,019458451
19	2008	Austria	AT	Employed People	Forestry	Percentage	0,069361714	0,006401943
20	2008	Austria	AT	Employed People	Liquid biofuels	Percentage	0,002191463	0,000202267
21	2008	Austria	AT	Employed People	Paper	Percentage	0,050033273	0,004617968
22	2008	Austria	AT	Employed People	All Economy	Percentage	0	1

Figure 110. Preview of the final outlook of table "WeightSector_Bioeconomics"

	Year	Country's Code	Indicator	Sector	Unit	Value
1	2008	AT	GDP	All Economy	Million EUR	293761.9
2	2009	AT	GDP	All Economy	Million EUR	288044.0
3	2010	AT	GDP	All Economy	Million EUR	295896.6
4	2011	AT	GDP	All Economy	Million EUR	310128.7
5	2012	AT	GDP	All Economy	Million EUR	318653.0
6	2013	AT	GDP	All Economy	Million EUR	323910.2
7	2014	AT	GDP	All Economy	Million EUR	333146.1
8	2015	AT	GDP	All Economy	Million EUR	344269.2
9	2016	AT	GDP	All Economy	Million EUR	357608.0
10	2017	AT	GDP	All Economy	Million EUR	369341.3
11	2018	AT	GDP	All Economy	Million EUR	385361.9
12	2008	BE	GDP	All Economy	Million EUR	351743.1
13	2009	BE	GDP	All Economy	Million EUR	346472.8
14	2010	BE	GDP	All Economy	Million EUR	363140.1
15	2011	BE	GDP	All Economy	Million EUR	375967.8
16	2012	BE	GDP	All Economy	Million EUR	386174.7
17	2013	BE	GDP	All Economy	Million EUR	392880.0
18	2014	BE	GDP	All Economy	Million EUR	403003.3
19	2015	BE	GDP	All Economy	Million EUR	416701.4
20	2016	BE	GDP	All Economy	Million EUR	430085.3
21	2017	BE	GDP	All Economy	Million EUR	444991.1
22	2018	BE	GDP	All Economy	Million EUR	460419.4

Figure 111. Preview of table "Dataset_GDP"

	Year	Country's Code	Indicator	Sector	Unit	Growth Rate
1	2018	AT	GDP	All Economy	Percentage	0,04337614
2	2018	BE	GDP	All Economy	Percentage	0,03467103
3	2018	BG	GDP	All Economy	Percentage	0,072288788
4	2018	CY	GDP	All Economy	Percentage	0,065233923
5	2018	CZ	GDP	All Economy	Percentage	0,086512384
6	2018	DE	GDP	All Economy	Percentage	0,029617836
7	2018	DK	GDP	All Economy	Percentage	0,025619708
8	2018	EE	GDP	All Economy	Percentage	0,087179401
9	2018	EL	GDP	All Economy	Percentage	0,014537806
10	2018	ES	GDP	All Economy	Percentage	0,036470612
11	2018	EU27	GDP	All Economy	Percentage	0,034292086
12	2018	FI	GDP	All Economy	Percentage	0,032213733

Figure 112. Preview of the final outlook of table "GrowthRate_GDP"

	Year	Country's Code	Indicator	Sector	Unit	Weight on GDP
1	2008	AT	Value Added	Agriculture	Percentage	0,009818155
2	2008	AT	Value Added	All Bioeconomy	Percentage	0,04768724
3	2008	AT	GDP	All Economy	Percentage	1
4	2008	AT	Value Added	Bio-based chemicals, pharma...	Percentage	0,003426323
5	2008	AT	Value Added	Bio-based electricity	Percentage	0,000493281
6	2008	AT	Value Added	Bio-based textiles	Percentage	0,001445913
7	2008	AT	Value Added	Fishing and Aquaculture	Percentage	3,74453E-05
8	2008	AT	Value Added	Food, beverage and tobacco	Percentage	0,014659151
9	2008	AT	Value Added	Forestry	Percentage	0,003566494
10	2008	AT	Value Added	Liquid biofuels	Percentage	0,000291394
11	2008	AT	Value Added	Paper	Percentage	0,005441014
12	2008	AT	Value Added	Wood products and furniture	Percentage	0,00850807
13	2008	BE	Value Added	Agriculture	Percentage	0,006729912
14	2008	BE	Value Added	All Bioeconomy	Percentage	0,039912414
15	2008	BE	GDP	All Economy	Percentage	1
16	2008	BE	Value Added	Bio-based chemicals, pharma...	Percentage	0,00562997
17	2008	BE	Value Added	Bio-based electricity	Percentage	0,000316613
18	2008	BE	Value Added	Bio-based textiles	Percentage	0,001367526
19	2008	BE	Value Added	Fishing and Aquaculture	Percentage	0,000117984
20	2008	BE	Value Added	Food, beverage and tobacco	Percentage	0,019098598
21	2008	BE	Value Added	Forestry	Percentage	0,000275485
22	2008	BE	Value Added	Liquid biofuels	Percentage	0,000347634

Figure 113. Preview of the final outlook of table "Weight_VA_GDP"

	Year	Country's Code	Indicator	Sector	Unit	Value
1	2008	AT	Greenhouse gases	All Economy	Kilograms (per capita)	8081.55264
2	2009	AT	Greenhouse gases	All Economy	Kilograms (per capita)	7310.47639
3	2010	AT	Greenhouse gases	All Economy	Kilograms (per capita)	7702.35512
4	2011	AT	Greenhouse gases	All Economy	Kilograms (per capita)	7683.11283
5	2012	AT	Greenhouse gases	All Economy	Kilograms (per capita)	7312.5689
6	2013	AT	Greenhouse gases	All Economy	Kilograms (per capita)	7146.43741
7	2014	AT	Greenhouse gases	All Economy	Kilograms (per capita)	6869.27036
8	2015	AT	Greenhouse gases	All Economy	Kilograms (per capita)	6871.836
9	2016	AT	Greenhouse gases	All Economy	Kilograms (per capita)	6763.31723
10	2017	AT	Greenhouse gases	All Economy	Kilograms (per capita)	7106.86052
11	2018	AT	Greenhouse gases	All Economy	Kilograms (per capita)	6793.21272
12	2008	BE	Greenhouse gases	All Economy	Kilograms (per capita)	10513.11431
13	2009	BE	Greenhouse gases	All Economy	Kilograms (per capita)	9403.50954
14	2010	BE	Greenhouse gases	All Economy	Kilograms (per capita)	9890.12852
15	2011	BE	Greenhouse gases	All Economy	Kilograms (per capita)	9112.44232
16	2012	BE	Greenhouse gases	All Economy	Kilograms (per capita)	8738.31981
17	2013	BE	Greenhouse gases	All Economy	Kilograms (per capita)	8470.4929
18	2014	BE	Greenhouse gases	All Economy	Kilograms (per capita)	8266.98877
19	2015	BE	Greenhouse gases	All Economy	Kilograms (per capita)	8572.66301
20	2016	BE	Greenhouse gases	All Economy	Kilograms (per capita)	8458.14981
21	2017	BE	Greenhouse gases	All Economy	Kilograms (per capita)	8386.41053
22	2018	BE	Greenhouse gases	All Economy	Kilograms (per capita)	8326.27742

Figure 114. Preview of table "Dataset_AirEmissions"

	Year	Country's Code	Indicator	Sector	Unit	Growth Rate
22	2008	DE	Greenhouse gases	All Economy	Percentage	0
23	2008	RO	Greenhouse gases	All Economy	Percentage	0
24	2008	EL	Greenhouse gases	All Economy	Percentage	0
25	2008	IT	Greenhouse gases	All Economy	Percentage	0
26	2008	NL	Greenhouse gases	All Economy	Percentage	0
27	2008	CZ	Greenhouse gases	All Economy	Percentage	0
28	2008	ES	Greenhouse gases	All Economy	Percentage	0
29	2009	DE	Greenhouse gases	All Economy	Percentage	-0,080380999
30	2009	BE	Greenhouse gases	All Economy	Percentage	-0,105544821
31	2009	BG	Greenhouse gases	All Economy	Percentage	-0,143633357
32	2009	EL	Greenhouse gases	All Economy	Percentage	-0,070942041
33	2009	FR	Greenhouse gases	All Economy	Percentage	-0,061881541
34	2009	DK	Greenhouse gases	All Economy	Percentage	-0,070878557

Figure 115. Preview of the final outlook of table "GrowthRate_AirEmissions"

	Year	Country's Code	Indicator	Value, base year 1990	Growth compared to 1990	2020 Target
1	2018	AT	Greenhouse Gases	102,66	0,0266	-0,2
2	2018	BE	Greenhouse Gases	82,67	-0,1733	-0,2
3	2018	BG	Greenhouse Gases	57,16	-0,4284	-0,2
4	2018	CY	Greenhouse Gases	153,81	0,5381	-0,2
5	2018	CZ	Greenhouse Gases	64,82	-0,3518	-0,2
6	2018	DE	Greenhouse Gases	70,44	-0,2956	-0,2
7	2018	DK	Greenhouse Gases	70,69	-0,2931	-0,2
8	2018	EE	Greenhouse Gases	49,98	-0,5002	-0,2
9	2018	EL	Greenhouse Gases	90,84	-0,0916	-0,2
10	2018	ES	Greenhouse Gases	119,74	0,1974	-0,2
11	2018	EU27	Greenhouse Gases	79,26	-0,2074	-0,2
12	2018	FI	Greenhouse Gases	81,41	-0,1859	-0,2

Figure 116. Preview of table "2020Target_AirEmissions"

	Year	Country's Code	Indicator	Sector	Unit	Value	2020 Target
1	2008	AT	Share of Renewable Energy i...	All Economy	Percentage	0,2879	0,34
2	2009	AT	Share of Renewable Energy i...	All Economy	Percentage	0,31041	0,34
3	2010	AT	Share of Renewable Energy i...	All Economy	Percentage	0,31207	0,34
4	2011	AT	Share of Renewable Energy i...	All Economy	Percentage	0,31553	0,34
5	2012	AT	Share of Renewable Energy i...	All Economy	Percentage	0,32736	0,34
6	2013	AT	Share of Renewable Energy i...	All Economy	Percentage	0,32666	0,34
7	2014	AT	Share of Renewable Energy i...	All Economy	Percentage	0,33553	0,34
8	2015	AT	Share of Renewable Energy i...	All Economy	Percentage	0,33502	0,34
9	2016	AT	Share of Renewable Energy i...	All Economy	Percentage	0,33374	0,34
10	2017	AT	Share of Renewable Energy i...	All Economy	Percentage	0,33141	0,34
11	2018	AT	Share of Renewable Energy i...	All Economy	Percentage	0,33806	0,34
12	2008	BE	Share of Renewable Energy i...	All Economy	Percentage	0,0359	0,13
13	2009	BE	Share of Renewable Energy i...	All Economy	Percentage	0,04715	0,13
14	2010	BE	Share of Renewable Energy i...	All Economy	Percentage	0,06002	0,13
15	2011	BE	Share of Renewable Energy i...	All Economy	Percentage	0,06275	0,13
16	2012	BE	Share of Renewable Energy i...	All Economy	Percentage	0,07089	0,13
17	2013	BE	Share of Renewable Energy i...	All Economy	Percentage	0,0765	0,13
18	2014	BE	Share of Renewable Energy i...	All Economy	Percentage	0,08043	0,13
19	2015	BE	Share of Renewable Energy i...	All Economy	Percentage	0,08026	0,13
20	2016	BE	Share of Renewable Energy i...	All Economy	Percentage	0,08752	0,13
21	2017	BE	Share of Renewable Energy i...	All Economy	Percentage	0,09113	0,13
22	2018	BE	Share of Renewable Energy i...	All Economy	Percentage	0,09478	0,13

Figure 117. Preview of table “Dataset_ShareOfRenewable”

	Year	Country's Code	Indicator	Sector	Unit	Growth Rate
20	2008	ES	Share of Renewable Energy i...	All Economy	Percentage	0
21	2008	CZ	Share of Renewable Energy i...	All Economy	Percentage	0
22	2008	DK	Share of Renewable Energy i...	All Economy	Percentage	0
23	2008	EU27	Share of Renewable Energy i...	All Economy	Percentage	0
24	2008	HR	Share of Renewable Energy i...	All Economy	Percentage	0
25	2008	HU	Share of Renewable Energy i...	All Economy	Percentage	0
26	2008	RO	Share of Renewable Energy i...	All Economy	Percentage	0
27	2008	SK	Share of Renewable Energy i...	All Economy	Percentage	0
28	2008	CY	Share of Renewable Energy i...	All Economy	Percentage	0
29	2009	HR	Share of Renewable Energy i...	All Economy	Percentage	0,073228418
30	2009	IE	Share of Renewable Energy i...	All Economy	Percentage	0,313799149
31	2009	LU	Share of Renewable Energy i...	All Economy	Percentage	0,042719829
32	2009	BE	Share of Renewable Energy i...	All Economy	Percentage	0,313370474
33	2009	PT	Share of Renewable Energy i...	All Economy	Percentage	0,064402198
34	2009	EU27	Share of Renewable Energy i...	All Economy	Percentage	0,103511426

Figure 118. Preview of the final outlook of table "GrowthRate_ShareOfRenewables"

	Year	Country's Code	Indicator	Sector	Unit	Value	2020 Target
1	2008	AT	Final Energy Consumption	All Economy	Million tonnes of oil equivalent	27.75	1086
2	2009	AT	Final Energy Consumption	All Economy	Million tonnes of oil equivalent	26.40	1086
3	2010	AT	Final Energy Consumption	All Economy	Million tonnes of oil equivalent	28.02	1086
4	2011	AT	Final Energy Consumption	All Economy	Million tonnes of oil equivalent	27.18	1086
5	2012	AT	Final Energy Consumption	All Economy	Million tonnes of oil equivalent	27.22	1086
6	2013	AT	Final Energy Consumption	All Economy	Million tonnes of oil equivalent	27.87	1086
7	2014	AT	Final Energy Consumption	All Economy	Million tonnes of oil equivalent	26.79	1086
8	2015	AT	Final Energy Consumption	All Economy	Million tonnes of oil equivalent	27.50	1086
9	2016	AT	Final Energy Consumption	All Economy	Million tonnes of oil equivalent	28.07	1086
10	2017	AT	Final Energy Consumption	All Economy	Million tonnes of oil equivalent	28.53	1086
11	2018	AT	Final Energy Consumption	All Economy	Million tonnes of oil equivalent	27.83	1086
12	2008	BE	Final Energy Consumption	All Economy	Million tonnes of oil equivalent	37.00	1086
13	2009	BE	Final Energy Consumption	All Economy	Million tonnes of oil equivalent	34.82	1086
14	2010	BE	Final Energy Consumption	All Economy	Million tonnes of oil equivalent	37.94	1086
15	2011	BE	Final Energy Consumption	All Economy	Million tonnes of oil equivalent	35.21	1086
16	2012	BE	Final Energy Consumption	All Economy	Million tonnes of oil equivalent	35.36	1086
17	2013	BE	Final Energy Consumption	All Economy	Million tonnes of oil equivalent	36.55	1086
18	2014	BE	Final Energy Consumption	All Economy	Million tonnes of oil equivalent	34.23	1086
19	2015	BE	Final Energy Consumption	All Economy	Million tonnes of oil equivalent	35.90	1086
20	2016	BE	Final Energy Consumption	All Economy	Million tonnes of oil equivalent	36.39	1086
21	2017	BE	Final Energy Consumption	All Economy	Million tonnes of oil equivalent	36.09	1086
22	2018	BE	Final Energy Consumption	All Economy	Million tonnes of oil equivalent	36.37	1086

Figure 119. Preview of table "Dataset_EnergyEfficiency"

	Year	Country's Code	Indicator	Sector	Unit	Growth Rate
18	2008	AT	Final Energy Consumption	All Economy	Percentage	0
19	2008	BE	Final Energy Consumption	All Economy	Percentage	0
20	2008	ES	Final Energy Consumption	All Economy	Percentage	0
21	2008	CZ	Final Energy Consumption	All Economy	Percentage	0
22	2008	DK	Final Energy Consumption	All Economy	Percentage	0
23	2008	EU27	Final Energy Consumption	All Economy	Percentage	0
24	2008	HR	Final Energy Consumption	All Economy	Percentage	0
25	2008	HU	Final Energy Consumption	All Economy	Percentage	0
26	2008	RO	Final Energy Consumption	All Economy	Percentage	0
27	2008	SK	Final Energy Consumption	All Economy	Percentage	0
28	2008	CY	Final Energy Consumption	All Economy	Percentage	0
29	2009	HR	Final Energy Consumption	All Economy	Percentage	-0,02972973
30	2009	IE	Final Energy Consumption	All Economy	Percentage	-0,105542901
31	2009	LU	Final Energy Consumption	All Economy	Percentage	-0,068493151
32	2009	BE	Final Energy Consumption	All Economy	Percentage	-0,058918919
33	2009	PT	Final Energy Consumption	All Economy	Percentage	-0,011382114
34	2009	EU27	Final Energy Consumption	All Economy	Percentage	-0,05406657

Figure 120. Preview of the final outlook of table "GrowthRate_EnergyEfficiency"

	Year	Country's Code	Indicator	Sector	Unit	Value
1	2010	AT	Circularity Rate	All Economy	Percentage	0,066
2	2011	AT	Circularity Rate	All Economy	Percentage	0,068
3	2012	AT	Circularity Rate	All Economy	Percentage	0,076
4	2013	AT	Circularity Rate	All Economy	Percentage	0,089
5	2014	AT	Circularity Rate	All Economy	Percentage	0,099
6	2015	AT	Circularity Rate	All Economy	Percentage	0,11
7	2016	AT	Circularity Rate	All Economy	Percentage	0,114
8	2017	AT	Circularity Rate	All Economy	Percentage	0,116
9	2018	AT	Circularity Rate	All Economy	Percentage	0,114
10	2010	BE	Circularity Rate	All Economy	Percentage	0,126
11	2011	BE	Circularity Rate	All Economy	Percentage	0,135
12	2012	BE	Circularity Rate	All Economy	Percentage	0,167
13	2013	BE	Circularity Rate	All Economy	Percentage	0,171
14	2014	BE	Circularity Rate	All Economy	Percentage	0,182
15	2015	BE	Circularity Rate	All Economy	Percentage	0,184
16	2016	BE	Circularity Rate	All Economy	Percentage	0,183
17	2017	BE	Circularity Rate	All Economy	Percentage	0,204
18	2018	BE	Circularity Rate	All Economy	Percentage	0,218
19	2010	BG	Circularity Rate	All Economy	Percentage	0,021
20	2011	BG	Circularity Rate	All Economy	Percentage	0,018
21	2012	BG	Circularity Rate	All Economy	Percentage	0,019
22	2013	BG	Circularity Rate	All Economy	Percentage	0,025

Figure 121. Preview of table "Dataset_CircularityRate"

	Year	Country's Code	Indicator	Sector	Unit	Growth Rate	EU27 Comparison
49	2011	EU27	Circularity Rate	All Economy	Percentage	-0,046728972	0,102
50	2011	EL	Circularity Rate	All Economy	Percentage	-0,185185185	0,102
51	2011	EE	Circularity Rate	All Economy	Percentage	0,604395604	0,102
52	2011	PT	Circularity Rate	All Economy	Percentage	-0,055555556	0,102
53	2011	CZ	Circularity Rate	All Economy	Percentage	0,018867925	0,102
54	2011	PL	Circularity Rate	All Economy	Percentage	-0,148148148	0,102
55	2011	CY	Circularity Rate	All Economy	Percentage	-0,05	0,102
56	2011	DE	Circularity Rate	All Economy	Percentage	-0,054545455	0,102
57	2012	DK	Circularity Rate	All Economy	Percentage	-0,084507042	0,11
58	2012	CZ	Circularity Rate	All Economy	Percentage	0,166666667	0,11
59	2012	CY	Circularity Rate	All Economy	Percentage	0,052631579	0,11
60	2012	DE	Circularity Rate	All Economy	Percentage	0,028846154	0,11
61	2012	BG	Circularity Rate	All Economy	Percentage	0,055555556	0,11
62	2012	BE	Circularity Rate	All Economy	Percentage	0,237037037	0,11

Figure 122. Preview of the final outlook of table "GrowthRate_CircularityRate"

APPENDIX B. DASHBOARD'S QR CODE

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APPENDIX C. DASHBOARD'S PAGES VIEWS

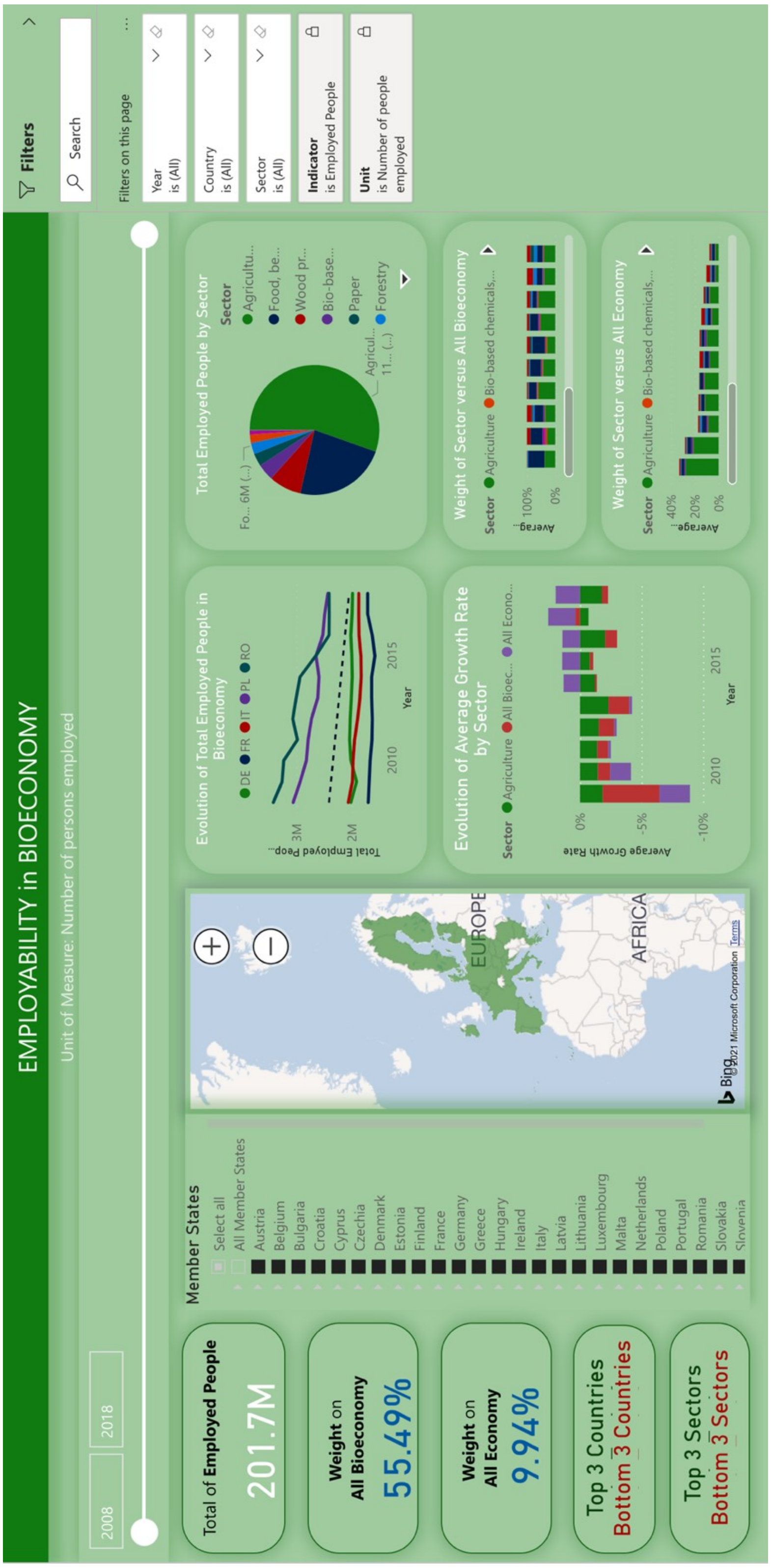

Figure 123. "Employed People" Page View

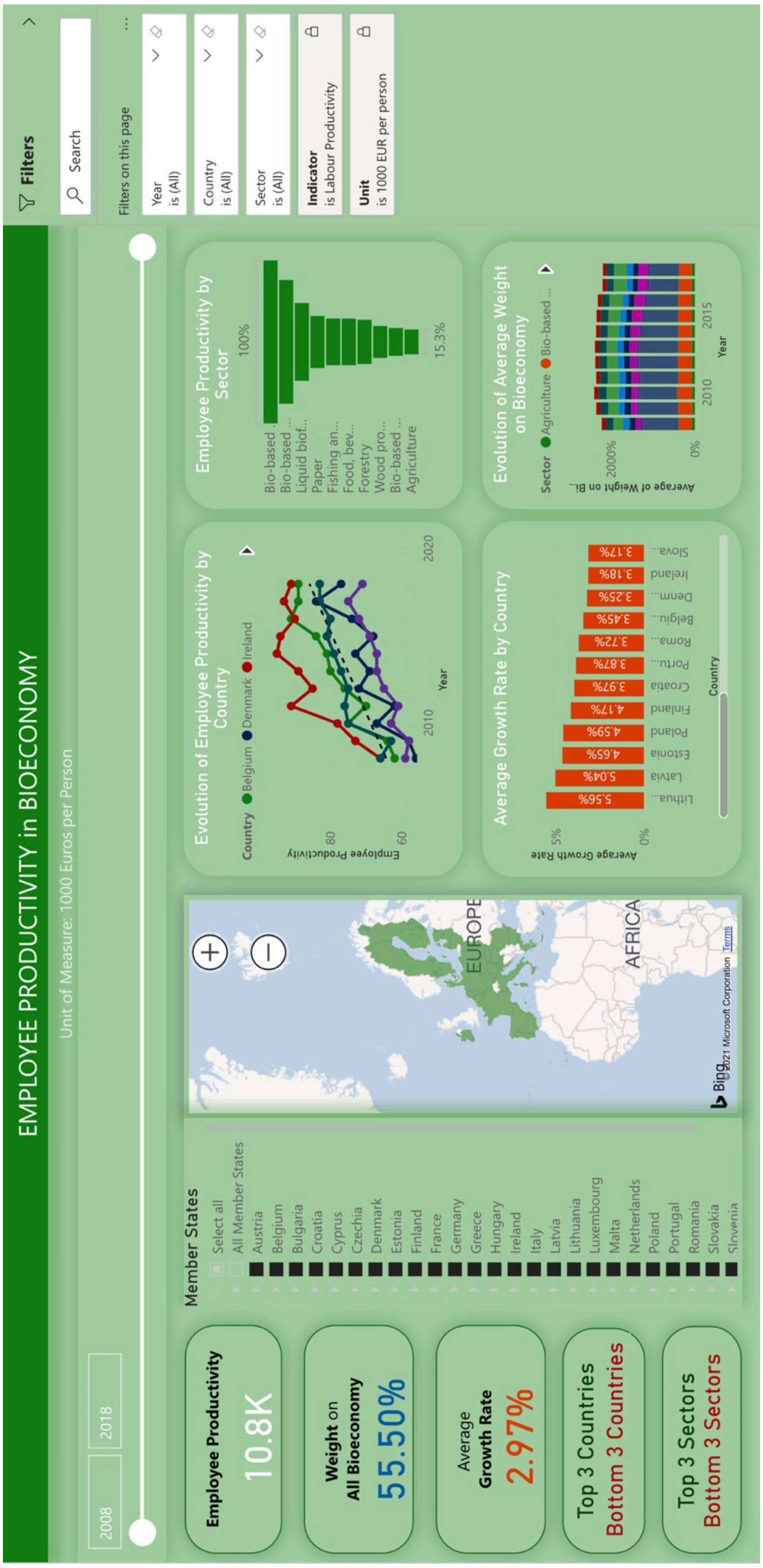

Figure 124. "Labour Productivity" Page View

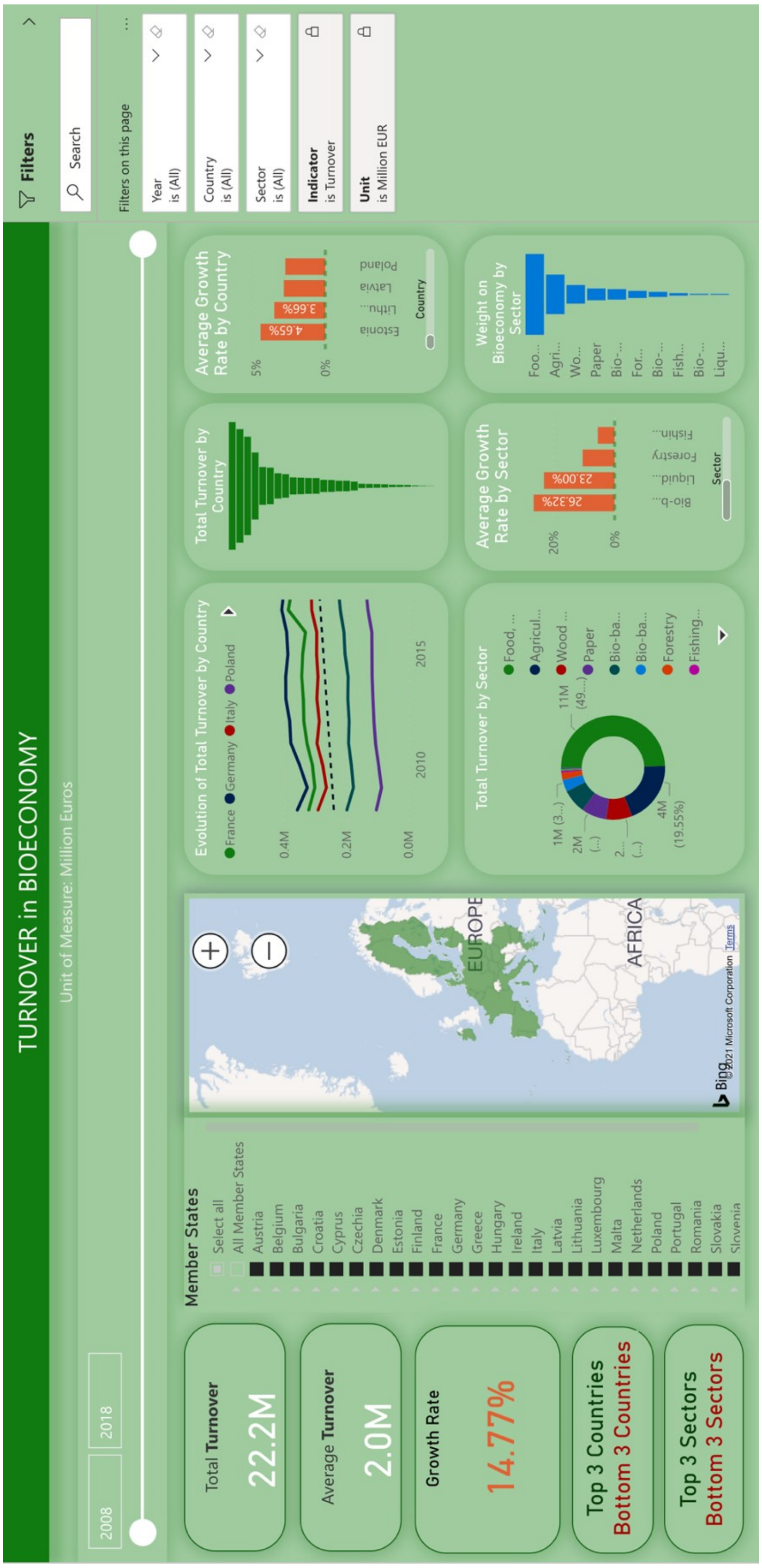

Figure 125. "Turnover" Page View

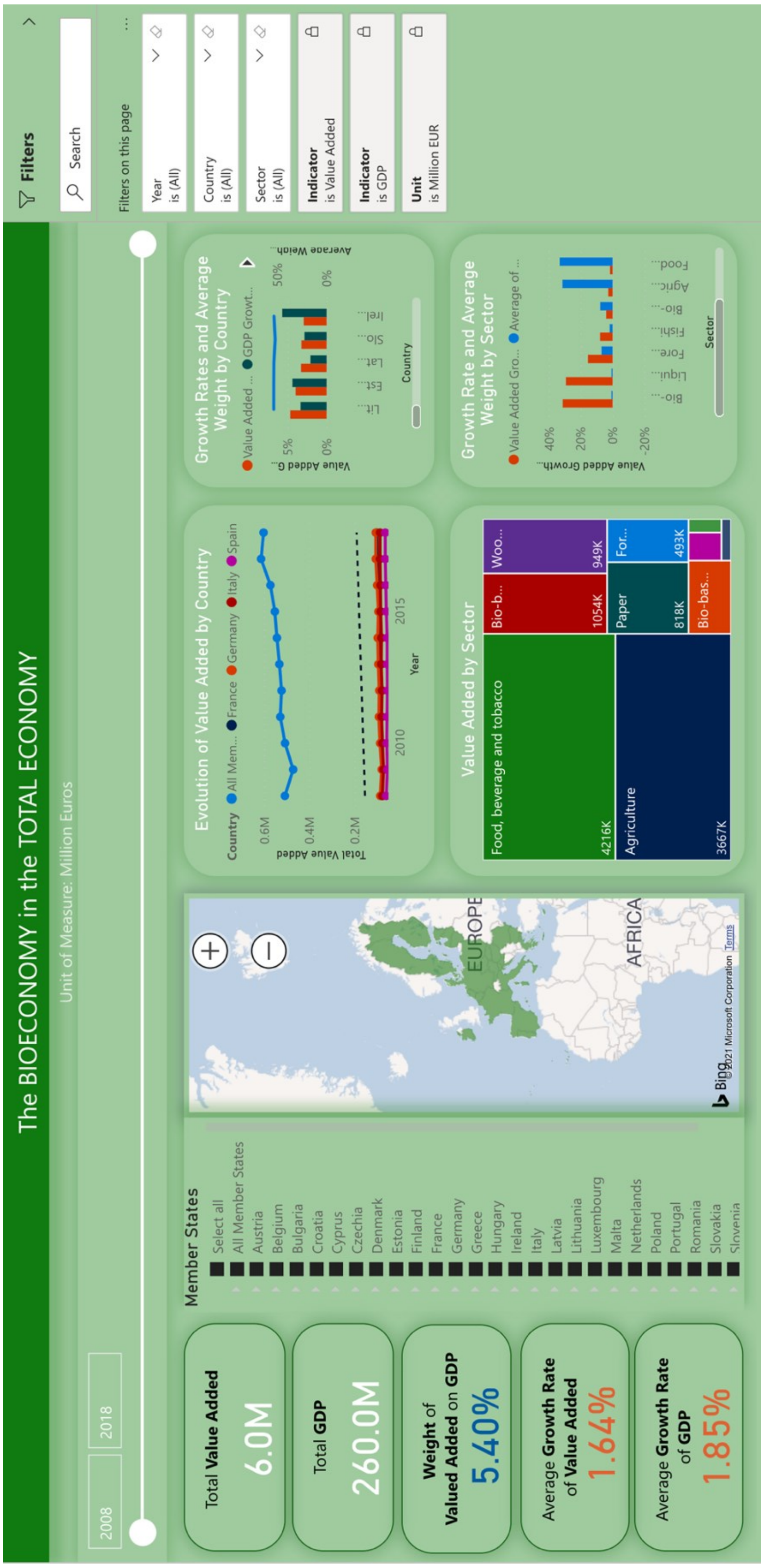

Figure 126. "Value Added and GDP" Page View

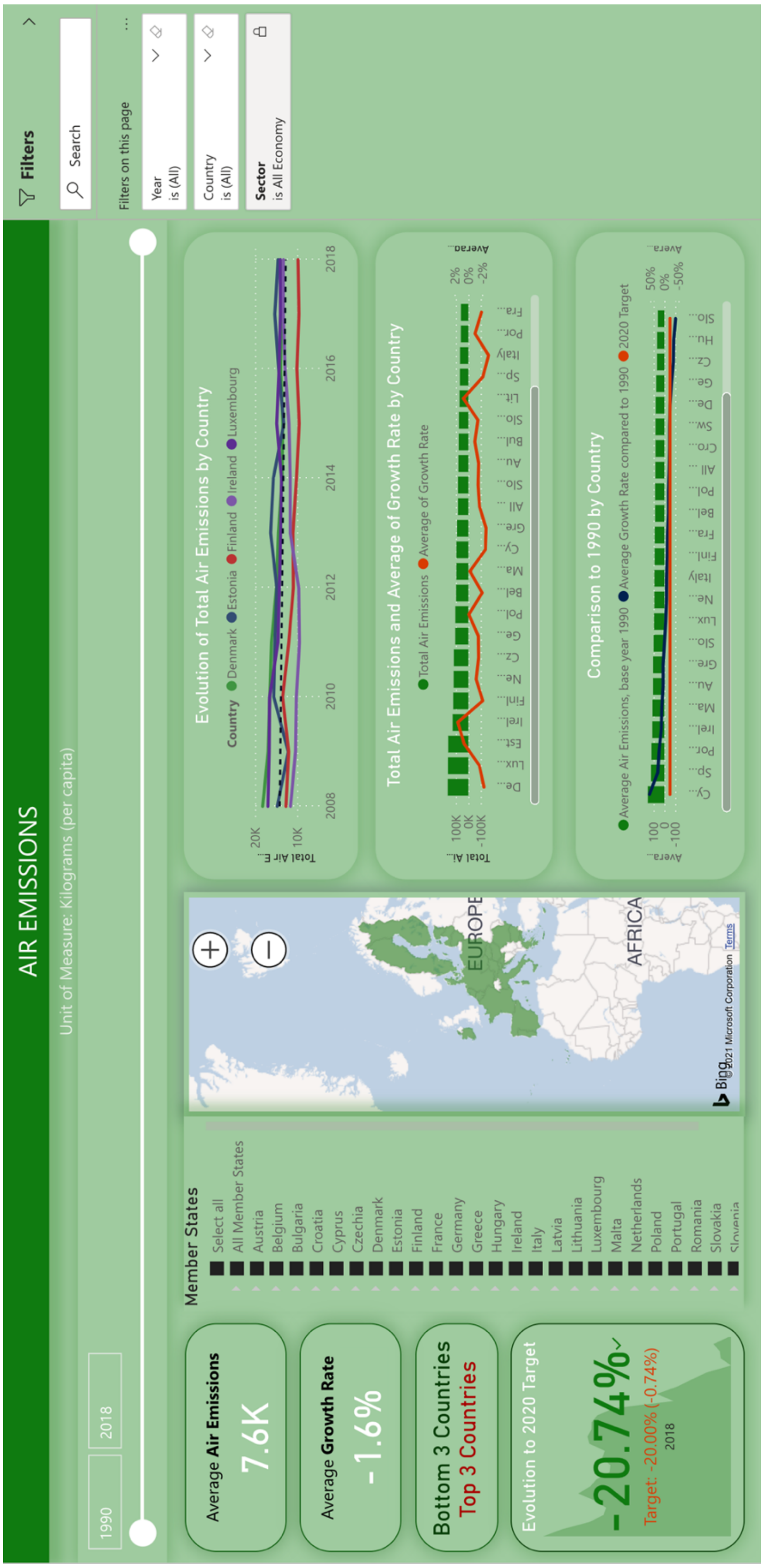

Figure 127. "Greenhouse Gases" Page View

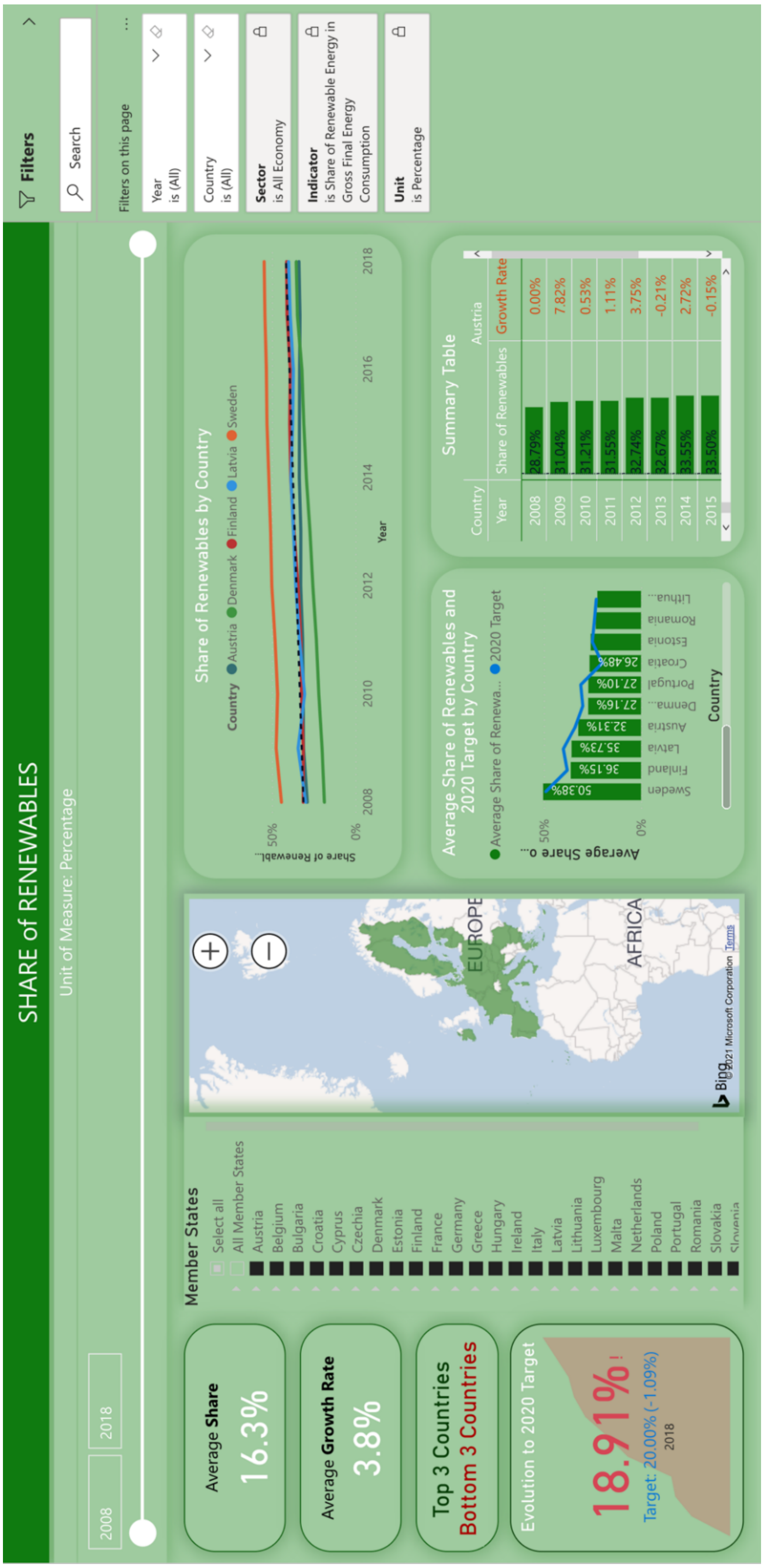

Figure 128. "Share of Renewable Energy" Page View

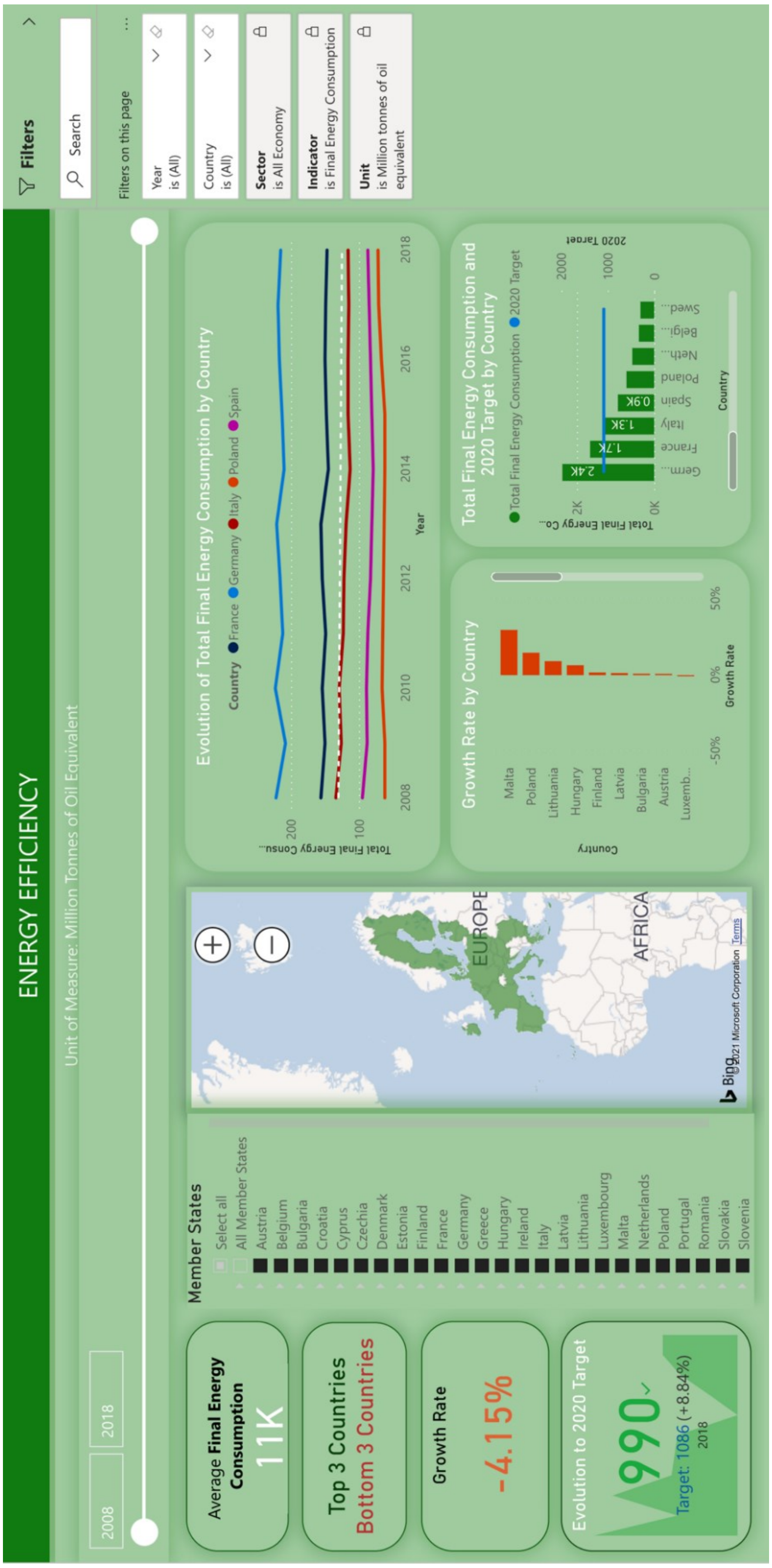

Figure 129. "Final Energy Consumption" Page View

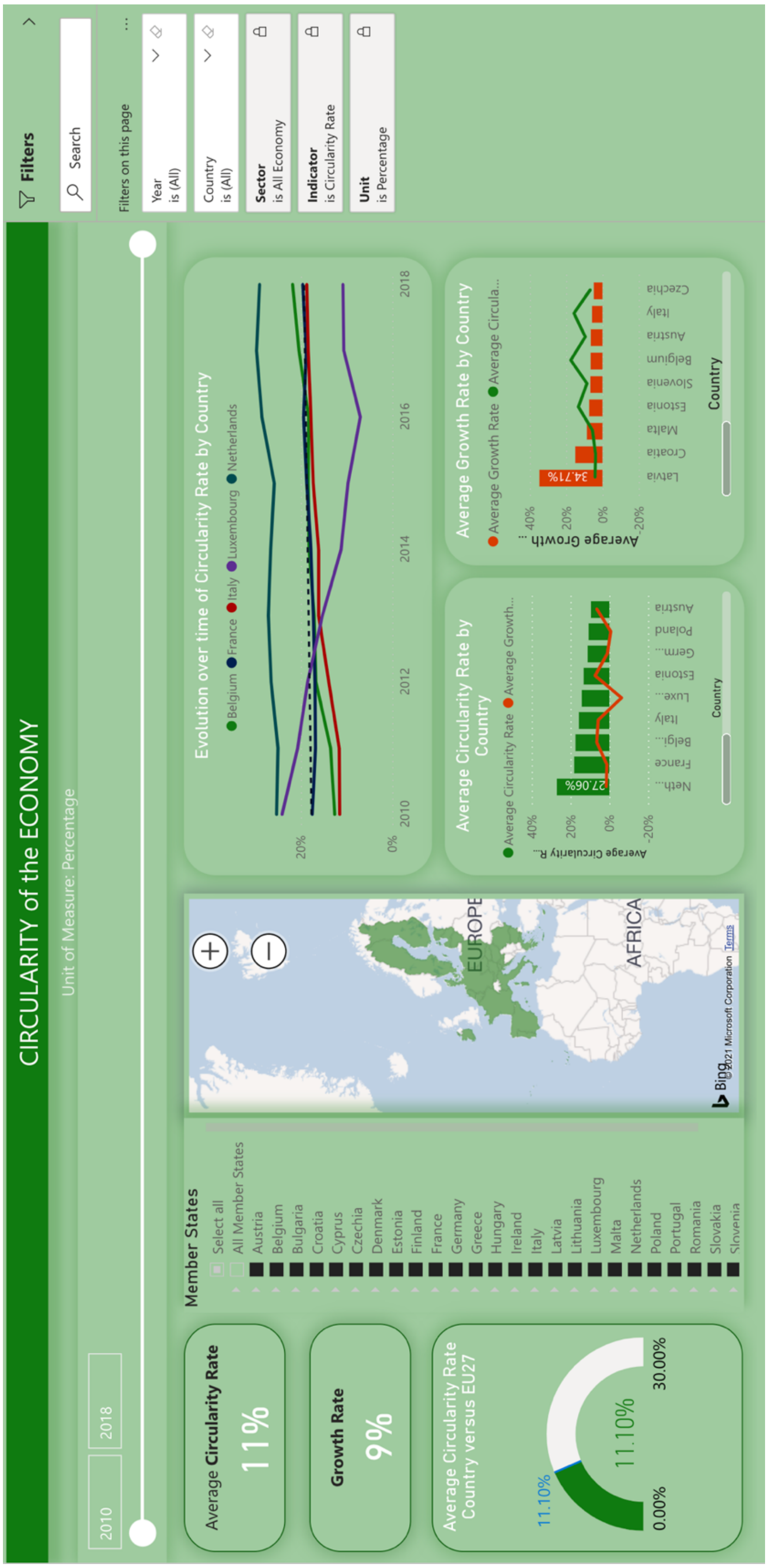

Figure 130. "Circularity Rate" Page View