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Circular Bioeconomy: A comparison of structural Differences and Similarities between Germany and Italy

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Abstract

According to experts, our current economic system will require two planets to sustain itself. In the current global and European contexts, a new model of prosperity is required to accommodate the changing environment. A paradigm change is necessary, one that combines the foundation for human flourishing within the limits of the earth. This is why more and more nations decided to introduce bioeconomy and circular bioeconomy strategies in their policy frameworks. Every country needs their own specific measures due to the several differences, but they might share also some common features. This thesis investigates the differences and similarities between two countries belonging to the European Union, namely Germany and Italy, through a systematic literature review according to the PRISMA framework.

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List of Abbreviations

BE	Bioeconomy
BIT	Bioeconomy In Italy
CBE	Circular Bioeconomy
CE	Circular Economy
CO_2	Carbon Dioxide
EEG	Erneuerbare Energiengesetz (Renewable Energy Sources Act)
EPD	Environmental Product Declaration
EU	European Union
G7	Group of Seven
GM	Genetically Modified
ICTs	Information and Communication Technologies
KBBE	Knowledge-Based Bioeconomy
MLP	Multi-Level Perspective
NRRP	National Recovery and Resilience Plan
OFMSW	Organic Fraction of the Municipal Solid Waste
PRISMA	Preferred Reporting Items for Systematic Reviews and Meta-Analyses
Ps	Prosperity, People, Planet, Peace and Partnership
R&D	Research and Development
RD&D	Research, Development and Demonstration
SDG	Sustainable Development Goal
SME	Small and Medium-scale Enterprise
SWOT	Strengths, Weaknesses, Opportunities, Threats
UN	United Nations

1. Introduction

1.1 Problem statement

Human history is witnessing the emerging of a single, tightly coupled socio-ecological system of global proportions. Currently, the world face unprecedented challenges that will only intensify in the future. In the last two hundred years, we have gone through an industrial era based on a fossil-fueled and linear economy. Over these years, the society changed dramatically, since the industrial era's outputs have improved economic, technological and social conditions. However, as a result of this impressive economic growth, the environment has also experienced an unprecedented level of degradation. According to scientists, in two decades our present economic system will need two planets to sustain itself. In today's global and European contexts, we need a new model of prosperity to fit the new environment. It will be necessary for policies as well as production and consumption habits to change. A shift in the economic paradigm is required, one that incorporates the basis for human prosperity within the planetary boundaries (Hetemäki et al., 2017).

According to Rockström et al. (2009), as humans have advanced toward the end of the industrial revolution (the Anthropocene), many key Earth System processes have drifted outside the Holocene range of variability. For this reason, the scientific community has warned of planetary risks associated with climate change and stratospheric ozone crossing thresholds so far. To avoid deleterious or even catastrophic environmental change on a continental or global scale, humanity must respect certain non-negotiable planetary preconditions. Rockström et al. (2009) identified nine planetary boundaries: climate change, ocean acidification, stratospheric ozone, global Phosphorus and Nitrogen cycles, Atmospheric Aerosol Loading, Freshwater Use, Land Use Change, Biodiversity Loss, and Chemical Pollution. In 2009, when Rockström et al. (2009) made this research, humanity had already transgressed at least three boundaries, but according to newer researchers, such as Steffen et al. (2015), the number of boundaries trespassed has increased to four. This situation might be further aggravated by the expected population growth. At present, the global population is growing by 83 million, and it is expected to reach 8.5 billion people in 2030 (Hetemäki et al., 2017).

Toward ending poverty, protecting the planet, and promoting prosperity, the Paris Agreement on climate change, the 2030 Agenda for Sustainable Development and its Sustainable Development Goals (SDGs), were endorsed (Hetemäki et al., 2017).

According to Sachs et al. (2019), they demand profound changes in every country, which may require steps from governments, civil society, science, and business. The SDGs direct their attention on targets for Prosperity, People, Planet, Peace, and Partnership, known as the five Ps. By the middle of the century, countries participating in the Paris Agreement are required to decrease their greenhouse-gas emissions to zero (Sachs et al., 2019). The SDGs outcomes, and those of the Paris Agreement, have been viewed by various authors as interdependent with complex interconnections between humans, technical systems, and natural systems (Sachs et al., 2019).

The realization of these goals can only be achieved and implemented through new ideas, and the critical question now is how to achieve these goals. (Hetemäki et al., 2017). It is clear that getting to these ambitious global objectives will not be achievable through business as usual. Hetemäki et al. (2017) argue that it will be necessary to embrace a circular bioeconomy as part of the solution. Already implemented bioeconomy strategies have proven the need to promote the use of renewable biomass to replace fossil-based raw materials and products in order to build a more sustainable society. Always according to Hetemäki et al. (2017), an economic system based on a bioeconomy contributes to overall economic sustainability and involves a wide range of industries and services, such as clothing, housing, health services, medical services, and food production. A long-term strategy for decoupling economic expansion from environmental deterioration should involve a paradigm shift, from a fossil-based to a bio-based and circular one (Hetemäki et al., 2017).

In order for it to be successful, it must be sustainable economically, socially, and environmentally. The development of a long-term circular bioeconomy strategy demands a coherent policy framework that connects key sectors and policies. Rather than advancing it just as a separate sector of interest to mainly rural areas, the bioeconomy must be mainstreamed within the rest of the economy. Especially the principles of circularity should be integrated to the bioeconomy. Indeed, when combined together, they are more effective and make more sense for achieving social objectives than if they were pursued separately (Hetemäki et al., 2017).

As for Europe, in 2012, the European Commission laid the foundation for the development of bioeconomy strategies by formulating its strategy “Innovating for Sustainable Growth: A Bioeconomy in Europe” (European Commission, 2012).

The objective of the bio-economy strategy and its action plan is to create a more sustainable and innovative society, one that combines the use of resources for industrial uses with safe access to food while safeguarding the environment (European Commission, 2012, p. 8). Consequently, they will influence policy plans in the bioeconomy sector by contributing to a more consistent policy environment and better collaboration and coordination between the policies of national states, the European Union, but also at a global level. (European Commission, 2012, p.8).

Despite major recent changes, many strategies require updating to reflect the latest developments. According to Micheaux Naudet & Marrazzo (2021), there are several bioeconomy drivers in European regions, that have massive effect on how the bioeconomy is perceived and promoted in those specific areas Always according to Micheaux Naudet & Marrazzo (2021), the emphasis on bioeconomy often stems from the utilization of biological resources or industrial expertise on the subject.

Additional elements that stimulate the bioeconomy are political measures to boost competitiveness and encourage economic growth, as well as the necessity to decrease a region's reliance on imported raw resources and energy (Micheaux Naudet & Marrazzo, 2021).

The development of the bioeconomy can also be part of an action directed at addressing environmental or territorial challenges. These could include the loss of rural populations or the effects of climate change on rural areas, in addition to addressing SDGs (Micheaux Naudet & Marrazzo, 2021). However, always according to Micheaux Naudet & Marrazzo (2021), the shift to a new paradigm of circular bioeconomy that ensures sustainability, does not come without difficulties, like ensuring food security, managing the competition between various uses of biomass, and at the same time make sure that this paradigm is an advantage for everyone.

1.2 Research objective and Research question

In addition to its established and emerging policy areas at global, national, and regional levels, the bioeconomy embraces a wide array of policy areas that share its objectives, yet can result in a fragmented and complex policy environment (European Commission, 2012). The starting point of the research and the overarching goal is to analyze the heterogeneous conditions concerning the concept of circular bioeconomy, within different regions of the European Union. Indeed, European countries do have some similarities but they do not necessarily share the same features.

Stegmann et al., 2020 cross-country comparison revealed that circular bio-economies within European regions do not develop in the same way at the same time. Again, according to Stegmann et al. 2020, for example, Germany's circular-bioeconomy indicators progressed the most on average in comparison to the rest of the EU-10. Circular bioeconomies in Slovakia, Poland, and Latvia were faster in comparison to the rest of the EU-10 as well. However, despite dedicated national bioeconomy strategies, the circular bioeconomies in Finland, Spain, The Netherlands, and Portugal improved the slowest.

However, according to Urmetzer & Pyka (2014), certain sectors with structural affinities enable for sectorial policy learning across national borders. This is especially true for the European Union countries that are embedded in common European institutions and share certain cultural features (Urmetzer & Pyka, 2014).

The first research objective of this thesis is to introduce the topics of bioeconomy. This research will point out the main elements characterizing the bioeconomy as well as the limitations associated to this topic and more precisely the fact that the Bioeconomy is often considered intrinsically sustainable and "circular" per se. However, Pfau et al., (2014) demonstrated that in light of the diversity of problems and conditions, it cannot be assumed that the bioeconomy is sustainably viable. After the introduction about the main topic, the thesis will focus on stating what the circular bioeconomy concept implies. According to Tan & Lamers (2021), circular economies aim to reduce dependence on the exploitation of (new) natural resources by extending the amount of time resources spend inside the techno-sphere via alternate use cycles. It is feasible to combine the circular economy with the bioeconomy, a term that encompasses economic activities connected to the creation, development, production, and use of biological products and processes for energy, materials, and chemicals (Tan & Lamers, 2021). As mentioned also by Stegmann et al. 2020, Circular Bioeconomy (CBE) is a relatively new term and there has been only limited attempt to define it and describe what it actually means, and the main elements which characterize it.

The last objective, which is related to the research question of the thesis, is the comparison of two countries of the European Union, namely Italy and Germany. These two countries have both developed their own bio-economy strategies in the last years. According to Hetemäki et al. (2017), Germany implemented its national bioeconomy strategy in 2014, adopting a more holistic approach which views the bioeconomy as a broad societal change involving a variety of industrial sectors, such as agriculture, forestry, horticulture, fisheries, zoology, food processing, the wood, paper, leather,

textile, chemical, and pharmaceutical industries, as well as parts of the energy sector (Priefer et al. 2017).

Italy officially adopted its national strategy called "BIT-Bioeconomy in Italy" three years later, in 2017. The Italian bioeconomy ranks third in Europe (330 billion euros in turnover, 2 million employees), making it a key component of the national economy; its fields of excellence are food and biobased products (Fava et al. 2021).

The ultimate research question of this thesis is: ***"What are the structural differences and similarities of the two countries (Italy and Germany) regarding the implementation of a circular bioeconomy's strategy?"***

1.3 Structure of the Thesis

The thesis is organized in six chapters. The first chapter corresponds to an introductory part, where the problem statement, the research objectives, and research question are specified.

The second chapter is dedicated to the theoretical background of the concept of bioeconomy. The aim of this chapter is to introduce the topic and explain it through definitions, main features and also limitations associated to the subject. Although the bioeconomy has been praised for its key role in addressing grand challenges, there has been little consensus about what a bioeconomy actually means (Bugge et al., 2016).

Therefore, it is essential for the acquaintance of the topic to start from the definition of main elements and characteristics. In the second chapter, the sub-topic of circular bioeconomy will be included too. Even though it might seem a repetition, the circular bioeconomy requires further in-depth analysis, since it combines both aspects of bioeconomy and circular economy. A bioeconomy can substitute fossil-based, non-renewable, and non-biodegradable materials with renewable or biodegradable ones (Bugge et al., 2016). Circularity alone cannot provide biobased materials with additional functionality, such as a longer lifespan, more durability, or less or no toxicity (Hetemäki & Hurmekoski, 2016). The circular economy and bioeconomy are complementary concepts that present many synergies when they are combined (Antikainen et al., 2017).

Furthermore, in this chapter, the main limitations of the bioeconomy and circular bioeconomy will be stated. According to Hetemäki et al. (2017), circular economies and bioeconomies do not automatically lead to sustainability; they must be made sustainable. Non sustainable bioeconomies may actually create a number of

sustainability conflicts. According to Tan & Lamers (2021), the growing demand for biofuels will lead to a rise in biomass production, which in turn will result in more competition between farmers for farmland. Moreover, a rivalry might rise for fresh water consumptions and even food vs fuel consumption (Tan & Lamers, 2021).

The third chapter concerns the methodology through which the research question of this thesis will be answered. The first section entails an overview about the research design, followed by a short description of why the chosen countries (Italy and Germany) are of interest. The last part of the chapter calls for the methods through which the research will be conducted, which is a systematic literature review according to the *"Preferred Reporting Items for Systematic Reviews and Meta-Analyses",* also called "PRISMA" scheme. More specifically, the two countries will be treated separately in order to find more materials related to the topic of circular bioeconomy.

The following chapter concerns the results of the literature review conducted in the third chapter. More specifically, the results from search string Germany and search string Italy will be carried out and explained.

The discussion of the results will be outlined in the fifth chapter. Specifically, the comparison of the two countries' review will be performed, which actually answers the research question. The sixth and last chapter corresponds to the conclusion of this thesis, after considering the comparison of the two countries results.

2. Theoretical background

2.1 Bioeconomy

2.1.1 Overview

As societal challenges such as climate change, resource scarcity, and environmental pollution escalate, sustainable systems of production and consumption are needed (McCormick & Kautto, 2013). The economic, agricultural, energy, and technological system of an economy based on biomass is dramatically different from one based on fossil fuels. An emerging bioeconomy, also called a bio-based economy or knowledge-based bioeconomy (or KBBE), is based on renewable biological resources, such as plants and animals, for materials, chemicals, and energy (McCormick & Kautto, 2013). Urmetzer & Pyka (2014) define the knowledge-based bioeconomy as "an economy that is based on the production and dissemination of new knowledge about renewable biological resources and their potential to be sustainably converted into food, feed, bio-based products and bioenergy with the aim to overcome the wastefulness of production and consumption in its full dependency on fossil resources" (p. 2).

From an environmental, social, and economics perspective, the design and execution of this kind of economy can address a number of sustainability concerns (McCormick & Kautto, 2013). Indeed, according to Urmetzer & Pyka (2014) the progress of the biotechnology industry is where the need for innovation is currently most evident. Nevertheless, the transition to a bioeconomy entails a major socio-economic shift and must involve various aspects, such as changes in technology, markets, user habits, policy, culture, and institutions in order to satisfy the demand of sustainability, which unavoidably is associated to the bioeconomy (Urmetzer & Pyka, 2014).

According to Viaggi (2018) a growing emphasis has been placed on the bioeconomy in global policy frameworks, indeed the bioeconomy has been affected by policy objectives of many countries (p.1). For instance, G7 countries are increasingly focusing on this strategy. As a result of its Bioeconomy strategy and Horizon 2020 Research Framework Program, the EU has played an important role in promoting the bioeconomy (Viaggi, 2018, p.1).

The origin of the bioeconomy can be traced back to the origins of humankind. Life has always relied on biological resources (Viaggi, 2018, p.8). The activities of hunting and

gathering living resources have always been necessary for human survival since the beginning of time. According to Viaggi (2018), in the last couple of centuries, the development of the fossil economy has dramatically altered this picture, first based on carbon and then on oil (p.8). Besides providing energy, fossil fuels have become a major source of materials (e.g.; plastic) for a variety of other applications (Viaggi, 2018, p. 9).

Moreover, Viaggi (2018) argues that, in the meantime science considerably progressed and this enhanced the creation of a basis for the biotechnology sector (p. 9). Viaggi (2018) states that for instance a key step was the complete understanding of the DNA structure, which provided many possibilities for genetically modified plants and animals. Moreover, as a way to address the shortage of fossil fuels and in connection with worries about climate change, the rise of bioenergy production has also significantly increased (p. 9).

Despite the general definition of the bioeconomy as replacing fossil resources with bio-based alternatives, three perspectives are emerging in the scientific literature: resource, biotechnology, and agroecology (D'Amato, Bartkowski, et al., 2020). It is evident that implementing one or more of these visions into strategies will require adjustments in land use with remarkable trade-offs (D'Amato, Bartkowski, et al., 2020).

Throughout Europe, national strategies differ depending on what biomass is available in each country, but they generally depend on diverse economic sectors and industries such as forestry, food, chemistry, pharmaceuticals, and textiles for their development. Meanwhile, the United States has focused heavily on biofuels and biotechnology in its strategy (D'Amato, Bartkowski, et al., 2020).

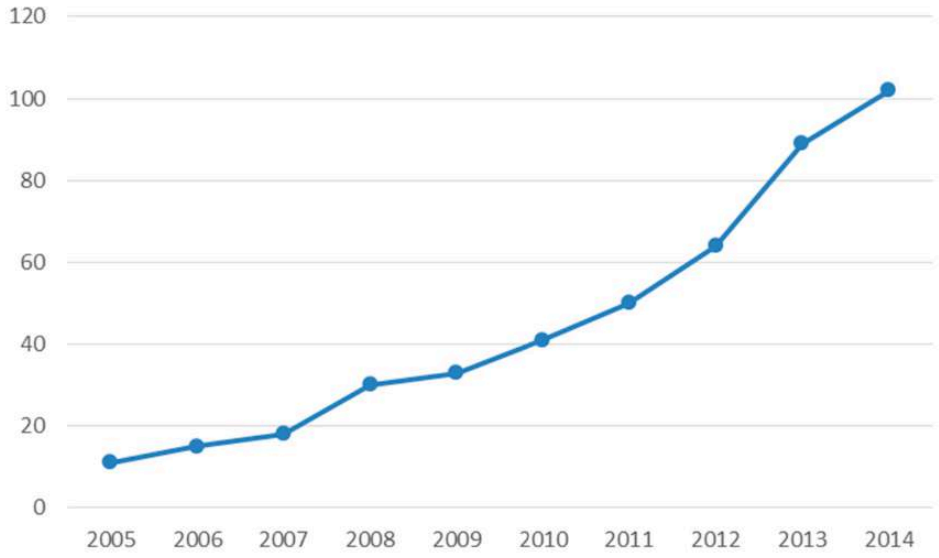
2.1.2 The rise of the concept

Over the past decade, research and policy debates have strengthened the concept of the bioeconomy globally.

Bugge et al. (2016) ***conducted a bibliometric analysis of the scientific literature on the bioeconomy. The bibliometric analysis relies on a literature retrieval based on indexed scientific articles from Web of Science's Core Collection. The authors have identified 453 papers for the period 2005-2014. A growing body of scientific literature has focused on this topic, as shown in***

Figure 1.

Figure 1. Number of papers per year (n= 453 papers)



Source: Bugge et al. (2016) p.3

It is interesting also to know where most researches about bioeconomy actually come from. The authors Bugge et al. (2016) also conducted a research analyzing 992 addresses listed in the database and they found two important information: the country of origin and the organization.

Table 1. Countries with most articles

Country	Number of papers
United States	116
Netherlands	45
United Kingdom	43
Germany	27
Canada	22
Belgium	21
Italy	20
People's Republic of China	19
Australia	18
Sweden	14

Source: personal adaptation based on Bugge et al. (2016) p.5

The majority of papers (73%) list the address of a university, 13% the address of a research institute, 6% the address of a company, 1% the address of an international organization, and 6% the address of a public agency.

For what concerns the country of origin, in Table 1 are reported the ten countries with most articles (Bugge et al., 2016). From the table it is possible to notice that Germany and Italy, the countries taken into consideration for the discussion about structural similarities and differences in this thesis are both in the list, meaning that it is a relevant and well researched topic in both countries.

According to Bonaiuti (2014) the term "bio-economics" was first coined by Zeman in the late 1960s to refer to an economic system that acknowledges the biological foundation of substantially all economic activities. Nonetheless, according to Birner (2017), the label "bio-economics" as it is currently used differs significantly from the term "bioeconomy," which originally referred to the use of biological knowledge for industrial and commercial goals. According to Birner (2017), although the concept of bioeconomy has been initially launched by scientists who were disturbed about industrial repercussions of advances in biotechnology, staff members of the European Commission consciously promoted the concept of bioeconomy, which has become a key policy concept in Europe. As the concept of bioeconomy developed in the EU, the term "knowledge-based" was included to make it a "knowledge-based bioeconomy". It was the innovation policy of the EU at the time that called for a "knowledge-based" approach. An economy based on knowledge requires investments in innovation and highly skilled labor, which is at the core of the knowledge-based economy concept. In recent years, the EU has been remarkably successful in promoting the concept of a knowledge-based bioeconomy (Birner, 2017).

According to Bugge et al. (2016), since the bioeconomy concept has a multitude of origins and a wide distribution across many scientific fields, it is necessary to examine the various approaches to understand this concept which have been presented in the academic literature. The bioeconomy can therefore be categorized into three ideal types, which will be listed below and are taken from Bugge et al. (2016), p.9.

1. A *bio-technology vision*: underlines the crucial value of biotechnology research, application, commercialization.
2. A *bio-resource vision*: that concentrates on the development of new value chains as well as the role of research, development, and demonstration (RD & D) connected to biological raw materials in industries including agricultural,

marine, forestry, and bioenergy. The bio-resource vision emphasizes the potentials in upgrading and converting the biological raw resources, whereas the bio-technology vision starts with the potential application of science.

3. A *bio-ecology vision*: draws attention to the importance of ecological processes that maximize energy and nutrients, promote biodiversity, and prevent monocultures. This vision places an emphasis on locally concentrated circular processes and systems as opposed to the previous two visions, which placed an emphasis on research and development in worldwide systems.

The technical perspective appears to significantly influence at least the first two visions, considering the importance of bioeconomy research in natural and engineering sciences.

Bugge et al. (2016) go more into detail with the description of various bioeconomy visions in the literature, and the respective explanation will follow.

The *bio-technology vision*'s focus is economic growth. Despite positive effects on climate change and the environment, according to this view economic growth takes precedence over sustainability. The increased economic growth will result from capitalization of biotechnologies, therefore investments in research and innovation represent an absolutely significant aspect. Innovation processes are similar to the linear model of innovation, in which research is the first step, followed by product development, production, and marketing. The production of biotechnology products will generate little or no waste, so waste will not be a major concern.

The *bio-resource vision* focuses both on economic growth and sustainability. Indeed, increasing bio-innovations is expected to produce both economic growth and environmental sustainability. Processing and converting bioresources into new products are the key component of the bioresource vision. In the bio-resource vision, waste management also occupies a prominent role. An important concern is reducing the production of organic waste throughout the value chain and the production of waste, which is impossible to prevent, is a critical element for the generation of renewable energy. Research and innovation activities also play a significant role in value creation under the bio-resource vision, similar to the bio-technology vision. Nevertheless, while the former emphasizes research across multiple fields in biotechnology, the latter emphasizes a narrower point of departure. Cross-sectoral collaborations and customer interaction are key drivers of innovation in the bio-resource vision, as opposed to the bio-technology vision. Moreover, as part of the bio-

resource vision, rural areas are emphasized as having a considerable potential for fostering development.

In the *bio-ecology vision*, sustainability is at the heart of its aims and objectives, whereas economic growth and employment creation are clearly less considered. The bio-ecology vision emphasizes promoting biodiversity, conserving ecosystems, providing ecosystem services, and preventing soil degradation as ways of creating value. In addition, bio-waste is only utilized to produce energy at the final stage of the cycle, once it has been recycled and reused. The bioecological view emphasizes the identification and use of organic practices that are eco-friendly and promote land use efficiency through reusing, recycling, and reusing waste. In contrast to the two other bioeconomy visions, the bioecology vision focuses on an ecological perspective rather than a technically focused one. However, it is not implied that research and innovation are not significant, but that each of them has a different focus. Similar to bio-resource visions, the bio-ecology vision stresses the chances for rural and peripheral areas (Bugge et al., 2016).

According to Birner (2017), a resource substitution perspective became more prominent in the twenty-first century, notwithstanding that biotechnology innovation has been long regarded as a potential for the bioeconomy.

The description of how these two perspectives have evolved over time is shown in Table 2, which is also based on Birner (2017) ‘s work. According to the author, a major motivating factor for the resource substitution perspective was the concept of "peak oil". According to this concept, oil extraction rates peaked at this time, and that extraction rates would decline after the peak, meanwhile oil prices would continue to rise. As oil prices rise, biomass offers additional comparative advantage as an energy and material source (Headey & Fan, 2008). However, this does not come without criticism. In fact, as stated also by Headey & Fan (2008), following the oil price crisis, food prices spiked because food crops were increasingly used for biofuel. According to the authors, there has been a significant increase in biofuel demand since 2003, and 25% of the USA corn crop was consumed by biofuels in 2007; two-thirds of global maize exports are from the United States. Furthermore, especially in the United States, biofuels have significantly reduced grain stocks (Headey & Fan, 2008). Therefore, biomass utilization as an energy source may cause tension between food availability and biofuel production. This is one of the critics directed toward bioeconomy which will be further discussed in paragraph 2.1.3 (Challenges and Limitations).

Table 2. Changing perspectives of the bioeconomy

Perspectives	Resource Substitution perspective (first decade of the 21st century)	Biotechnology innovation perspective (second decade of the 21st century)
Relation to fossil resources	"Peak oil", scarcity of fossil energy resources	New exploration technologies for oil; low volatile prices
Major driving forces	Expectations that prices will continue to increase	Paris climate agreements Advances in the biological sciences
Overall rationale	Resource substitution	Innovation for sustainable development

Source: personal adaptation based on Birner, (2017) p.23

In parallel with the changing perspectives and global goals, the concept of bioeconomy is also changing. As already mentioned, there are a number of differences between the definitions, not only on an international scale but also on a national and regional one (Beluhova-Uzunova & Shishkova, 2019).

Countries are increasingly adopting policies and strategies aimed at promoting the bioeconomy. Birner (2017) defines "bioeconomy strategies" to refer to documents released by national governments or parliaments that contain policy or strategy information. As we examine bioeconomy strategies developed by governments, it is useful to consider their comparative advantages when it comes to establishing different aspects of their bioeconomy.

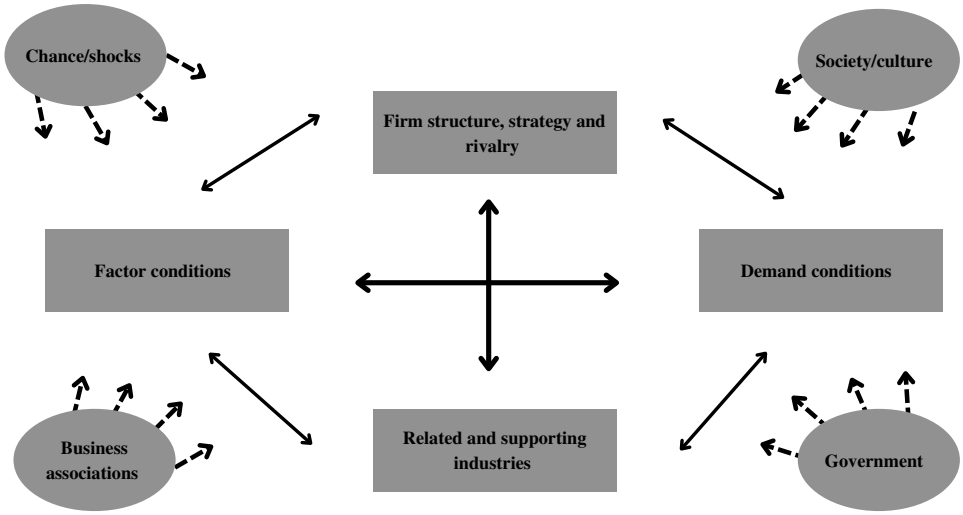
Birner (2017) uses the "diamond model", developed by Porter (1990). In order to determine a country's competitive advantage, the "diamond" model uses four basic elements:

1. Factor conditions
2. Demand conditions
3. Firm structure, strategy and rivalry
4. Related and supported industries

In

Figure 2 the elements and factors as well as relations are depicted. These four areas are typically targeted in strategies to promote the bioeconomy.

Figure 2. The diamond model of comparative advantage



Source: personal adaptation based on (Birner, 2017)

According to Porter (1990), bioeconomy development is affected by five types of factor conditions: *natural conditions* which refers to land endowment and agroclimatic conditions that affect a country's ability to produce biomass competitively; *labor resources* meaning that the government can play a major role in preparing its workforce for the bioeconomy, especially by making an investment in education and professional growth; *knowledge resources* indicates that public research on bioeconomy to foster innovation is one of the main measures that governments can implement to develop their bioeconomies*; capital resources* are necessary because in order to make risky investments, it is essential to have access to capital, especially venture capital and finally, *infrastructure* are necessary, especially transport and information and communication technologies (ICTs).

For what concerns the demand conditions, Birner (2017) affirms that it is possible for governments to foster consumer demand for biobased products by promoting labels that simplify the choice of products and public procurement rules can also be implemented by governments to increase public demand for bio-based products.

The third element is the firm structure, strategy and rivalry. On this regard, the author says that in order to maximize the bioeconomy's potential, it is important to encourage and promote a competitive environment among firms engaging in the industry, limiting too much market power among them.

The last factor of the model is the one concerning related and supporting industries. Birner (2017) relates it to the concept of clusters and affirms that this concept depends on the assumption that the improvement of the bioeconomy requires a solid, regionally integrated network of firms that are interrelated and support one another along the value chain, such as by offering specialized inputs and services. As history has shown, governments have limited ability to form clusters from the very beginning and it would be more effective to recognize and strengthen emerging clusters instead (Birner, 2017). According to Birner (2017), various interactions among the actors depicted are crucial for the development of the bioeconomy. Imaginably, it may occur that the various players have converging or adverse interests, that may lead to political and economic mechanisms that are more or less supportive to the bioeconomy.

2.1.3 Challenges and Limitations

Although there is unanimity on the bioeconomy objectives, it is arguable how these goals should be accomplished in reality, so it is necessary to assess the strategies' strengths and weaknesses (Hetemäki et al., 2017).

The early definition of bioeconomy given by OECD in 2009 states that "bioeconomy can be understood as a world in which biotechnology contributes to a considerable extent to the economic output" (Hetemäki et al., 2017). However, in the report of Global Bioeconomy Summit (2015), it is stated that many shares this definition of the bioeconomy "*as the knowledge-based production and utilization of biological resources, innovative biological processes and principles to sustainably provide goods and services across all economic sectors*" (p.4). In practice, it involves the conversion of a system of energy and components creation relying on limited resources to a system based on renewable energy sources. The definitions of "bioeconomy" so far have focused on the resource base, i.e., economic activity that relies on renewable bio-based resources, but not on the sustainability of the economy and the way of life associated with it. Sustainability, however, cannot be achieved solely by using renewable resources, as can be seen in the case of bioenergy use, which is charged with sustainability issues (Gawel et al. 2019). Always according to Gawel et al. (2019), three prerequisites are thus required for a sustainable bioeconomy:

1. Sustainability of the resource base
2. Sustainability of production and consumption processes and products (in particular environmental compatibility)

3. Circular processes of material fluxes.

In addition, the authors affirm that the concept of bioeconomy has been subjected to strong criticism due to the insufficient availability of biomass and the potential unsustainable use of land, which are the primary constraints to its further development. The increase in demand for bio-based products will place additional pressure on biomass and land resources, intensifying interactions with the food industry, as already mentioned in the previous paragraph (2.1.2).

The concept of bioeconomy has been the subject of two main critiques: "fundamental critiques" and "greenwashing critiques" (Birner, 2017; Gawel et al., 2019).

The first critique refers to the studies of (Birch, 2006; Birch et al., 2010) which links the bioeconomy to a broader critic of neoliberalism. Indeed, the authors affirm that Neoliberalism is a philosophy that extends the market ethic into all aspects of economic, social, and political life, both as a mechanism to achieve efficiency in economic activity and as a moral code to promote liberty and individualism. Due to its ties to neoliberal precepts, competitive discourse and practice tend to collapse a distinction between market value and ethical value, resulting in commercial value becoming the primary principle for political economy (i.e., how economic exchange is organized. The bioeconomy can thus suffer from several negative effects caused by neoliberalism. A related concern is that the concept has been promoted in order to serve the interests of large corporations seeking to commercialize innovations in life sciences and to apply technologies which are debated in society, such as genetic engineering and synthetic biology (Birner, 2017).

As mentioned before, the second type of critique, is named the “greenwashing critiques”. Essentially, the purpose of this critique is to make sure that the term “bio” is not misappropriated to depicted an economically unsustainable system as “sustainable”, but also to ensure that innovations in the life sciences are effectively employed to facilitate the transition to a sustainable economic system (Birner, 2017).

According to the author, as a result of rising criticism against the bioeconomy, two trends have emerged in recent years that have contributed to the development of the bioeconomy concept:

1. “Greening” the bioeconomy
2. Shift in focus from the supply side to the demand side

Related to the first trend, as some definitions suggest, the bioeconomy is not per se sustainable despite being based on renewable resources. It is also not per se able to solve sustainability problems; sometimes it even creates new ones, as demonstrated by the studies on the use of biomass for energy purposes which was partly responsible for the food price crises of 2008/2009 as evidenced by Headey & Fan (2008).

For what concern the second trend, recently, the bioeconomy has placed more emphasis on its demand side and, more generally, on its social impact. According to Birner (2017) it is crucial for the bioeconomy that people's preferences and values are transposed into their needs and demands for (new) biobased goods. As a further extension of the societal integration of the bioeconomy, it is also possible to regard the bioeconomy as one of the elements of a process of transformation of society, which is necessary to create a sustainable economic, environmental, and social environment (Birner, 2017). It is recognized that there are significant issues related to this shift, which leads to the hypothesis that economic incentives and legislation promoting an environment conducive to the transformation. In conclusion, "a great societal transformation" is required, which entails significant adjustments to infrastructures, manufacturing processes, regulatory systems, and lifestyles. It also advocates for new ways for politics, society, science, and the economy to connect (WGBU, 2011).

2.2 Circular bioeconomy

2.2.1 Definition

The concept of sustainability in the bioeconomy goes beyond merely substituting non-renewable resources with renewable ones, but rather incorporates a broader range of societal and ecosystem goals (Viaggi, 2018, p.64).

Along with the concept of the green economy, another theory related to the bio-economy has developed recently: the concept of a "circular economy". In order to ensure that the bioeconomy is, in fact, sustainable, it is important that the two economies' principles will be linked (Birner, 2017).

Nonetheless, there is limited amount of circularity in the economy (measured by the share of materials flowing back into the anthropic system) at present (Viaggi, 2018, p.21). Indeed, based on Haas et al., (2015)'s estimates, roughly 4 gigatonnes of waste materials are recycled globally each year, a relatively small flow compared to 62 gigatonnes per year of processed materials and outputs of 41 gigatonnes per year (p.

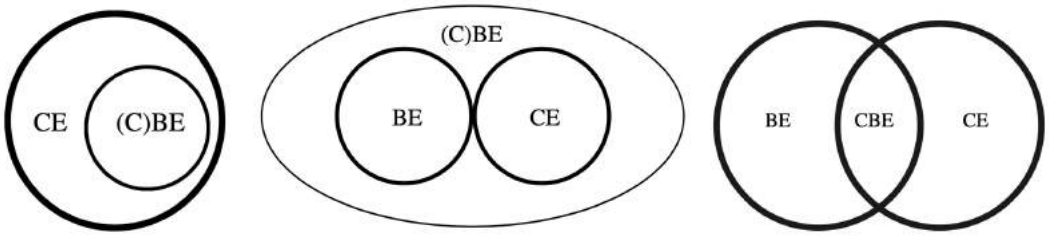
765). In addition, biomass has an indirect impact on overall circularity, depending on the production methods and systems used.

"Bio-economies" based on agricultural biomass are gaining prominence in the USA. These economic systems offer a pathway towards energy independence and a more environmentally friendly society. According to Jordan et al., (2007), if biomass is produced in a sustainable way (meaning without damage to soil, water, or ecological carbon stocks), then it may be considered as renewable, and the CO_2 that results from the production and residues, may be recycled into new biomass in ecological cycles, thus, biomass itself can be considered to be part of the circular flow (Viaggi, 2018, p. 21).

Stegmann et al. (2020) conducted a literature review and analysis of keywords published in academic literature. According to the authors' assessment, three overarching perspectives have been identified on the CBE in relation to the two concepts of the bioeconomy and the circular economy.

The first viewpoint is given by Ellen MacArthur Foundation, (2013), which considers the bioeconomy as part of the circular economy. A similar vision is shared also by Tennes & Peck (2020) who affirm that there is an increasing convergence of the concepts of BE (Bioeconomy) and CE (circular economy) to describe a 'circular bioeconomy' (CBE), which emphasizes retention of value for renewable resources and increased circularity in the material cycle. By integrating the CE principles, sustainability weaknesses associated with BE may be alleviated. A different perspective is given by D'Amato, Veijonaho, et al. (2020) and Hetemäki et al. (2017) who promote a more comprehensive vision of the CBE and suggest that it encompasses more than just the bioeconomy or circular economy. According to Carus & Dammer (2018) and Philp & Winickoff (2018), both a bioeconomy and a circular economy aim for the same goals: a world characterized by sustainability and resource efficiency and reduced carbon emissions. As a means of contributing to the climate targets, the circular economy as well as the bioeconomy avoid using additional fossil carbon. According to Tennes & Peck (2020), through the circular economy, processes become more efficient and recycled materials are used more frequently to decrease emissions of fossil carbon (whether enclosed in the material or released as a result of the production process). As part of the bioeconomy, fossil carbon is replaced by renewable carbon in the form of biomass from agriculture, forestry and marine environments, as well as wastes and by-products (Tennes & Peck, 2020).

Figure 3. Circular Bioeconomy's perspectives



Ellen MacArthur Foundation (2013) Tennes and Peck (2020) | Carus and Dammer (2018) Philp and Winickoff (2018) | D'Amato et al. (2018) Hetemäki et al. (2017)

Source: personal adaptation from Stegmann et al., (2020), p.4

In light of this, the authors Carus & Dammer (2018) state that, circular economy and bioeconomy are two different but somehow complementary approaches and that the concept of "circular bioeconomy" can be expressed as the intersection of these two concepts, as graphically represented in figure 3. Stegmann et al. (2020)'s analysis of publications related to CBE also exhibits analogous aspects that are specified in this thesis for a better explanation and about the features of circular bioeconomy. In table 3, a summary of the findings of Stegmann et al. (2020), is displayed.

Table 3. CBE key elements

Features	Explanation
Use of wastes and residues as a resource	Analyzed by all researches and keywords used 3.5 times more than BE documents
Resource efficiency	Efficient use of biomass is considered by all researches but with different definitions.
(Integrated) biorefineries	Important for almost all publications considered. A definition of biorefinery: *"the sustainable processing of biomass into a spectrum of marketable products (food, feed, materials, chemicals) and energy (fuels, power, heat)"* (Van Ree et al., 2012).
Maintaining the value [...] and waste hierarchy	[...] of products, materials and resources for as long as possible. Two fundamental aspects of CE that are therefore applied to CBE. The authors also suggest that one of the key characteristics of the CBE

	is the optimization of the value of biomass over time. Optimization can be based on economic factors (e.g. for profit), environmental factors (e.g. to reduce greenhouse gas emissions) and/or social factors (e.g. to increase employment) and ideally should consider all three pillars of sustainability at the same time.
Cascading use of biomass	Considered by six out of nine publications. Cascading has various definitions in literature but usually the common theme is the *"sequential use of resources for different purposes"* (Olsson et al., 2018). Although, according to the same author, cascading can also be interpreted as a prioritization of value to the greatest extent possible.
Waste management	Relevant topic in CBE publications and key-words associated with it are mentioned 4.2 times more compared to BE publications.
Recycling	Absolutely fundamental topic in CBE publications considered.
Circular product design	It only has a marginal share of keywords both for BCE and BE documents.
Sharing and durability/prolonged use	Some (four out nine) publications recommend increasing product utilization within the CBE by sharing products and recognizing bio-based products as having a prolonged lifespan or being durable. But this is not considered relevant or not considered at all by most researches.
Sustainability, Climate Change and other Environmental Impacts	More dominant in CBE publications than in BE ones.
Social aspects	There is a lack of attention paid to social aspects in the CBE discourse.

Source: personal elaboration from Stegmann et al., (2020), p.5.

Considering all these elements, the authors Stegmann et al. (2020) provide the following definition of the CBE:

"The circular bioeconomy focuses on the sustainable, resource-efficient valorization of biomass in integrated, multi-output production chains (e.g. biorefineries) while also making use of residues and wastes and optimizing the value of biomass over time via cascading. Such an optimization can focus on economic, environmental or social aspects and ideally considers all three pillars of sustainability. The cascading steps aim at retaining the resource quality by adhering to the bio-based value pyramid and the waste hierarchy where possible and adequate" (p.5)

2.2.2 Further considerations

According to Tan & Lamers (2021), a key challenge for stakeholders is indeed that the relationship between the circular economy and the bioeconomy lacks consensus, meaning that there is not a unique solution to describe the circular bioeconomy other than what stakeholders understand about the two theories individually. According to the authors, both concepts have potentials and limitations. Among its objectives, the circular economy endeavors to improve efficiency and reduce waste by reducing inputs, implementing sustainable designs, implementing improved practices, and reusing and recycling waste. Likewise, the bioeconomy put emphasis on the sustainable utilization of renewable resources for economic, environmental, and social gains and enables a transition from fossil fuels to biomass-based inputs for industry (Tan & Lamers, 2021). Nonetheless, circular economies tend to neglect the social dimensions significantly due to their primary focus on economics and environmental benefits (Tan & Lamers, 2021).

The improvement in efficiency often leads to rebound effects that conduce to an increase in production and consumption, which consequently leads to a failure to achieve net environmental benefits. The authors provide as an example that the increased fuel efficiency of passenger vehicles may result in greater driving, which therefore produces increased greenhouse gas emissions. Always according to Tan & Lamers (2021), it is important to note that intensifying biomass production might compete with forests' various socio-economic, and biological roles as well as their ability to provide fresh water and food, which was already mentioned in previous paragraphs. A thriving bioeconomy may displace economic output and employment in a wide variety of industries and may also compete with other advanced technologies.

Academics, policymakers, and industry players are increasingly recognizing the circular bioeconomy's importance. Although it has great potential for growth, there is risk of it to develop in a limited, unsustainable manner.
Indeed, there are two potential paths for circular bioeconomies articulated by Hadley Kershaw et al. (2021):

1. A delimiting path
2. A sustainable path

The first possibility paves the way to a scenario where problems and solutions are defined narrowly by a limited range of stakeholders who place a high priority on economic value.
First of all, a narrow range of players in richer countries prevail and control processes defining circular bioeconomies, primarily due to academic research and policies emerging from and focusing on the European frame of reference. Moreover, citizens are rarely considered and mostly industrial players ask for public support. For instance, Azadi et al. (2016), affirms that it is difficult for small-scale farmers to adopt genetically modified (GM) crops due to the lack of seed availability and accessibility, price issues, and a lack of adequate information as well as high manufacturing and research costs. Furthermore, the restrictive implications of intellectual property rights might dispossess farmers who lack resources of the benefits of GM technologies.
Secondly, circular bioeconomy strategies neglect important dimensions of sustainability, that can be approached in different ways. Furthermore, there is a strong tendency for them to assume that current socioeconomic systems will persist rather than to engage in more radical transitions such as degrowth.
A third issue concerns the tendency of current circular bioeconomy strategies to prioritize economic value over other value drivers. Most of the literature and policies tend to neglect social aspects. Hetemäki et al. (2017) gives relevance to the concept of narratives. As a key component of mental models, social beliefs, and practices that orient an individual's decisions and behaviors, narratives play an important role in helping to bring about positive change. It is necessary to convey a narrative that engages most people in order for circular bioeconomy growth to be successful and practically realized (Hetemäki et al., 2017). For example, Hetemäki et al. (2017) argue that urban citizens may have a bad opinion towards bioeconomy policies, like the EU Common Agricultural Policy because they might think that only rural population will benefit from them. In other words, these policies may be considered as taking tax

revenue from urban citizens' pockets in order to support rural areas. Therefore, for the bioeconomy, and it goes without saying also for the CBE, to be successful, an urban bioeconomy narrative that engages and is supported by the urban population is necessary.

The second alternative contributes to the social, environmental, and economic well-being of the community by incorporating the input of multiple stakeholders and experts. The authors Hadley Kershaw et al. (2021) suggest that, rather than thinking in terms of a single circular bioeconomy, it is more beneficial to envision many circular bio-economies with different perspectives. Ideally, these efforts are based on local or regional initiatives that develop circular bioeconomy approaches that are suitable to the context and that incorporate social innovations and alternatives to the market and involving more different actors in the governance.

According to Azadi et al. (2016), one means of pursuing this more sustainable path towards circular bioeconomies is through responsible innovation and they state that "*responsible innovation is an approach to the governance and practice of research and innovation that aims to align innovation with societal values, needs, and priorities*" (p. 544). They further add that conscious innovation involves foreseeing ethical and environmental consequences of new technical innovations, contextualizing them in the broader systemic changes, taking into account the motivations for and impacts of innovation.

In light of a more comprehensive and inclusive view of the BE and CBE, Hetemäki et al. (2017) highlight some requirements for a successful development and implementation of the circular bioeconomy. Beside social inclusiveness and environmental sustainability they mention also R&D, technological change and skills. They affirm that, at present, the society is in the initial stages of developing novel bio-based products and technologies, therefore more R&D resources are required in order to facilitate the process and speed it up. This is a considerable problem for big corporations but, it goes without saying, even more for small and medium-scale (SME) enterprises.

According to Hetemäki et al. (2017), for innovation and new business opportunities to become more widely realized, this must be changed. In this situation the relevance of new players, such as start-ups, chemical companies, textile manufacturers, consumer goods producers, and construction firms is vital, as they provide additional resources and investments to the industry

Hetemäki & Hurmekoski (2016) also highlights the fact that with the introduction of new bioeconomy products on the market, it is becoming increasingly important to understand how market, policy, and society are interacting. In their research, the authors focus on the forest industry and they affirm that several established forest products and businesses are experiencing major declines, while simultaneously new products and businesses are emerging, for example bioenergy, biochemicals and prefabricated wood products. The forest sector can therefore be considered in a phase of *creative destruction*, concept theorized by Schumpeter in 1940 which implies the decline and eventual disappearance of some economic activities and sectors, while simultaneously introducing new technologies, products, and business models (Hetemäki & Hurmekoski, 2016).

Thus, to better understand these dynamics, it is necessary to ask some fundamental questions. Some of them are the following (Hetemäki et al., 2017, p.28):

- What are the market prospects and competitive advantages for different products and in which regions should their value chains be located?
- What are the impacts on employment trends and skill requirements for the future?
- How can we use digital technology, big data and artificial intelligence to optimize, identify and appreciate new pathways and value chains, process data, and create indicators to monitor all dimensions of the sustainability of bioeconomy?

Regulation changes, consumer behavior, trade patterns, CO_2 and energy prices, emergence of new sustainable energy technologies, biomass, etc., all have an impact on the circular bioeconomy. In order to better understand what impacts they might have they need to be assessed.

Moreover, Hetemäki et al. (2017) point out another factor related to investments which is risk-taking capacity, since innovations usually involve high-risks. Public sector investment can be supported if there is an expectation of wider positive spillover effects and especially in the case of knowledge-related risks and pioneering pilot. Furthermore, another path especially indicated for SMEs is to favor the emergence of a “business ecosystems”, enabling a sort of collaborations between small and large companies. Besides risk-related advantages, it also facilitates the efficient use of resources and minimization of waste (Hetemäki et al., 2017).

3. Methodology

3.1 Research Design

As already mentioned, the third chapter of this thesis is aimed to try to give an answer to the research question on which this work is based. In fact, the main focus is to examine what are the structural differences and similarities of Italy and Germany regarding the implementation of a circular bioeconomy's strategy.

In order to be able to answer to the research question, a systematic literature review (SLR) based on the PRISMA framework will be conducted. The benefits of systematic reviews are numerous. In the first instance, they provide an overview of all available evidence on a particular topic clearly and comprehensively. In addition, SRLs serve to identify knowledge gaps in a specific field that require further investigation (Poklepović Peričić & Tanveer, 2019).

Reviews of the literature are playing an increasingly important role in practice and academia. A systematic and rigorous approach, however, is necessary to conduct an effective literature review (Louise, 2013).

The Preferred Reporting Items for Systematic Reviews and Meta-Analyses (PRISMA) statement original version was published in 2009 and the purpose of the document was initially to facilitate the transparent reporting of reasons for conducting a systematic review, as well as what the authors did and what they found. In the update version, PRISMA 2020, there is a new reporting guidance that incorporates advances in methods for identifying, selecting, evaluating, and synthesizing studies. In order to facilitate implementation, the items have been restructured and presented in a more practical manner. The PRISMA 2020 statement includes a 27-item checklist, an enlarged checklist with reporting guidelines for each item, a PRISMA 2020 abstract checklist, and redesigned flow diagrams for original and updated reviews (Page et al., 2021, p.1).

The research question implies a comparison of the Italian and German strategies on circular bioeconomy, however, in order to do a more accurate and solid review, I decided to treat the two countries separately and then compare them in the fourth chapter of the thesis.

3.2 The case of Germany

The German government was among the first ones to introduce the concepts of bioeconomy and circular economy. The circular economy was envisioned by German ministries and advisory councils as an essential component of a "great transformation" from the beginning. According to Leipold & Petit-Boix (2018), in fact, since the 1980s, *Kreislaufwirtschaft*, German for circular economy, has informed German business debates and practices. Moreover, the bioeconomy is conceptualized as naturally linked to the circular economy. Germany implemented the first "National Policy Strategy on Bioeconomy" in 2014, according to Bioökönomierat (2015), namely the German Bioeconomy Council (p.131). The abovementioned council is an independent advisory committee to the German Federal Government, established in 2009. Its primary objective is to provide advice on how to foster sustainable bioeconomies throughout Germany and throughout the world (Bioökönomierat, 2015, p.134). By engaging in political and scientific dialogue, publishing positions statements, and spreading the vision for the future of the bioeconomy, it promotes the future of the bioeconomy to a broader audience. Moreover, this council focuses its efforts on both long-term goals and day-to-day policy demands (Bioökönomierat, 2015, p.134).

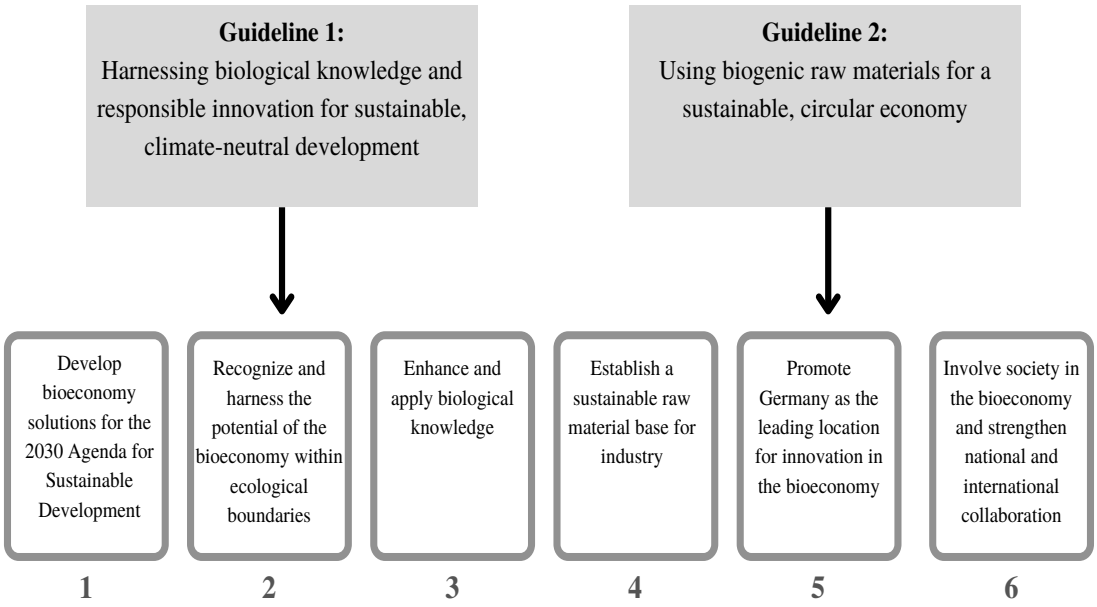
The German Bioeconomy Council prepared a relevant report called "Synopsis and Analysis of Strategies in the G7" in 2015. The report starts with a review of G7 nations' bioeconomy goals and key regulatory efforts implemented, including the EU. This review intends to give significant insights and identify potential for mutual learning and eventual collaboration by addressing similarities and contrasts in political approaches (Bioökönomierat, 2015). The report is a precious source of information about the strategies of bioeconomy in different countries, and it is often cited in papers concerning this topic.

The German Federal Ministry of Education and Research (*Bundesministerium für Bildung und Forschung-BMBF*) together with the German Federal Ministry of Food and Agriculture (*Bundesministerium für Ernährung und Landwirtschaft-BMEL*) published a report about the National Bioeconomy Strategy. In the report it is stated that the National Bioeconomy Strategy sets the groundwork for Germany to improve its position as an influential actor in the field of bioeconomy, and develop tomorrow's technologies and jobs. The German Federal Government accepts its worldwide commitment in the interrelated international bioeconomy with this strategy (BMBF & BMEL, 2020, p.4)

Moreover, the BMBF & BMEL (2020) specify that the goals and actions outlined in the National Bioeconomy Strategy are supported by two guiding principles. The first piece of advice emphasizes how advanced technology and understanding of biological systems are the cornerstones of an economy that is forward-looking, climate-neutral, and sustainable. The use of biogenic resources is the focus of the second principle, which pertains to the raw materials that are utilized by industry as well as the need for a sustainable and circular economy. The goals and actions outlined in the National Bioeconomy Strategy are supported by two guiding principles. The first piece of advice emphasizes how advanced technology and understanding of biological systems are the cornerstones of an economy that is forward-looking, climate-neutral, and sustainable. The use of biogenic resources is the focus of the second principle, which pertains to the raw materials that are utilized by industry as well as the necessity for a sustainable and circular economy (BMBF & BMEL, 2020).

The National Bioeconomy Strategy of the Federal Government tackles a wide range of goals aimed at different societal levels and economic sectors. It is articulated in six strategic objectives which are described in Figure 4.

Figure 4. The bioeconomy strategy of the German government



Source: personal elaboration based on BMBF & BMEL, (2020), p.5)

With regard to research financing, the pertinent framework conditions, and cross-cutting instruments, specific implementation targets have been developed for each of these strategic aims. Within the context of research funding, the relevant framework

conditions, and cross-cutting instruments, specific objectives have been created for each of these strategic goals. These objectives will guide the implementation of the above-mentioned six strategic goals (BMBF & BMEL, 2020).

3.3 The case of Italy

The Italian government encouraged the formulation of a National Bioeconomy Strategy in 2017-BIT, which was then amended (BIT II) in recent years (Fava et al., 2021). According to Fava et al. (2021), these pillars are (p. 124):

- Production of renewable biological resources
- Their conversion into valuable food/feed
- Bio-based products
- Bio-energy
- Transformation and valorization of bio-waste streams

The Bioeconomy strategy is carried out as part of the National Smart Specialization Strategy, emphasizing on "Health, Food and Life Quality" and "Sustainable and Smart Industry, Energy and Environment". It is executed considering the objectives of Italy's National Strategy for Sustainable Development in order to reconcile environmental sustainability with economic development (Italian Government, 2017).
According to Fava et al. (2021), Italy's bioeconomy is a key component of the country's economy, ranking third in Europe with 330 billion euros in yearly revenue and 2 million workers. From 2011 to 2017, an increase by about 1.25 % on turnover and employment was registered, and from 2017 to 2018 a further increase of 2% (Fava et al., 2021, p.124). However, the ambition for the Italian bioeconomy is to boost both revenue and employment by 15% in the time range 2017-2030 (Italian Government, 2019). Considering Italy's crucial geopolitical location in the Mediterranean area, BIT II comprises initiatives aimed at encouraging sustainable production, social cohesion, and political stability in this region via the adoption of bioeconomy policies (Fava et al., 2021).
In the BIT report it is possible to find the milestones for future Italian Environmental strategies, which are located in the Environmental Annex to the Stability Law. Here some measures that are considered particularly important, according to the (Italian Government, 2019, p.41)

- Green Public Procurement
- Incentives for the purchase of post-consumption materials
- Creation of a Natural Capital Committee
- The establishment of a system of Payment for Ecosystem and Environmental Services
- System of Payment for Ecosystem and Environmental Services
- Catalogue of environmentally friendly and harmful subsidies.

Always in the BIT document we can read that a "National Sustainable Development Strategy" was developed, based on the 2030 Agenda for Sustainable Development, issued by the United Nations (UN) in 2015. The National Sustainable Development Strategy establishes a set of strategic options and national goals categorized into six sectors.

The bioeconomy-related strategic alternatives can be divided into three main groups (Italian Government, 2019, p.43):

- People:
  - ⇒ Fighting poverty and social exclusion, eliminating territorial differences.
  - ⇒ Promote health and wellbeing.
- Planet
  - ⇒ Halt the loss of biodiversity.
  - ⇒ Ensure the sustainable management of natural resources.
  - ⇒ Create resilient communities and territories, preserve landscapes and cultural heritage.
- Prosperity
  - ⇒ Fund and promote sustainable research and innovation.
  - ⇒ Ensure sustainable production and consumption patterns.
  - ⇒ Decarbonize the economy.

At this point it is also important to mention a very recent plan that is expected to be extremely helpful for the country's economy, namely the National Recovery and Resilience Plan (NRRP). This plan is the result of the funding program of the EU in response to the crisis caused by the COVID-19 pandemic, which is called Next Generation EU (NGEU).

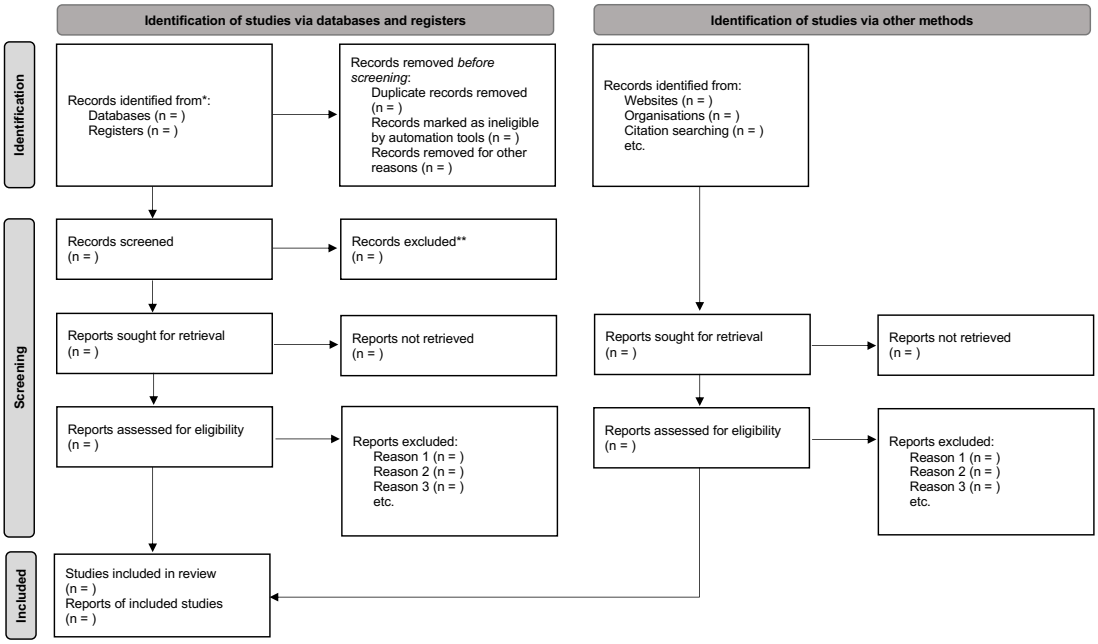
The Italian Recovery and Resilience Plan, which is strongly co-owned by Regional and Local Authorities (who are in charge of implementing around 40% of the investments supported by the Recovery and Resilience Facility), integrates an intensive reform agenda with an enormous investment program. The Recovery and Resilience Facility (RRF) and REACT-EU are the two most important NGEU instruments, and Italy is the first recipient in absolute terms. The RRF distributes 191.5 billion euros in resources for usage between 2021 and 2026, of which 68.9 billion are grants (Italian Government, 2021, p.3). The plan is arranged around six domains of intervention (called "missions") and comprises 16 components to be accomplished via a combination of investments and reforms for each mission (D'Alfonso, 2022). The second mission is dedicated to the "Green Revolution and Ecological Transition" (Italian Government, 2021, p.4). Among other aspects, this section considers circular economy projects and a better waste management, taking into account regional disparities of the country (Council of the European Union, 2021, p.272). Moreover, a bioeconomy element can be found in Mission 2, Component 2 (Council of the European Union, 2021, p.309), which concerns energy transition. The reform consists of adopting legislation to broaden the scope of bio-methane initiatives in order to strengthen support for clean bio-methane.

3.4 Systematic Literature Review according to PRISMA scheme

As specified in 3.1 Research Design, the Systematic Literature Review has been conducted in line with the methodology of the PRISMA framework for the two countries separately. This decision is taken in order to rescue more information, since the joint research of the two countries would have given very scarce information.
In Figure 5 it is possible to see the PRISMA 2020 flow diagram for new systematic reviews, which represents the process that will be adopted in this thesis in order to answer the research question. Scopus is regarded as the leading database for this study due to the fact that it contains a considerable amount of publications and is trustworthy. Strings are constructed in a manner that allows them to obtain the most relevant information in the study so as to meet the research query. Therefore, the strings that I used in Scopus database are the following:

- "circular" AND "bioeconomy" AND "Germany"
- "circular" AND "bioeconomy" AND "Italy"

Figure 5. PRISMA 2020 flow diagram for new systematic reviews which included searches of databases, registers and other sources



Sources: based on (Page et al., 2021, p.5)**.**

Furthermore, I added a filter to the language of the papers that should be included in the research, since for this thesis it is important that every source is written in English. The list of documents with the related information downloaded from the Scopus website will be reported in the Appendix. Moreover, I added to the list of the relevant material also the report of the National Bioeconomy Strategies of both corresponding countries, in order to have a more direct and general comprehension of the policies, legislations and data collected and issued by the governments.

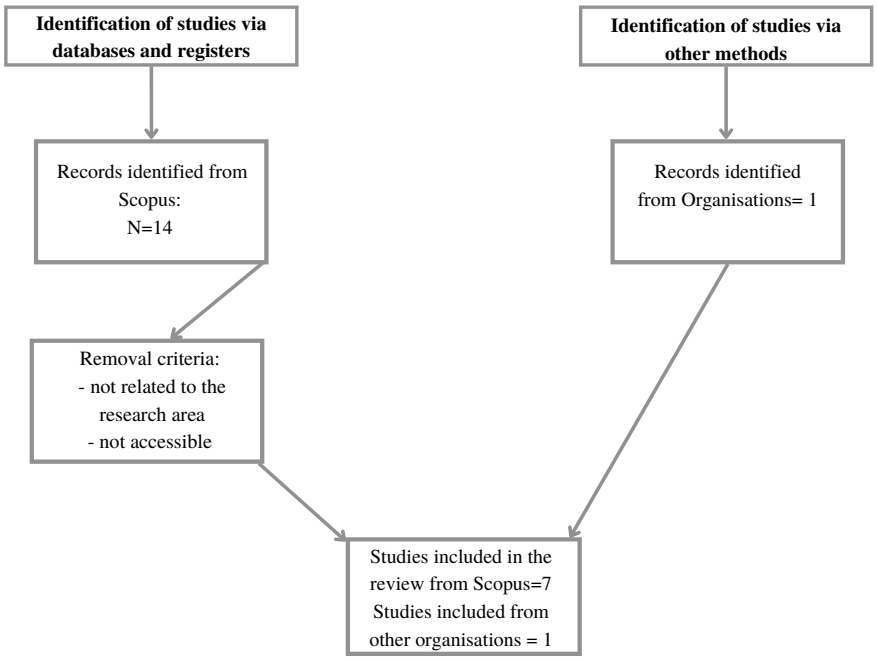
Starting from Germany, the research made on the database Scopus resulted in fourteen papers and reports. Seven of these documents were excluded from the relevant material because they are not considered relevant for the research. Indeed, one of the eligibility criteria for the papers to be considered are the significance and pertinence to the subject of study, therefore economics and business-related fields.

Four of the six excluded concern agricultural, microbiology or geology studies and are not strictly connected or not at all connected to political or economic aspects of the circular bioeconomy.

Moreover, one paper was excluded because it was related to tourism and was quite out of the topic, as it implied more about the hotel strategies around Europe. Finally, this paper was also not involved in the review because it was not accessible with a regular student account. Other two papers were also excluded for said reason. Therefore, only

seven papers plus the document containing the National Bioeconomy Strategy were eventually considered eligible for the review.

Figure 6. SLR process for Germany



Source: author's elaboration based on (Page et al., 2021)

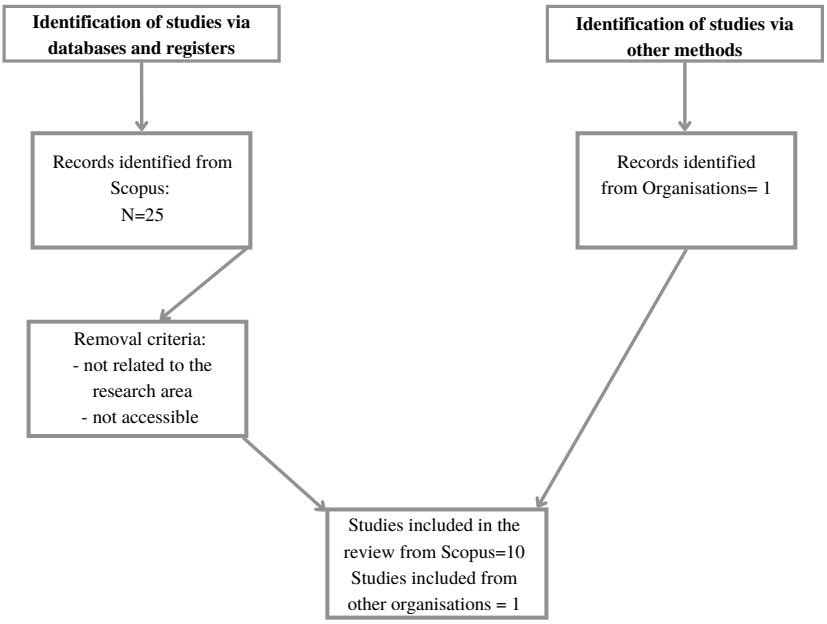
In Figure 6, I summarized the results of the identification of studies in order to give a visual representation of it.

For what concerns Italy instead, the research made in Scopus resulted in twenty-five documents, and the complete list with related information can be found in the Appendix. Only ten of these twenty-five scripts are going to be evaluated for this study. The grounds for exclusion of papers are the same as those examined in German's case, therefore pertinence to the area of research and accessibility of the papers. The primary screening excluded thirteen studies. In particular, three of them were related to agriculture or biochemistry area and the others were not accessible.

As for the case of Germany, I also included in the review the Italian Bioeconomy Strategy (BIT-Bioeconomy in Italy), in order to evaluate and compare the relative features of the two approaches.

Figure 7 depicts the visual representation of the research. The next chapter of the thesis will be dedicated to the exposition of the results of the research about the two countries.

Figure 7. SLR process for Italy



Source: author's elaboration based on (Page et al., 2021)

4. Results

4.1 Results of search string Germany

The first document analyzed and that can be considered a starting point for the research about this country is the "National Bioeconomy Strategy" of Germany, issued by the Federal Government.

As already mentioned in 3.2 The case of Germany, the objective of maximizing the bioeconomy's potential and using it to accomplish sustainability and climate objectives is supported by two guiding principles which are useful for the implementation strategies included in the new Bioeconomy Strategy. These two are: "*harnessing biological knowledge and responsible innovation for sustainable, climate-neutral development*" and "*using biogenic raw materials for a sustainable, circular economy*" (BMBF & BMEL, 2020, p.5).

Moreover, the Federal Government's Bioeconomy Strategy tackles a wide range of goals, summarized in Figure 4, set at many societal levels and applicable to all economic sectors and they are mainly addressed for research funding and development of suitable policy framework. Research and development are crucial to the discovery, advancement, and implementation of the bioeconomy's contribution to the creation of a sustainable economy. A solid understanding of biological systems provides the foundation for the creation of novel products and processes. The freedom to explore unknown territory must be provided to science in order for it to produce wholly innovative future technologies and revolutionary inventions.

The German Federal Government encourages excellent and open research, without favoring any particular technology (BMBF & BMEL, 2020, p.22). The focus of research is as already stated, expanding biological knowledge and using this acquired expertise to generate bio-based innovations. The contamination of ideas and creative combination of various fields should result in sustainable competitive innovation, with the aid of digitization, that makes possible to process huge amounts of data and integrate them intelligently (BMBF & BMEL, 2020, p.25)

A crucial aspect of the knowledge-to-application transfer is a tighter networking of the relevant players. The German Federal Government supports the connections between producers and consumers in a supply chain by, for instance, sponsoring relevant collaborative initiatives or forming clusters (BMBF & BMEL, 2020, p.32).

Furthermore, it supports the early and open integration of enterprises and economic experts into the innovation process, since this guarantees that these procedures are adequately market-oriented (BMBF & BMEL, 2020, p.31)

Another important aspect is the financial support to start-ups SMEs. In general innovation cycles of products related to bio-sciences takes more time compared to other products, these enterprises usually need dedicated investment in addition to that required by many other sectors. Currently, specific measures to support small and medium-sized businesses and start-ups are being developed (BMBF & BMEL, 2020, p.32).

The cross-border exchange of information generates synergies for both the working partners and the bioeconomy as a whole. The German Federal Government will continue to enhance the environment for international education and research (BMBF & BMEL, 2020, p.33). The National Bioeconomy Strategy also identify to improve the policy framework.

These are:

- Reduction of the pressure on land
- Sustainable production and supply of biogenic raw material
- Establishment and development of bioeconomy supply chains and networks
- Market launch and establishment of bio-based products, processes and service
- Exploitation of the potential inherent in the bioeconomy for the development of rural areas
- Exploitation of the potential of digitization for the bioeconomy
- Political coherence

In particular, in the area of sustainable production and supply of biogenic raw material it is specified that, the agricultural sector's viability should be continuously enhanced. Moreover, to better meet the growing demand for organic goods and to broaden the variety of revenue opportunities for agricultural enterprises, the amount of agricultural land in Germany devoted to organic farming will increase to 20 percent by 2030.

Another component of the German bioeconomy is forestry. It offers the majority of the biogenic raw materials utilized in Germany today. The purpose of sustainable forest management is economic performance, ecological responsibility, and social fairness; thus, the Federal Government seeks to achieve a long-term, future-proof balance between the rising demands imposed on forests and their sustainability (BMBF & BMEL, 2020, p.41).

Another interesting aspect regards the supply chains and networks. Besides encouraging the formation of new supply chains, also existing bioeconomy supply chains must be optimized to minimize raw material utilization, safeguard the environment by minimizing the employment of non-renewable raw materials, and increase their competitiveness. Moreover, whenever practicable and acceptable, a cascade and linked use of resources should be pursued in accordance with the principles of resource efficiency and sustainability (BMBF & BMEL, 2020, p. 42).

The guidelines of the German Circular Economy Act (*Kreislaufwirtschaftsgesetz*) regulating the safeguarding of natural resources and the ecologically responsible treatment of waste must be followed (BMBF & BMEL, 2020, p.42).

At first, the demand for bio-based product alternatives is insufficient for their production to be economically sustainable. A possible solution proposed in the National Bioeconomy Strategy is to create a system of product labels and, if relevant, certification labels, that would foster transparency and increase consumer confidence in bio-based goods. Public procurement is a further critical tool that may be used to encourage the development of bio-based products. Indeed, the public sector's market strength and role model function may act as market enhancers for new goods and services (BMBF & BMEL, 2020, p.44).

Another aspect mentioned in the strategy is the development of rural areas. Rural regions play an essential part in the bioeconomy. The rise of the bioeconomy in Germany has enormous potentiality when it comes to value generation, employment, and rural quality of life and the majority of Germany's biomass is generated and processed in rural regions for use as food or animal feed, material, or energy (BMBF & BMEL, 2020, p.44).

For what concerns the papers found in Scopus, it is important to remark that they cover various topics, but three out of seven are about biogas use and biogas plants. In particular, these are the papers of Rojas Arboleda et al. (2021), Theuerl et al. (2019) and González-Arias et al. (2021).

According to Rojas Arboleda et al. (2021), biogas now is a significant component of Germany's energy mix, particularly as a means of producing electricity. The authors say that their study aims to identify the most significant influencing variables in the growth of the biogas system in order to comprehend its integration into the larger energy systems of 2050. The potential decrease of environmental consequences, such as greenhouse gas emissions, was one of the driving forces behind the initial development of the bioenergy sector. Between 2000 and 2017, about 8400 new biogas

plants were constructed in the country. The establishment of these biogas plants was mainly due to the Renewable Energy Sources Act (known as the EEG, whose German name is *Erneuerbare Energiengesetz*). However, given that the EEG will end by 2050, it is unknown what the biogas system will look like at that time, particularly in light of the adjustments in biomass use necessitated by bioeconomy initiatives (i.e. the utilization of bio-based resources for the production of high value-added materials to the detriment of their direct use as energy). For instance, while the growth of biogas plants has been consistent in the past, their development in the future is less assured due to the reliance of previous development on subsidies such as the Renewable Energy Resources Act (EEG).

Rojas Arboleda et al. (2021), moreover, states that up to fifty percent of these facilities will shut down operations because of weak economic viability if the subsidy program is discontinued in the latter part of this decade.

The study of González-Arias et al. (2021) also deals with the issue of poor profitability of the biogas plants. In particular, they focus on the profitability of upgrading biogas to biomethane in the region of Brandenburg, located in the northeast of Germany. Converting biogas to biomethane permits the separation of methane and carbon dioxide, which could reduce the total carbon dioxide emissions and promote the region's natural gas independence (González-Arias et al., 2021).

In order to estimate the profitability, they used the method of discounted cash-flow. The results vary depending on the size of the biogas plant evaluated. Indeed, the small plants present negative net present value, whereas the medium and big plants were profitable. The solutions that the authors propose are either to subsidize the investments or to increase the size of the small plants and make them medium/large which shows economic advantage. The consideration of the cost involved with waste management is an additional approach to improve the profitability of small facilities. This expense might become a revenue if waste is turned into materials and energy with additional value, hence increasing the plant's net present value.

A more extended consideration and use of residues as crucial component of future biogas plants is theorized also by Theuerl et al. (2019). The authors envision that the biomass cycle is replenished by residues from other production systems and then the energy is transferred back to other manufacturing systems. Indeed, according to Theuerl et al., (2019), it is crucial to unlock residues since the supply of residue does not necessitate agricultural land, therefore, it typically does not compete with food production or threaten biodiversity which are among the challenges of bioeconomy.

Moreover, biogas production has the benefit of being relatively predictable and unaffected by weather fluctuations which is not true for other renewable energy sources.

Klein et al. (2022) instead in their research focus on agri-food waste valorization in the as a pathway to the circular bioeconomy. They focused their research in one German region (Lower-Saxony) and on two products' value chain, namely potatoes and rapeseed. The authors interviewed stakeholders of these sectors in the region and found that also in this case the policies related to renewable energy sources have strong implications. In fact, the EEG permitted the distribution of bonuses for energy generated from renewable raw materials, but then bonuses were cancelled and this creates distortions in by-product utilization.

Both Klein et al. (2022) and Rojas Arboleda et al. (2021) draw conclusions about biogas plants in Germany requiring a different view compared to how the present plants are operating. According to Klein et al. (2022), practices of valorization ultimately result in multiple-use systems with changeable and dynamic links between producers and consumers of by-products. Rojas Arboleda et al. 2021) argue that the future of the biogas in Germany is a complex system, which consists of a high number of interacting components that cause emergent complex behaviors. They found that a shared perspective in the field is that the biogas system will evolve into a biorefinery-like facility, producing several products along to energy, heat, and synthetic natural gas it now generates, also considering that biogas (and its byproducts) may play a significant role in waste and residue management operations and offer vital agricultural fertilizers.

Another topic found in the literature from Scopus, is businesses and innovation related to the circular bioeconomy. According to Leipold & Petit-Boix (2018), in the view of European policymakers, we shall achieve a circular economy via business innovation or the promotion of current circular economy-based sustainable business models. However, we know very little about how European firms perceive or adopt this approach, or if it promotes business innovation or sustainable business models. The findings of a document analysis and participant observation indicate that business stakeholders associate the circular economy primarily with existing practices and technological business models and currently do not consider innovation in areas such as social or organizational business models. The part of the research about German stakeholders conducted by Leipold & Petit-Boix (2018), shows that circular economy businesses are mostly divided into three categories: 1) expanding already existing

business models such as recycling (for instance paper/paperboard); 2) replacing crude-oil based substances with bio-based substances and 3) making conventional materials biodegradable, e.g. plastics (p. 1131). The authors state that it is interesting to observe that German stakeholders instinctively associate bio-based products to a circular economy, which is not observed in their peer European stakeholders. Moreover, they found that business models such as recycling and substituting fossil resources with bio-based resources, are highly represented, but less established business models, such as sharing and leasing are almost completely absent. This can be seen also in the number of obstacles faced in the circular economy that German stakeholders were asked to name; none of them related to social or organizational business models.

Also, several activities mentioned by stakeholders are not a business model for the business itself, but rather a business model for external certification schemes that just provide a convenient label Leipold & Petit-Boix (2018).

According to Theuerl et al. (2019), future agricultural biogas generation will need business environments defined by the integration of plans, partnerships, procedures, and guiding structures and this condition may itself demand a business environment that is prone to innovate and learn. Moreover, the authors argue that in Germany, subsidies received for example through the Renewable Energies Act, have generated little incentives for capacity creation in the area of business model and business environment development. Individuals, companies, and societies need further capabilities for creating business models and handling business environments.

To conclude the part concerning Germany, it is significant to estimate the progress of the circular bioeconomy in this country. This type of study was made by Kardung & Drabik (2021) that assessed whether the circular bioeconomies in ten chosen European Union member states advanced or regressed between 2006 and 2016 considering 41 indicators. The comparative analysis suggests that Germany is the leader in the circular bioeconomy. Indeed, the indicators concerning this country advanced the most on average compared to other European countries considered.

In the research of Duque-Acevedo et al. (2020) quantitative and qualitative bibliometric indicators have been investigated to examine the development of the output on the Circular Economic Production Models (CEPMs) which are circular economy, bioeconomy, circular bioeconomy. It emerged that Germany is a forerunner in the policies related to the bioeconomy.

4.2 Results of search string Italy

Also in the case of Italy, the first document analyzed is the National Bioeconomy Strategy of Italy, which is called BIT (Bioeconomy in Italy).
The Italian Bioeconomy Strategy is part of another action plan which is the National Smart Specialization Strategy (SNSI). According to Ferrari & Sitta (2021), the purpose of the Smart Specialization Strategy is to establish priorities for investment in research, development, and innovation that complement the resources and productive capability of territories in order to achieve competitive advantage and a sustainable growth path in the medium and long term (p.189).
Two strategic plans have been created in relation to the Bioeconomy: agri-food and bio-based economy, both of which are cornerstones of this Strategy and that arise from a public-private sector collaborative approach that defines the entrepreneurial discovery process (Italian Government, 2019, p.37).
Moreover, the Environmental Annex to the Stability Law of 2014, entitled "Measures for Promoting the Green Economy and Limiting the Excessive Use of Natural Resources", provides the major objectives for future environmental initiatives in Italy Green economy and circular economy are mentioned as the primary objectives, achieved through (Italian Government, 2019, p.41).

- Green public procurement;
- Incentives for the purchase of post-consumption material;
- Management of specific waste fractions;
- Creation of a Natural Capital Committee, which is in charge of assessing the effect of public policies;
- System of Payment for Ecosystem and Environmental Services;
- Catalogue of environmentally friendly and harmful subsidies;

The revision of the National Sustainable Development Strategy, based on the 2030 Agenda for Sustainable Development, was one of the most key aspects of the Environmental Annex (Italian Government, 2017, p.42).
Furthermore, it is stated that the general objective of the strategy is “to increase the current Italian Bioeconomy turnover and jobs by 15%, while increasing the level of circularity in the economy” (Italian Government, 2019, p.61). Hence, the concept of circular bioeconomy is directly stated in the strategy plan.

In the BIT document, they also mention many times the promotion of bioeconomy in the Mediterranean area, by using the potential of the PRIMA and BLUEMED programs, which aim to enhance the region's primary production and bioindustry potential, therefore generating new employment, social cohesion, and political stability (Italian Government, 2019, p.69).

According to Mari et al. (2020), in Italy and in other Mediterranean countries climate change has a heavier impact than in the rest of Europe. Southern Europe is the European region characterized by the greatest danger resulting from climatic changes for key sectors and infrastructures.

For what concerns the bio-based industries, the priority is to enhance production of bio-based goods and bioenergy in the context of a circular economy by means of initiatives and R&I designed to actually increase the demand for bio-based products and how new markets can be formed as well as introducing new innovative and inclusive business solutions and to monitor and track the biomass supply (Italian Government, 2019, p.76). Currently, Italy is also a leader in the bio-based industry thanks to the levels of innovation already achieved through a multitude of patented technology technologies developed especially in the chemistry and industrial biotechnology sectors. Bio-based apparel and textiles, bio-based pharmaceutical, bio-based chemicals and bio-based plastic and rubber are among the most developed industries (Italian Government, 2019, p.11).

Moreover, the BIT strategy includes a focus on social dimension of the bioeconomy. Here it is highlighted that social awareness and dialogue with consumers is necessary and they must become key players in the social transition that can be stimulated by the bioeconomy. Eco-labeling is a crucial requirement to communicate and dialog with consumers and need to be further developed (Italian Government, 2019, p.35).

The paper written by Fava et al. (2021), is about the BIT strategy. They argue that over the next years, the plan should ensure a 1.25% annual rise in turnover and employment in the Italian bioeconomy and should significantly strengthen Italy's growth and competitiveness in this important sector of the European economy and Green Deal program. The Italian bio-based sector has developed new industrial techniques for the generation of bio-based products utilizing non-food and remaining biomass and urban biowaste. Italy is a pioneer in the high-tech environmental requalification and conversion of old industrial zones and sites into bio-refineries, which produce innovative products (Fava et al., 2021). According to Fava et al. (2021), in these plants, the biomass is used efficiently, adopting a cascading approach use and therefore

adding value to the use of agricultural products, thanks to the cooperation between SMEs, large companies and local farmers.

Within the EU, Italy ranks second (after Germany) in the production of biogas and bio-methane (Fava et al., 2021).

The topic of biogas and bio-methane is also treated in some papers coming from the research about Italy. According to D'adamo & Sassanelli (2022), biomethane may be seen as a paradigm for the circular bioeconomy via which sustainable best practices can be adopted.

However, quite a diverse and significant range of obstacles to its complete adoption may be identified. Indeed, there is an evident need to comprehend how to distribute and supply biomethane's latent value to everyone involved in society in a sustainable manner. The main barrier to achieving sustainability successfully is the vast range of different flows involved and that require systemization of data and information. The first thing that might come to mind is digital technologies. Thus, D'adamo & Sassanelli (2022) also theorize that the creation of innovation ecosystems is required to stimulate collaboration and support the emergence of communities which are capable to develop sustainable solutions.

The Italian government intends to pump 2,3 billion cubic meters of biomethane into the gas network by 2026 and the National Federation of Methane Distributors and Transporters (*Federmetano*) forecasts the production of 8 billion cubic meters of methane by 2030 (D'adamo & Sassanelli, 2022, p.7). In this context, the regions of central-southern Italy on the Adriatic coast, namely Marche, Molise, Abruzzo and Puglia (MMAP), have begun collaborating to reinforce the Adriatic ridge and serve as a point of general contact with the rest of Italy and Europe. D'adamo & Sassanelli (2022) also found that the idea of the biomethane community can be considered as a supportive factor to sustainability. The aggregation of regions is beneficial as it is suited for intercepting available public funds. In addition, teamwork would facilitate the accumulation of expertise and resources, which might give a greater influence in the market (D'adamo & Sassanelli, 2022).

Tamantini et al. (2021) also deal with the topic of biorefineries. However, they focus on the use of forestry industry's residues to produce wood biomass. This may potentially be utilized in biorefineries, although these wastes are predominantly employed for energy production at present, although it would allow the manufacture of high-value products. However, lignocellulosic feedstock-based biorefineries are still unusual in Europe, and far more uncommon in Italy (Tamantini et al., 2021).

Also according to the research of Paletto et al. (2022), the forest-wood supply chain in Italy is presented as quite weak, because of the low commercial value per unit of wood product and the low quantity of valuable wood products affecting the durability of finished and semi-finished goods.

Moreover, Pieratti et al. (2019) also treats the topic of forest-wood value chain. In particular, he underlines that adopting the "cascade" principle to the forest sector and promoting wood consumption primarily for wood products rather than energy generation might be a viable choice.

More insights about the forest sector in Italy come from the research of Falcone et al. (2020). They performed a SWOT analysis, which represents a helpful tool to recognize the potential opportunities and threats as well as strengths and weaknesses. In particular, they integrated the SWOT analysis with a multi-level-perspective (MLP) approach that provides a holistic systemic approach for investigating the connection between dynamics occurring at different levels of analysis. The first is the socio-technical landscape (namely the macro level of the model) corresponds to a set of institutional rules, technical knowledge, and social interaction patterns shaping the fundamental configuration of technologies (Falcone et al., 2020, p.2).

The second level, therefore the meso-level of the model is the socio-technical regime, includes all institutions, techniques, rules, and practices that determine the normal development and use of technologies and the third is niche innovations (micro-level), may be thought of as "incubation rooms" where promising innovations are produced and used while being shielded from general market selection (Falcone et al., 2020, p.2). Particularly, regime shift occurs when a niche technology is sufficiently developed and landscape-level forces are applied to provide possibilities for niches to break through and cause drastic changes in socio-technical regimes. However, always according to Falcone et al. (2020), external influences at the regime level and internal variables at the niche level may severely restrict the potential for niche innovations to emerge and replace the current regimes. The research of Falcone et al., (2020) focuses on conditions at the landscape level since the Italian forest sector is still in the initial phase. The authors focused on landscape-level factors that may facilitate the formation of novel forest-based niches. From a practical point of view, the following techniques were regarded as the most viable for application in Italian forest policy (Falcone et al., 2020, p.8):

- Improving environmental and forest planning tools by defining vi- able methods of circular management and revitalize the Italian rural economy
- Promoting investment in forest infrastructure
- Supporting entrepreneurship programs for forest professionals.
- Enhancing innovative forest-based value chains to provide different income opportunities in rural areas and strengthen the role of the forest industry in a circular bioeconomy perspective.

Therefore, Falcone et al. (2020) conclude by saying that the implementation of successful methods to accelerate the transformation of the Italian forest sector to a circular bioeconomy should indeed be based on a combination of tactics intended to take advantage of opportunities and strengths while addressing weaknesses and risks.
Another topic that resulted from the research string concerning Italy is the integration of the CBE paradigm to the organic fraction of the municipal solid waste (OFMSW), researched by Taffuri et al. (2021). Precisely, they used the city of Turin, located in the north-western part of the country as a case study. The study takes into consideration only the food bio-waste. Indeed, bio-waste accounts for 34% of municipal garbage in the EU, and about 60% of bio-waste is food waste. In terms of urban identity and development initiatives, food plays a crucial role in Turin being the Italian city that is more dominant in the market of food. However, food wastes and losses were evidently substantial and recycling is minimal (Taffuri et al., 2021). At the moment, the OFMSW is accompanied by environmental and economic externalities, associated with incapacity of treating municipal waste and an increased cost since bio-resources are not controlled in the metropolitan territory. According to Taffuri et al. (2021), the decentralization of OFMSW treatment at the municipal level provides significant benefits over the centralized management system, including lower transportation, a possible increase in community participation, and the ability to develop local nutrient and energy networks. In this approach, a decentralized bio-waste treatment network may generate local bio-waste recovery circuits by bringing bio-waste inputs, treatment locations, and bio-product outputs closer together. Therefore, the new system proposed by the authors that integrate the CBE principles would be a solution for the city. They argue that many advantages may occur through a more holistic approach which implies post-consumption and bio-waste usage (Taffuri et al., 2021).
Pagliaro (2020) also deals with the topic of waste. In particular, he discusses he economic feasibility of metropolitan solid waste incineration to provide electrical

power and heat and consider Lombardy, also situated in the north-western part of Italy, as a case study. Urban garbage is a very poor candidate for "renewable" energy. In Italy its combustion for energy production cannot be financed any more as it was for many years, and this is true for almost all nations with waste-to-energy facilities. Moreover, Pagliaro (2020) argues that there is another issue. High recycling and composting rates lead to the production of "fuel" with insufficient calorific value. Because of this, waste-to-energy facilities located in these areas are required to import municipal waste from areas with poor rates of recycling and composting in order to increase the calorific value of a "fuel" that would otherwise be unfit for burning. This is the issue now affecting the waste-to-energy plants in Lombardy, where already in 2018, 18.2% of the trash burnt in its facilities must be imported from other regions and countries. Therefore, policymakers must recognize that recycling and composting are in direct competition with incineration for the same raw material: municipal solid trash. However, in a long-term perspective, policymakers should focus on the transition from waste-to-energy to waste-to-wealth according to circular bioeconomy principles (Pagliaro, 2020).

The last paper made by Palmieri et al. (2017) resulting from the research string about Italy concerns a certification tool, called Environmental Product Declaration (EPD), offering reliable data on the environmental effectiveness of goods or services. The EPD has been created to distinguish products and services based on their environmental performance, allowing consumers to make responsible decisions. Therefore, it is an ideal corporate policy instrument for any businesses who aspire to embrace the Green Economy. Palmieri et al. (2017) state that companies that decide to implement a sustainable business policy have repercussion on the environment they are located, influencing how the other stakeholders will behave. The authors use as a case study the company named “Acciaierie di Sicilia”, a producer of steel in Sicily. This is an exemplary example of a company that behave proactivity, supporting a "green" strategy with reliable certification that provides economic advantages to suppliers, mostly through the purchase of their scrap, and technical-manufacturing efficiency benefits, thanks to an analysis of the environmental impacts of the products (Palmieri et al., 2017).

5. Discussion

This section will be dedicated to the discussion of the results from the research strings about the two countries and to provide an answer to the fundamental research question of this thesis, namely what are the main differences and similarities between Germany and Italy in the implementation of a circular bioeconomy strategy. Both countries are frontrunners in the bioeconomy and rank respectively first and third in terms of total turnover in the bioeconomy sector (Imbert et al., 2017, p.73).

Starting from the comparison of the two national strategies, the first thing to say is that while the German bioeconomy strategy was done before the EU's strategy, which was adopted in 2012, Italy's strategy was formed in response to the EU one, which urges European member states to adopt national policies. Moreover, according to Imbert et al. (2017), the two countries adopted two different approaches to strategy formation that might be considered each on the opposite side of a spectrum. Germany's strategy, indeed, results more in a deliberate top-down method, meaning that strategy creation entails a systematic formulation procedure. On the other hand, Italy adopts an emergent, bottom-up process which means that such processes consist of several iterative phases, which may build a logical whole that directs further behavior. The Italian strategy is also strongly influenced and driven by industrial stakeholders and therefore emphasizes more market development. The German strategy strongly focuses on long-term R&D investments and creation of knowledge and innovation and this aspect is more emphasized than in the case of the Italian strategy. A similar observation was also made by Imbert et al. (2017).

According to Ronzon et al. (2015), in the member states of the European Union, four major directions of national bioeconomies are distinguishable: a bioeconomy dominated by agricultural employment, a bioeconomy geared toward the agri-food industry and bio-based chemical industries, a turnover of the bioeconomy primarily generated by forestry and downstream industries and finally non-specialized bioeconomies (p.4). Both countries taken into consideration (Italy and Germany) are comprised in the second category, hence agri-food and bio-based chemical industries.

In both the national strategies, public procurement is named as an important measure. In particular, in the Italian strategy it is considered as one of the primary policy initiatives for the realization of a circular bioeconomy.

In the German strategy, public procurement is an additional relevant strategy which may be utilized to encourage the development of goods produced with bio resources.

Indeed, the market power and role model function of the public sector may operate as market boosters for new products (BMBF & BMEL, 2020, p.44).

In the Italian strategy, moreover, the development of cooperation between Mediterranean countries is stressed, since Italy has a relevant and strategic role in the Mediterranean basin, for its geographical and political position. The German strategy instead focuses more on cooperation and dialogue with the other European counterparts.

The social aspects related to the bioeconomy are also more mentioned in the Italian strategy compared to the German one. Italy's strategy dedicates a chapter to the social dimension of bioeconomy, claiming that in order for a feasible transition to the bioeconomy paradigm, also the society must transform. Therefore, it is important to promote social awareness and encourage structures that support social structures that will eventually lead to a more conscious behavior.

The topic of biogas plants and biorefineries is mentioned in both researches concerning the two countries, however there is a predominance of this subject in the results regarding Germany. The similarities between the two countries in this field concern the importance that this sector has. Indeed, according to Rojas Arboleda et al. (2021), biogas now is a significant component of Germany's energy mix, particularly as a means of producing electricity, and Fava et al. (2021) state that Italy ranks second, after Germany, in the production of biogas. Nonetheless, the papers concerning biogas in Germany deal more with how the biogas plants will operate in the future, considering that the EEG, the German Renewable Energy Sources Act will come to an end and no more public subsidies will be given to financially support the biogas plants, an issue that will particularly affect the profitability of small size plants.

The corresponding Italian researches do not mention in particular this aspect. Indeed, according to Eyl-Mazzega et al. (2019), the two countries adopted different policy frameworks. While Germany first introduced public subsidies and then converted to an auction-based system based on price ceilings, Italy's support scheme for biomethane is fully financed by transport fuel suppliers. However, only in the transport sector this is feasible, in the other sectors the investment costs are too high. Furthermore, in both countries' researches, it is underlined that, in order to achieve a sustainable and efficient production of biogas, it is necessary to "unlock residues" and adopting a cascading principle (Fava et al., 2021; Theuerl et al., 2019). Therefore, in both countries, it is emphasized the importance of implementing circularity principles to the practices of bioeconomy.

In the papers concerning Italy, the forest sector is more mentioned. Indeed, three researches regard the forestry industry, whereas the research about Germany did not provide any results about this topic. Nevertheless, as also confirmed by Tamantini et al. (2021) and Hetemäki et al. (2017) the forest sector in Europe is mostly underestimated, with the exception of Finland and Sweden. However, forests in Europe are about 40% of the total land area, hence they provide a large potential supply of biomaterial, without competing with food production (Hetemäki et al., 2017).

For what concerns the innovation and development of business models in the framework of circular bioeconomy regarding the two countries, the researches come from Germany, and in particular with the paper of Leipold & Petit-Boix (2018). Here the authors state that there are three main categories of business models related to (circular) bioeconomy and they are mostly related to bio-products. However, the innovation regarding social aspects in the business models is substantially absent. Nonetheless, some hints about a particular sector come from Imbert et al. (2017) that compares the bio-plastic sector in the two countries. In Germany, the industrial systems already encompass path dependencies regarding increasingly sophisticated recycling systems for conventional plastics. On the contrary, in Italy bioplastics have been long advocated as an alternative option for minimizing the environmental repercussions of plastic waste, considering the country's less developed recycling system. This favored the emergence of new actors and alliances.

Another topic that has relevance in the research about Italy but not in the German case is the municipal waste management and utilization. A relevant aspect regarding this topic that might directly policies is that recycling/composting and incineration are competitors for the same product, which is municipal waste. A valorization of waste concerning Germany was also made by Klein et al. (2022). In this case, instead of municipal waste, agricultural products' residues were considered, and the studies reveal how emergent by-product valorization paths create distinctive multi-use systems.

6. Conclusion

In the academic as well as political discussion, the topic of sustainability has been long debated, however sometimes it appears very difficult to implement the measures that are actually needed because of economic, social or political limitations. However, in the current global and European contexts, a new paradigm is urgently required to accommodate the changing environment. Changes will be needed in legislation, production and consumption patterns. In fact, nowadays there is evidence that the current economic system and lifestyle are no longer compatible with the preservation of a healthy state of our planet. The notion of circular bioeconomy has recently made its way into European bioeconomy initiatives and studies, combining the features of bioeconomy and circular economy. In the European context, most nations have adopted a national strategy to address a more sustainable path by the implementation of circular economy and bioeconomy principles. Although, European countries are really diverse, for geographical, cultural economic reasons, thus the various measures must be adapted accordingly. The purpose of this thesis was to capture what the literature has to say about the main characteristics of the countries and find the main differences and similarities about the implementation of a circular bioeconomy strategy. In particular, two countries were considered, Italy and Germany. However, most researches come from the agriculture or chemical sciences, whereas the economic and business-related studies were less present. Moreover, another research gap that might be interesting to address in the future is related to the social aspects related to the topic. In order to successfully change the paradigm, social awareness and dialogue should definitely be enhanced more than now, so people can have the means to better understand the importance of this topic and the relevance this might have for the planet they are living in. However, this has to come from the governments and how they design the policies, also concerning the promotion to the transition to more business models related to circular bioeconomy. In fact, beside engaging the whole society to these themes, they should provide the right incentives and encourage the research and innovation concerning the topic. In this sense, Germany seems to perform better, not only compared to Italy but also compared to the other European countries and is considered a leader in this field. One aspect that has particular relevance in the literature is the biogas and biorefineries plants. In fact, in the researches concerning both the two countries this topic is mentioned in several papers. The production and supply of energy is an issue that has always played a major role in political debates,

especially since when we became aware that fossil resources are not infinite and their residues create environmental and health problems and the discussion about renewables sources of energy has gained momentum. However, since a few months, and precisely since when the war in Ukraine started, it is even more relevant and plays a vital role for the European economies, especially for those countries like Germany and Italy that are strongly dependent from foreign energy sources. Indeed, according to Eurostat (2022) the energy imports dependency of Germany was around 63% and Italy was around 73%. In particular, Germany imports 66.1% of natural gas from the Russian Federation and Italy 43.3%, according to (Eurostat, 2022). Hence, it is clear that a development of alternative sources of energy is needed, not only for sustainability concerns but also in order to avoid shortage threats that might eventually arise. Biomass has been a significant and adaptable source of renewable energy for many decades, and it is projected that to play a considerable role in the future. The possible uses of bio-mass are manifold, although it is necessary that its production and use is appropriately governed (Thrän et al., 2020).

7. References

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Appendix

Results from search string Germany

Authors	Title	Year	**Source title**	DOI	Link
[No author name available]	Sustainable Tourism X	2022	WIT Transactions on Ecology and the Environment		https://www.scopus.com/inward/record.uri?eid=2-s2.0-85136293493&partnerID=40&md5=3791564c8e58a11fd55036c2c8a38873

[No author name available]	19th International Multidisciplinary Scientific Geoconference, SGEM 2019	2019	International Multidisciplinary Scientific GeoConference Surveying Geology and Mining Ecology Manage		https://www.scopus.com/inward/record.uri?eid=2-s2.0-85084371597&partnerID=40&md5=eb89ba343cd5a38b5e3902ebacd9d91f

			ment, SGEM		
Dallendörfer, M., Diekeln, S., Hensleit, M., Siekmann, F., Venghaus, S.	Investigating citizens' perceptions of the bioeconomy in Germany – High support but little understanding	2022	Sustainable Production and Consumption	10.1016/j.spc.2021.11.009	https://www.scopus.com/inward/record.uri?eid=2-s2.0-85120446319&doi=10.1016%2fj.spc.2021.11.009&partnerID=40&md5=5f4cee97adba12e3e88dafdc669311a3

Duque-Acevedo, M., Belmonte-Ureña, L.J., Yakovleva, N., Camacho-Ferre, F.	Analysis of the circular economic production models and their approach in agriculture and agricultural waste biomass	2020	International Journal of Environmental Research and Public Health	10.3390/ijerph17249549	https://www.scopus.com/inward/record.uri?eid=2-s2.0-85098202782&doi=10.3390%2fijerph17249549&partnerID=40&md5=e499b885e5074903d842221cc10086bf

	management				
Gawel, E., Purkus, A., Pannicke, N., Hagemann, N.	A governance framework for a sustainable bioeconomy: Insights from the case of the German wood-based	2018	World Sustainability Series	10.1007/978-3-319-73028-8_26	https://www.scopus.com/inward/record.uri?eid=2-s2.0-85071494101&doi=10.1007%2f978-3-319-73028-8_26&partnerID=40&md5=1d376bdd8eca3ae085be1386292dfcf9

	bioeconomy				
González-Arias, J., Baena-Moreno, F.M., Gonzalez-Castaño, M., Arellano-García	Unprofitability of small biogas plants without subsidies in the Brandenburg region	2021	Environmental Chemistry Letters	10.1007/s10311-020-01175-7	https://www.scopus.com/inward/record.uri?eid=2-s2.0-85099433313&doi=10.1007%2fs10311-020-01175-7&partnerID=40&md5=d05f7e662f241010e0eab8c9159102dd

a, H., Lichtfouse, E., Zhang, Z.					
Jiménez, D.J., Öztürk, B., Wei, R., D.bugg, T., Gomez, C.V.	Merging Plastics, Microbes, and Enzymes: Highlights from an International	2022	Applied and Environmental Microbiology	10.1128/aem.00721-22	https://www.scopus.com/inward/record.uri?eid=2-s2.0-85135381919&doi=10.1128%2faem.00721-22&partnerID=40&md5=8872dba79f30933579f09c636e5cdbe1

A., Galan, F.S., Castro-Mayorga, J.L., Saldarriaga, J.F., Tarazona, N.A.	Workshop				
Kardung, M., Drabik, D.	Full speed ahead or floating	2021	Ecological Economics	10.1016/j.ecolecon.2021.107146	https://www.scopus.com/inward/record.uri?eid=2-s2.0-85109573066&doi=10.1016%2fj.ecolecon.2021.107146&partnerID=40&md5=b214a9e856e39ee4c03a61719e5a6b2c

	around? Dynamics of selected circular bioeconomies in Europe				
Klein, O., Nier, S., Tamásy, C.	Towards a Circular Bioeconomy? Pathways and Spatialities of	2022	Tijdschrift voor Economische en Sociale Geografie	10.1111/tesg.12500	https://www.scopus.com/inward/record.uri?eid=2-s2.0-85117134096&doi=10.1111%2ftesg.12500&partnerID=40&md5=8fa970e3de4a7b09459ea3b19c17835c

	Agri-Food Waste Valorisation				
Leipold, S., Petit-Boix, A.	The circular economy and the bio-based sector - Perspectives of European and German stakeholders	2018	Journal of Cleaner Production	10.1016/j.jclepro.2018.08.019	https://www.scopus.com/inward/record.uri?eid=2-s2.0-85053038776&doi=10.1016%2fj.jclepro.2018.08.019&partnerID=40&md5=e798571baf4b4341791cb1fa68bdca97

Rojas Arboleda, M., Pfeiffer, A., Bezama, A., Thrän, D.	Anticipatory study for identifying the key influential factors of the biogas system in Germany contributing to the	2021	Futures	10.1016/j.futures.2021.102704	https://www.scopus.com/inward/record.uri?eid=2-s2.0-85101696132&doi=10.1016%2fj.futures.2021.102704&partnerID=40&md5=ce4c48a7375ccaeb71bc0686dbed9869

	energy system of 2050				
Theuerl, S., Herrmann, C., Heiermann, M., Grundmann, P., Landwehr, N., Kreid	The future agricultural biogas plant in Germany: A vision	2019	Energies	10.3390/en12030396	https://www.scopus.com/inward/record.uri?eid=2-s2.0-85060943848&doi=10.3390%2fen12030396&partnerID=40&md5=075a762552d2c87a7cca5df61c072d71

enweis, U., Prochnow, A.					
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Piana, P., Ingrao, C., Bertino, A.	to apply bio economy in the sustainable steel sector		ce, Engineering and Management		

Erklärung*

Hiermit erkläre ich,

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Matrikelnummer **936242**

dass ich bei der vorliegenden

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Circular Bioeconomy: A comparison of structural Differences and Similarities between Germany and Italy

Semester **4th Semester**

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