

# Bioeconomy Concept and Its Relation to Circular Economy and Resource Management

Martin Greimel 

Centre for Bioeconomy, BOKU University

[martin.greimel@boku.ac.at](mailto:martin.greimel@boku.ac.at)

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## ABSTRACT

Bioeconomy is referred as a main contributor to solve several of the big societal challenges (e.g. biodiversity loss, climate change, raw material shortage, etc.). But the concept of Bioeconomy does not have a general acknowledged description. This article gives a historic background, describes the present concepts and gives an overview of planned political strategies and action plans.

## Introduction

During the first oil shock, when mankind swiftly became aware of the finite nature of fossil resources, the concept of the Bioeconomy, which had already been philosophized about by Linnaeus and Darwin, made its first career (Reinheimer, H. 1913). Cautionary calculations about the limits of growth or measures such as the “Car-free day” and a return to “Mother Earth” were based on scientific considerations about the Bioeconomy. The holistic approaches that emerged at that time are now subsumed under the term “Ecological Bioeconomy” (Zawojcka und Siudek, 2016). When oil prices fell again, bioeconomic considerations quickly lost their appeal.

At the beginning of the 21st century, the Bioeconomy began a second career. By this time industrialized countries recognized biomass as a new economic factor. The Bioeconomy was now defined as the replacement of non-renewable raw materials with biomass (Patermann und Aguilar, 2018). With this “Substitutive Bioeconomy”, new sustainable products and materials were to be developed

from biomass, or fuels were no longer to be produced from crude oil but from biomass.

However, the “Substitutive Bioeconomy” has shown its pitfalls: In the first decade of the 2000s more corn was grown for fuel than for food production in the USA. The price of corn quadrupled on the Chicago mercantile exchange and as a consequence the price of corn for tortilla production in Mexico was suddenly four times as high, which led to social tensions.

Building on the knowledge gained, a sustainable circular Bioeconomy, also known as a “Transformative Bioeconomy” (Friedrich, et al. 2021; Ramcilovic-Suominen, et al., 2022; Eversberg und Fritz, 2022; Pungas, 2023) is developing today.

## Materials and methods

### *Sustainable circular bioeconomy*

Earth is currently the only known planet in the solar system that provides a habitat for living beings. As the Earth is a

closed system (with the exception of solar energy), all raw materials are available in limited quantities. In the current linear economic system, we extract raw materials from the planet and process them into material or energy products. Now that the demand for the limited available raw materials has risen sharply due to the industrial revolution and the increase in the earth's population, a shift away from the linear economic system towards a circular economy is inevitable.

The aim of the sustainable, circular Bioeconomy is to increasingly replace raw material requirements with renewable raw materials (biomass). Renewable raw materials grow in large quantities every year with the help of solar energy. All other raw materials, such as fossil or mineral raw materials, take millions of years to be created or renewed. All raw materials on earth are subject to a natural cycle. However, this cycle has been altered in many ways by human production and consumption and is no longer sustainable (Eversberg, et al., 2023a; Giuntoli, et al., 2023; Schmidlehner, 2023; Giampietro, 2023b). In order to prevent further negative changes and effects (climate change, loss of biodiversity, etc.) the cycle must be made sustainable again and the demand for raw materials must be greatly reduced. The sustainable, circular Bioeconomy strives to achieve this while taking economic, ecological and social aspects into account.

## Results and discussions

### *Principles of the sustainable, circular bioeconomy*

The 2nd thermodynamic principle states that the concentration of matter decreases with a change of state (i.e. use) and can only be maintained or increased by adding energy. What does this mean in practice? Even in the utopian state of a perfect circular economy, there will always be energy and material losses in the processes (e.g. sampling, sorting, transporting, etc.) and both new material and energy must be added to compensate for the losses (Georgescu-Roegen and Nicholas, 1971). Since biomass, in contrast to all other raw materials, grows back in periods relevant to humans and the energy required for recycling is covered 100% by the sun, it should generally be prioritized as a source of raw materials. However, it is important to bear in mind that, on the one hand, the globally sustainably available biomass is limited and, in addition to human use, biomass serves to preserve all ecosystems which are again the basis for human life (Erb, et al., 2022).

In order to remain within global boundaries, a sustainable, circular Bioeconomy is based on the efficient design of processes (efficiency) in a regenerative circular

economy (consistency) with greatly reduced raw material requirements (sufficiency).

*Efficiency* refers to the design of processes and the development of new innovations. This enables highly effective use of the available biomass, where residual materials serve as recyclables for other applications.

*Consistency* is understood to mean systems that are in harmony with natural processes and the recycling of available raw materials should be optimized for this purpose. It should be noted that there are losses in every process due to physical laws (2nd thermodynamic law, see above).

*Sufficiency* is understood as the reduction of resource consumption based on the amount of raw materials and energy that is sustainably available.

These principles should be combined in such a way that social needs can be met through the use of biomass.

### *Challenges in the Bioeconomy*

A major limiting factor for the Bioeconomy is the limited availability of biomass (Erb, et al. 2022). From this point of view, the key question is what the available biomass should be used for: as food, as animal feed, for the manufacture of material products or as a source of energy? In most cases, energy use excludes further material use (an exception is, for example, the production of biochar, where energy is obtained and a product is produced at the same time), while energy use is still possible after material use. It is therefore essential to define a hierarchy of use (cascading use) for the available biomass in order to prevent conflicts of use and interest due to the limited availability of biomass.

The transformation to a circular Bioeconomy increases the demand for biomass. However, despite cascading use, not enough biomass can be provided to produce the same number of products as we produce today with non-renewable materials. "The same as before but in green" does not solve the social challenges of our time (Hausknost, et al., 2017). The sustainable, circular Bioeconomy has recognized this and, in addition to technically feasible and ecologically justifiable solutions, also focuses on increasing social acceptance of sufficiency: "What do I not need and still be happy".

### *Future developments and strategies*

Beside several regional bioeconomy strategies, more than 60 countries worldwide have already published a national Bioeconomy strategy or a Bioeconomy related strategy. At European level, the first Bioeconomy strategy was published in 2012 and revised in 2018. A further revision

is currently planned for 2025 (EU Europe, 2025). The evaluation of the European Bioeconomy strategy is a good example how the concept of the Bioeconomy is still under development. In 2022, the EU Commission presented a progress report on the basis of which, together with the 2023 reports from the Joint Research Centre (JRC), the European Council called on the Commission to revise the Bioeconomy strategy once again. In the aforementioned reports, the political context questions for the first time whether the necessary transformation is compatible with the “green growth” paradigm pursued by the Green Deal and the Bioeconomy strategy. However, the strategies based on economic growth, technological innovation and anthropocentric values have not led to the desired social and ecological changes. The JRC reports (Giuntoli et al. 2023) therefore present perspectives that are underrepresented in the Bioeconomy discourse and integrate them into an alternative vision for a “green, just and sufficient Bioeconomy”. This vision places environmental sustainability and social justice - independent of economic growth - at the centre.

## Conclusion

Transforming the Bioeconomy requires us to reflect on the stories we tell about ourselves, our place in nature and our relationship with each other. A participatory perspective with care, respect and reciprocity for and with other humans and non-humans is central to this. Technologies are important to achieve the green, just and sufficient Bioeconomy goals, but ethical considerations for new technologies need to be openly discussed.

Similar considerations to those in the JRC report are presented in the “Bioeconomy Youth Vision” of the EU Youth Ambassadors in 2024 as part of the Bioeconomy Changemakers Festival and at the same time 70 NGOs called in a position paper for the new EU Bioeconomy strategy to be both environmentally sustainable and socially just.

These documents indicate that, from the perspective of both science and civil society, the current revision of the Bioeconomy strategy should focus on a “new transformative Bioeconomy”. The areas of ecological sustainability and social justice should play a particularly important role in this.

The Circular bio-based Europe Joint Undertaking (CBE) organizes annual calls for projects. The design of the 2024 call for projects shows that the bio-based industry is aware that the raw material biomass is a scarce commodity and must therefore be used more consciously, efficiently,

sustainably and in a cascading manner. Furthermore, there is also a focus on biogenic niche raw materials (e.g. microalgae, yeasts, insects) and opportunities to utilize side streams/waste from the bio-based industry that are currently not or only little used.

Cooperation with the primary producers of biomass is also being intensified. Particular attention is being paid to the production of biomass outside of food and animal feed production.

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#### Declarations of interest

*The author declares no conflict of interest concerning the research, authorship, and/or publication of this article.*

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