



---

## CONCEPTS AND KEY SECTORS OF THE BIOECONOMY

**R. Beluhova-Uzunova\*, M. Shishkova, B. Ivanova**

Department of Economics, Agricultural University – Plovdiv, Plovdiv, Bulgaria

### ABSTRACT

Although the bioeconomy as a concept emerged in the late 20th century, it has generated a significant interest among researchers, policy makers and businesses in the last decade. The interdisciplinary character of the bioeconomy gives an opportunity to address major global challenges, both economic and environmental. The aim of the article is to outline different definitions, concepts, as well as to highlight the key bioeconomy sectors. The paper focuses on the links between the bioeconomy and circular economy, sustainable development, implementation of innovation, value chain formation as well as regional specialization. The survey applies historical, comparative, monographic methods of analysis. The theoretical roots and evolution of the concept are observed. The study analyses different approaches and perspectives regarding the bioeconomy sectors. The results indicate that there is no clear consensus on the definitions and key sectors of the bioeconomy in the global context. Despite the worldwide interest in bioeconomy, there are various challenges associated with the design and implementation of individual national, regional bioeconomy strategies, which could ensure the development of smart specialisation and green growth.

**Key words:** bioeconomy, transition, circular economy, sustainable development, green growth

### INTRODUCTION

The concept of bioeconomy has gained wide popularity over the past decade. The topic became part of various reports and strategies in a number of countries. Bioeconomy definitions and perspectives shift from factor substitution to biotechnology innovation perspective and nowadays the concept is much more complex and environmentally oriented than before.

The aim of the study is based on a literature review to outline different definitions, concepts and to highlight the key sector of the bioeconomy as well as the opportunities for the development of the sector. The paper focuses on links between bioeconomy and the circular economy, sustainable development and innovations.

The article is structured as follows: 1) the first part of the study outlines the material and methods of the survey. 2) The second section

focuses on the history and definition of bioeconomy. 3) In the third part, the concepts, vision and dimensions of the bioeconomy are presented. 4) The fourth part analyses the key sectors of the bioeconomy and their contribution to the EU-28 development. In the last section, some conclusion and recommendation are highlighted.

### MATERIALS AND METHODS

The survey applies historical, comparative, monographic methods of analysis. The key sectors of the bioeconomy are analyzed based on a review of policy documents, strategies, and statements in the respective field for a selected number of countries. The data related to the trends in bioeconomy is based on Eurostat database and Nova Institute surveys.

### BIOECONOMY- HISTORY AND DEFINITIONS

The use of natural resources and the development of farming could be traced back to about 10,000 BC (1). Since then, science has evolved and changed significantly. Progress in the field of life sciences and biotechnology has been a starting point for the emergence of the

---

**Correspondence to:** *Rositsa Beluhova-Uzunova, Department of Economics, Agricultural University – Plovdiv, 12 Medeleev Bld., 4000 Plovdiv, Bulgaria, e-mail: rosicab\_uzunova@abv.bg*

concept of bioeconomy (2). Although agriculture is one of the oldest sectors developed in parallel with human progress, the global challenges transformed it to a major topic in scientific word and policy agenda.

There is no universally accepted definition of the bioeconomy (3). The term “bioeconomics” was introduced by British biologist Hermann Reinheimer in “Evolution by Co-operation: A Study in Bioeconomics” published in 1913 (4). The author stressed the need for collaboration and development. In turn, Georgescu-Roegen was one of the first economists that pointed out the problems related to climate change and sustainability. He introduced the comprehensive theory of economic development, institutional change and biophysical constraints (5). According to Roegen “biological origin of the economic process and thus spotlight the problem of mankind's existence with a limited store of accessible resources unevenly located and unequally appropriated” (6).

An essential element in Georgescu-Roegen's use of the term bioeconomics was his concern that unlimited growth would not be compatible with the fundamental laws of nature (7).

The bioeconomy concept, however, gained popularity in the last decades of the XX century. This term started to differ from the early use of “bioeconomics”, which referred to the biological knowledge for commercial and industrial purposes (8). Bioeconomy was part of the strategic documents of the European Commission, including the 1993 White Paper. The strategic agenda outlined the importance of investments and innovative biotechnology for development (9).

Enriques and Martinez have offered one of the first definitions of the bioeconomy that attracted the attention of policy makers. According to the authors “bioeconomy as an economic activity based on scientific research and implementation focused on understanding the mechanisms and processes at the molecular (genetic) level, with the aim to implement and use it in industrial processes” (10).

Bioeconomy as a concept is highlighted in the 2001 OECD report (11) and in the strategy paper “The Bioeconomy to 2030: Designing a policy” (12). According to OECD “bioeconomy means the exchange of

knowledge resulting from the natural sciences to the new, environmentally friendly eco-efficient and competitive products” (12).

The European Commission presented several documents related to the topic. In 2010 the paper “Bioeconomy for Europe” introduced some production models based on biological processes and natural ecosystems (13). Bioeconomy, however, was defined in the strategy of using renewable biological resources in various sectors of the economy (14). According to this definition “bioeconomy is the sustainable production of renewable biological resources and their processing into food products, feed and industrial goods and into bioenergy” (14).

Although there are similarities between the definition of the EC and OECD, the latter one is focused more on the industrial biotechnology, biofuels, biorefineries, chemical industry, transport, and recycling.

Bioeconomy was also part of the discussions in the USA. According to the definition from the White House “bioeconomy is an economy based on the use of research and innovation in biological sciences in order to power the economic activity and to generate public profits (2).

The European Commission definition, however, is still under consideration. In the report (2016) entitled “European Bioeconomy Stakeholders Manifesto” the so-called “from cradle to grave” the concept was introduced. It focuses on applying the principle of cascading in the biomass chain; creating and strengthening the concept of “product life cycle” and “value chains” within the scope of bioeconomy (15).

With the update of the Bioeconomy strategy, a new definition was presented - “bioeconomy covers all sectors and systems that rely on biological resources –animals, plants, micro-organisms and derived biomass, including organic waste – as well as their functions and principles” (16).

The concept of bioeconomy is transforming in parallel with the perspectives and global goals and challenges. It should be noted that the definitions differ not only on international but also on a national and regional level.

**CONCEPTS, PERSPECTIVES AND DIMENSIONS**

In the first two decades of XXI century, the concepts related to bioeconomy and its elements and dimensions reshaped. Different reports stressed various aspects of the topic. In 2007 the so-called Cologne Paper, based on a workshop in the same city, emphasized the two dimensions of bioeconomy. On one hand, the paper highlights the role of biotechnology and on the other; bioeconomy was associated with the opportunities for resource substitution (17). In parallel with the reports in the EU, OECD outlined three elements of the bioeconomy (12):

- advanced knowledge for the development of new processes and products;
- using of renewable biomass for sustainable production;
- integration of knowledge of biotechnology in order to apply it in a wide range of sectors.

The policy agenda efforts to define and identify bioeconomy dimensions led to significant interest in the scientific world. Adamowicz has recognized the bioeconomy:

“as a separate sector of the modern economy; a new analytical and cognitive concept of scientific nature; a cross-sector, strategic form of analysis and programming of practical and scientific activities (18).

Based on an analysis of the origins and the diffusion of the bioeconomy concept across scientific fields, Bugge et.al (19) has identified the three perspectives of the bioeconomy. The first one is the biotechnology perspective, which focuses on the significant role of biotechnology and its application. The second one is the so-called bio-resource perspective that emphasizes on the research, development and establishment of new value chains. The last one is the bio-ecology perspective that outlines the importance of ecological processes.

Based on the elements and dimensions of the bioeconomy, the concept shifted and changed its perspective. Birner distinguished two phases in the development of bioeconomy (**Table 1**): 1) the resource substitution perspective and 2) the biotechnology innovation perspective (8).

*Table 1. Bioeconomy perspectives*

<b>Perspectives</b>	<b>Resource substitution perspective (first decade of the twenty-first century)</b>	<b>Biotechnology innovation perspective (second decade of the twenty-first century)</b>
<b>Relation to fossil resources</b>	Peak oil”, scarcity of fossil energy resources	New exploration technologies for oil; low, volatile prices
<b>Driving forces</b>	Expectation that prices will continue to increase	Advances in the biological sciences, new priorities in Agenda 2050
<b>Rationale</b>	Resource substitution	Innovation for sustainable development

Source: (8), (36)

Even though biotechnology innovation was recognized from the very beginning as an opportunity for the bioeconomy, the resource substitution perspective was more prominent in the first decade of the twenty-first century (8). According to the author the “peak oil” and increasing prices of the oil led to growing interest in biomass use. On the other hand, the raising crops area for biofuel and the biofuel policy and subsidies affect the food prices and cause their growth. These processes led to serious debate associated with food security and forced the implementation of new generation technologies and the use of waste products. The oil prices remain difficult to project, but the scarcity of oil was no longer an

argument for the resource substitution perspective (20).

The development of bioeconomy as a concept was accompaniment with raising criticism in two major aspects. Gottwald and Budde claim that the bioeconomy concept is directed to big enterprises and their interest and stimulates land grabbing and could not solve the problems with food security (21). On the other hand, the World Wide Fund for Nature pointed out that the real potential of bioeconomy is not fully realized and implemented (22). The criticism and the global challenges related to climate change and sustainability remodel the perspective and shifted it toward the

biotechnology innovations for sustainable development. In the second decade of the XXI century, the environmental challenges were included in definitions, policy agenda and strategic plans and papers. The processes of "greening" of bioeconomy emerged and the concept was linked to the green and circular economy (8, 23).

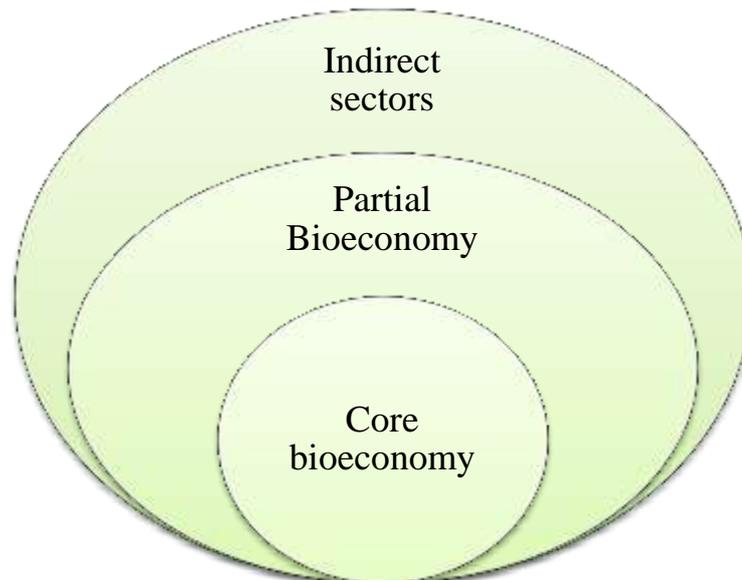
**KEY SECTORS OF THE BIOECONOMY**

In the past decade, more than 50 countries published bioeconomy related or dedicated strategies and even more are planning to develop strategic documents (24). Policy initiatives already exist at the supra-national level: the Scandinavian countries have founded the Nordic Bioeconomy and there is a special initiative BIOEAST in the Central and Eastern European countries (25, 26). This initiative points out that an east-west divide exists in the EU, with eastern countries serving only as raw material providers for big companies in the west and having limited access to research (27). Developing bioeconomy strategies for CEE countries could help in overcoming imbalances and better exploiting the existing potential. In the strategies, however, the definition and classification of bioeconomy sector vary. For example, the Netherlands highlights the bio-based economy, excluding the agriculture and food sectors (28). The United States exclude the energy, food, feed,

livestock, and pharmaceutical industries (29). There is no universally accepted classification, but it is really important to define which sectors to include in bioeconomy, especially when trying to measure its contribution to the international and national economy in terms of GDP and value added since the calculations would only take the included sectors into account (30).

Different authors and organization (31-34) analysed the sectors of the bioeconomy, their links and contribution. However, these surveys are not fully comparable because the sector varies among studies.

According to the new 2018 European Bioeconomy Strategy: "It includes and interlinks: land and marine ecosystems and the services they provide; all primary production sectors that use and produce biological resources (agriculture, forestry, fisheries and aquaculture); and all economic and industrial sectors that use biological resources and processes to produce food, feed, bio-based products, energy and services (biomedicines and health biotechnology are excluded)" (16). Based on the EU definition, a survey conducted by the European Commission classified the bioeconomy sectors as core bioeconomy, partial and indirect sectors (35).



**Figure 1.** Bioeconomy sectors

Source: (35)

Based on **Figure 1**, it could be concluded that there are certain core bioeconomy includes: agriculture, fishing and forestry, food industry and bioenergy, biofuels. Other sectors are part

of the bio-based economy, so as a partial bioeconomy are classified: chemical and plastic industry, construction, pharmaceutical

and textile industry, waste management and biotechnology.

The indirect sectors have an indirect impact as technologies, machinery, retail trade, water supply, services.

The basis for achieving sustainable results in the bioeconomy application, especially given its multi-sectoral dimension, is building cooperation between/among stakeholders (including research and development organizations, policy-makers and entrepreneurs). For this purpose, the relevant research and development need to be largely oriented towards solving specific problems faced by businesses. Addressing global challenges in combination with entrepreneurs'

individual goals would be a good basis for rapidly spreading innovative practices and their sustainable implementation. In this case, the role of policy makers is crucial. The latter is determined by the need to establish a regulatory framework as well as financial support for the implementation of bio-economic activities. In this regard, it is necessary to set up networks to support the dissemination of information among the stakeholders in such a way as to enable the achievement of the stated objectives and the satisfaction of the consumer's needs. Based on the European Commission classification contribution of bioeconomy to the European economy is presented in **Table 2** (37).

**Table 2.** Contribution of bioeconomy sectors to the total bioeconomy labour market, turnover and value added (%), EU-28, 2015.

Sector	Workers	Turnover	Value Added
Agriculture	51.0	16.8	28.0
Forestry	3.0	2.2	3.8
Fishing	1.2	0.5	1.1
Manufacture of food, beverages and tobacco	25.1	51.0	37.6
Manufacture of bio-based textiles	5.6	4.6	4.6
Manufacture of wood products and furniture	7.8	7.7	7.6
Manufacture of paper	3.6	8.3	7.3
Manufacture of bio-based chemicals, pharmaceuticals, plastics and rubber (excluding biofuels)	2.5	7.8	9.1
Manufacture of liquid biofuels	0.1	0.5	0.4
Production of bioelectricity	0.1	0.5	0.5

Source: (37)

According to the results, in the EU-28 bioeconomy work 18 million people. The sectors form EUR 2.3 trillion turnover and generate EUR 620 million value added. Bioeconomy represents 8% of the EU-28 labour force and 4% of the GDP. Agriculture and the manufacture of food, beverages and tobacco concentrate more than 67% of the value added and turnover and 76% of bioeconomy employment.

Although agriculture accounts for 51% of bioeconomy workers, it forms only 28% of the bioeconomy value added, which show lower productivity. By contrast, the manufacture of food, beverages and tobacco generates 37% of the bioeconomy value added. The manufacture of bio-based chemicals, pharmaceuticals, plastics and rubber (excluding biofuels) represent less than 3% of the labour force in the bioeconomy, but accounts for more than 9% of the value added. For the period 2008-

2015 the bioeconomy employment decreases while value added is increasing. The number of the labour force is reduced mainly because of the restructuring of the agricultural sector. On the other hand, the value added and labour productivity are increasing (31).

According to the European Commission in Bulgaria bioeconomy sectors employ 413 466 people and generate EUR 3 741 million value added and EUR 13 107 million turnover (37). In Bulgaria, there is relatively lower bioeconomy employment compared to the EU average (38%) compensated by a strong contribution of the forestry sector. On the other hand, the manufacture of bio-based textiles accounts for 15% of the labour force. By contrast, the bio-based chemicals, pharmaceuticals, plastic and rubber are underrepresented in the bioeconomy labour market and generated value added. The bioeconomy pattern is related to biomass-

producing sectors and the manufacture of food, beverage and tobacco sector. More labour-productive sectors are not very developed. The apparent labour productivity in all bioeconomy sectors is lower than the EU-28 average. Therefore, there remains a large potential for the development of the bioeconomy and challenges to overcome (27).

## CONCLUSIONS

Based on the analysis some conclusions and recommendation could be drawn:

1. The results indicate that there is no clear consensus about the definitions of bioeconomy in a global context. The concept of bioeconomy has evolved and has changed in order to address the emerging world challenges and it is related to the concept of the circular economy and the green economy.
2. There is no clear classification of the key sector of the bioeconomy, in this respect, the comparison between different studies, reports and strategies becomes more difficult.
3. Despite the worldwide interest in the bioeconomy, there are challenges associated with the design and implementation of national, regional bioeconomy strategies, which could ensure the development of smart specialization and green growth.
4. It is recommended the potential of bioeconomy to be presented and introduced to the society via platforms, events and workshops. Some education measures could be taken into account including master courses in Bioeconomy and of some subjects in the current university programs.
5. In general, there is a necessity for more cooperation and coordination at the international level in order to promote bioeconomy development and to enhance the potential of the concept. Global governance of the bioeconomy is very important and needs to be developed. On the other hand, cooperation and coordination between science and business are necessary in order to put into practice the principles of the bioeconomy.
6. Farmers and other stakeholders should be encouraged to implement bioeconomy activities and to realize its benefits and potential.

## ACKNOWLEDGEMENTS

This paper was supported by the Bulgarian Ministry of Education and Science under the

National Research Program "Healthy Foods for a Strong Bioeconomy and Quality of Life" approved by DCM # 577 / 17.08.2018"

## REFERENCES

1. Bocquet-Appel, J., When the World's Population Took Off: The Springboard of the Neolithic Demographic Transition. *Science*, 333 (6042): 560–561, 2011.
2. White House, National Bioeconomy Blueprint. The White House Washington, 2012
3. OECD, Meeting Policy Challenges for a Sustainable Bioeconomy. OECD Publishing, Paris, 2018.
4. Reinheimer, H., Evolution by Co-operation: A Study in Bio-economics. London: Kegan Paul, Trench, Trubner and Co., 1913.
5. Mayumi, K. Nicholas Georgescu- Roegen: His Bioeconomics Approach to Development and Change. *Development and Change Forum*, Volume 40, Issue 6, 2016.
6. Georgescu-Roegen, N., Inequality, Limits and Growth from a Bioeconomic Viewpoint. *Review of Social Economy*, Volume XXXV, Issue 3, pp. 361-375, 1977.
7. Bonaiuti, M., Bioeconomics. In Degrowth: A Vocabulary for a New Era Ed: D'Alisa, J. et.al., Routledge, London, 2014.
8. Birner R., Bioeconomy Concepts. In: Lewandowski I, Bioeconomy. Springer, Cham, 2018
9. European Commission, Growth, competitiveness, and employment. The challenges and ways forward into the 21st century. COM (93) 700 final. Brussels: 05.12.1993.
10. Martinez, J., Genomics and the World's Economy. *Science Magazine*, vol. 281 no 5379 pp. 925-926, 1998.
11. OECD. The Application of Biotechnology to Industrial sustainability, 2001.
12. OECD. The Bioeconomy to 2030: Designing a Policy Agenda. International Futures Programme, 2009.
13. European Commission, Bioeconomy Europe 2020. A Strategy for Smart, Sustainable and Inclusive Growth, Brussels, 2010.
14. European Commission, Innovating for Sustainable Growth: A Bioeconomy for Europe, Luxembourg: Publications Office of the European Union, 2012.
15. The Fourth BioEconomy Stakeholders' Conference, European Bioeconomy Stakeholders Manifesto. Building blocks.

- Draft version; Dutch Ministry of Economic Affairs: Utrecht, The Netherlands, 2016.
16. European Commission, Updated Bioeconomy Strategy 2018, Luxembourg: Publications Office of the European Union, 2018.
  17. EU, En route to the knowledge-based bioeconomy (“Cologne Paper”) German Presidency of the Council of the European Union (EU), Cologne, 2007.
  18. Adamowicz, M., European concept of bioeconomy and its bearing on practical use, *Economic and Regional Studies*, Volume 7 No 4, 2014.
  19. Bugge, T. et.al, What is the bioeconomy? A review of the literature. *Sustainability*, 8 (2016), pp. 1-22, 2016.
  20. Baumeister .C and Kilian L., Forty years of oil price fluctuations: why the price of oil may still surprise us. *J Econ Perspect* 30(1):139–160, 2016.
  21. Gottwald, F. and Budde J., Mit Bioökonomie die Welt ernähren?. Institut für Welternährung – World Food Institute, Berlin, 2015.
  22. World Wide Fund for Nature, Industrial biotechnology – more than green fuel in a dirty economy? World Wide Fund for Nature (WWF), Copenhagen, 2009.
  23. Socaciu, C., Bioeconomy and green economy: European strategies, action plans and impact on life quality. *Bulletin UASVM Food Science and Technology*, 71, 2014.
  24. Bracco, S. et.al, Assessing the Contribution of Bioeconomy to the Total Economy: A Review of National Frameworks. *Sustainability* 2018, 10.
  25. Refsgaard, K. et.al., The Rapidly Developing Nordic Bioeconomy: Excerpt from State of the Nordic Region. Nordic Council of Ministers: Copenhagen, Denmark, 2018.
  26. BIOEAST Vision Paper. BIOEAST-Central and Eastern European Initiative for Knowledge-Based Agriculture, Aquaculture and Forestry in the Bioeconomy, 2018.
  27. Ronzon, T. And M’Barek, R., Socioeconomic Indicators to Monitor the EU’s Bioeconomy in Transition. *Sustainability*, 10, 2018.
  28. CE Delft., Sustainable Biomass and Bioenergy in The Netherlands: Report 2015. CE Delft: Delft, the Netherlands, 2016.
  29. United States Department of Agriculture. An Economic Impact Analysis of the U.S. Biobased Products Industry: 2016 Update, United States Department of Agriculture (USDA): Washington, DC, USA, 2016.
  30. SAT-BBE, Tools for Evaluating and Monitoring the EU Bioeconomy: Indicators; Systems Analysis Tools Framework for the EU Bio-Based Economy Strategy. The Hague, The Netherlands, 2013
  31. Nova Institute, European Bioeconomy in Figures. Commissioned by Bio-Based Industries Consortium, 2016.
  32. The Nordic Bioeconomy Initiative. NordBio: Final report, Copenhagen: Nordisk Ministerråd, 2017.
  33. Capital Economics, The British Bioeconomy. An assessment of the impact of the bioeconomy on the United Kingdom economy, 2015
  34. Italian Presidency of Council of Ministers, BIT – Bioeconomy Strategy for Italy. Consultation Draft (English Version), 2016.
  35. European Commission, Bioeconomy development in EU regions Mapping of EU Member States’ / regions’ Research and Innovation plans & Strategies for Smart Specialisation (RIS3) on Bioeconomy, Luxembourg: Publications Office of the European Union, 2017.
  36. BÖR, Positions and strategies of the German bioeconomy – decided at the 8th session of the council 14.5.2014 German Bioeconomy Council (Bioökonomierat – BÖR), Berlin, 2014
  37. EUROSTAT DATABASE