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Literature Review

A Literature Review of International Bioeconomy Strategies

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Abstract

Since the 21st century, developed countries have paid increasing attention to bioeconomy strategies. In particular, since the spread of the New Crown Pneumonia epidemic, global biotechnology has surged, and the impact of significant public health and safety events has continued to escalate. Bioeconomy strategies have received unprecedented attention. In this context, sorting out and studying international bioeconomy strategies is essential. Therefore, this paper reviews selected national bioeconomy strategies and explored their characteristics.

Introduction

Bioeconomy is an economic state that corresponds to the agricultural, industrial, and information economies. The concept of "bioeconomy" first appeared in the late 20th century. In August 1999, the U.S. government introduced the idea of the "biologically based economy," marked by Clinton's Presidential Directive 13134, "*Development and Promotion of Bio-based Products and Bio-energy*." In May 2000, Davis and Meye introduced the formal concept of *Bioeconomy* [1]. Subsequently, the European Union and the Organisation for Economic Co-operation and Development (OECD) have put forward strategies and reports on the bioeconomy. In 2004, OECD published the "*Biotechnology for Sustainable Growth and Development*" report. The report explains the bioeconomy as "an economic form that uses renewable biological resources, efficient biological processes, and eco-industrial clusters to produce sustainable bio-based products and generate employment and income" [2]. In 2005, the European Commission published "*A New Perspective on the Knowledge-Based Bioeconomy*," which summarizes the bioeconomy as "the knowledge-based bio-economy" [3].

China has also paid early attention to the "bio-economy." In 2002, Chinese scholar Deng Xin'an defined "bio-economy" as "an economy based on the research, development, and application of life sciences and biotechnology, and built on biotechnology products and industries" [4]. The early emergence of bioeconomy policies and related research shows its importance to national sustainable development. With the development of science and technology, global biotechnology is developing rapidly and achieving innovative development. Moreover, in the new situation of the worldwide spread of infectious diseases, such as the new crown pneumonia epidemic, countries worldwide are paying great attention to developing and implementing bioeconomy strategies. Therefore, in this situation, this paper selects some countries' bioeconomy strategies for review and study to provide a reference for future sustainable development of bioeconomy strategies.

Overview of international bioeconomy strategies

The bio-economic strategies of selected countries and international organizations are shown in Table 1.

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Table 1: The Bio-economic Strategies of Countries or International Organizations.

National & International Organizations	Name of Some Strategies	Time of Strategy Launch
The United States	Clinton's Presidential Directive 13134—— "Development and Promotion of Bio-based Products and Bio-energy."	1999
	Fostering the Bioeconomy Revolution: Bio-based Products and Bioenergy	2000
	A New Biology for the 21st Century: Ensuring the United States Leads the Coming Biology Revolution	2009
	Bio-based Economy Indicator	2011
	National Bioeconomy Blueprint	2012
	An Action Plan for Plant and Animal Biotechnology Innovation	2018
	Bioeconomy Plan: Implementation Framework.	2019
European Commission	A New Perspective on the Knowledge-Based Bioeconomy	2005
	Innovation for sustainable growth: the European bioeconomy	2012
	Sustainable bioeconomy in Europe: strengthening the links between biology and economy, society and environment	2018
	Horizon Europe	2018
	Biotechnology Industry Manifesto 2019 - Reviving the EU's Biotechnology Ambition	2019
	The strategic innovation and research agenda (SIRA 2030) for a circular bio-based Europe	2020
	Foresight scenarios for the EU bioeconomy in 2050	2021
Germany	National Research Strategy Bio-economy 2030	1010
	National Bioeconomy Strategy	2020
OECD	Biotechnology for Sustainable Growth and Development	2004

Development of bioeconomy strategies in the United States

As early as 2000, the U.S. federal government released the report *Fostering the Bioeconomy Revolution: Bio-based Products and Bioenergy*. In 2009, the National Research Council NRC released "*A New Biology for the 21st Century: Ensuring the United States Leads the Coming Biology Revolution*". In September 2011, the U.S. Department of Agriculture released a policy report on Bio-based Economy Indicators. In 2012, the White House released the *National Bioeconomy Blueprint*, which sets forth five strategic goals for the bioeconomy. The plan proposes that the U.S. bioeconomy can fully reflect technological innovation to drive economic growth. The focus areas of the U.S. bioeconomy contain fields such as bioenergy, agriculture, and human health care [5].

In recent years, with the continuous changes in the economic and social environment, the U.S. has continued to make adjustments in its bioeconomy strategy. In March 2019, the U.S. Biomass Research and Development Council (BR&D) released its *Bioeconomy Plan: Implementation Framework*. The plan fully integrates current developments and effectively deepens based on the *National Bioeconomy Blueprint* released in 2012. The project's core goal is to accelerate the development of the U.S. bioeconomy through increased government investment, which will contribute to more excellent socio-economic development. The goal is to focus on gene editing, biomass conversion, carbon recycling, and science and technology infrastructure development. At the same time, to increase public recognition and participation in ecological sustainability [6].

Further specific subdivisions are planned accordingly in various sectors in the United States. In 2018, the U.S. Food and Drug Administration released an action plan for plant and animal biotechnology innovation [7]. The National Academy of Sciences reported related "*Driving Scientific Breakthroughs in Food and Agricultural Research by 2030*" in the same year" [8]. These two reports aim to achieve leadership in plant and animal genome editing and green industry development based on ensuring product quality and safety.

European developments in bioeconomy strategies

1. **European commission:** The European Commission maintains a high level of interest in the bioeconomy. The EU published "*Innovation for sustainable growth: the European bioeconomy*" and "*Sustainable bioeconomy in Europe: strengthening the links between biology and economy, society and environment*" in 2012 and 2018, respectively [9]. It also proposed strengthening bio-based industries in 2019 to further accelerate the implementation of the European Bioeconomy Strategy. In 2018, the EU proposed a new round of innovative R&D programs, the *Horizon Europe* program. The program proposes to raise nearly €100 billion to fund four components: open scientific research, global challenges and industrial competitiveness, open innovation, and strengthening the European Research Area in the period 2021-2027. Those directly related to the bioeconomy sector include €7.7 billion for health, €15 billion for climate and energy change, and €10 billion for food and natural resources [10]. In 2019, the European Bioindustry Association (EuropaBio) released the *Biotechnology Industry Manifesto 2019 - Reviving the EU's Biotechnology Ambition* [11]. This declaration proposes the development of policies for scientific innovation and the development of biotechnology innovation strategies, among others.

In March 2020, the EU Bio-based Industry Alliance published the draft report *The strategic innovation and research agenda (SIRA 2030) for a circular bio-based Europe*[12]. The draft sets out a vision for a circular bio-society in 2050. This vision is, in short, "a competitive, innovative and sustainable Europe; leading the shift to a circular bioeconomy; decoupling

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economic growth from resource depletion and environmental impacts." At the same time, the draft sets out the main challenges and roadmap to achieve this vision, as well as the milestones and key targets for 2030 [13]. In May 2021, the European Commission published the *Foresight scenarios for the EU bioeconomy in 2050*. This document provides a scenario analysis of climate-neutral and sustainable trends in the bio-economy in Europe and globally.

2. **Germany:** As the center of industrial development in Europe, Germany pays particular attention to the bio-economy. At the beginning of the 21st century, the German science and technology community considers biotechnology an essential driving force for the bioeconomy. In 2010, the German federal government adopted the *National Research Strategy Bio-economy 2030*. The core aim of the strategy is to develop a sustainable bioeconomy and improve national competitiveness through high-value renewable products. In 2014, the German Expert Committee on Bioeconomy recommended that research in the bioeconomy requires an interdisciplinary approach and that a dual regulatory education system in the framework of the bioeconomy should be fully considered [14]. In January 2020, the German federal government released a new *National Bioeconomy Strategy*. The strategy presents guidelines, strategic goals, and priority areas for the future development of the bioeconomy in Germany. The priority areas include research to expand biological knowledge, create bio-based innovations through biological knowledge, ensure sustainable development through bioeconomy solutions, etc. [15].

Main features of international bioeconomy strategies

The review mentioned above of the bioeconomy strategies of the United States, the European Commission, and Germany shows that each country attaches great importance to the bio-economy strategies, especially biotechnology and sustainability. Today's world is at a critical juncture in the development of the bio-economy. Accelerating the development of bioeconomy has become the consensus of major countries worldwide. The launch of the international bio-economy strategy has certain social factors. There are three main reasons for the emergence of this situation. One is to alleviate the five global problems facing contemporary economic and social development: food and nutrition, health care, environmental change, resources, and ecology. The second is achieving green transformation and upgrading the economy and society. The third is the technical requirements needed for green development. Under these three primary social contexts, the international bio-economy strategy has the following characteristics.

Focus on innovation in biotechnology: With the development of artificial intelligence, the Internet, and other science and technology, "biotechnology + artificial intelligence," "biotechnology + Internet," and other emerging convergence industries have triggered changes in medical and industrial fields. The bio-economy strategies of countries or international organizations are generally based on two basic understandings: (1) the bio-economy is growing and will be shaped by research results; (2) biomass is the essential resource that drives the bio-economy [16]. Therefore, countries pay special attention to frontier technologies related to biomass development and utilization and focus on developing emerging technologies and their integration with existing technologies.

Furthermore, countries hope to improve sustainable biomass's productive capacity and conversion economic efficiency by developing these aspects. The *National Bioeconomy Blueprint* issued by the U.S. proposes a representative bioeconomy technology system. The strategy proposes that the growth of the U.S. bioeconomy owes much to three fundamental technologies, including genetic engineering, DNA sequencing, and automated high-throughput manipulation of biomolecules. In addition to the United States, many countries have expressed interest in biotechnology innovation. For example, the EU proposed the Horizon Europe program in 2018 to strengthen funding for open innovation in the bioeconomy. Germany's newly released National Bioeconomy Strategy in 2020 offers to create bio-based innovation through bio-knowledge. Thus, countries are paying particular attention to innovation in biotechnology when developing their bio-economy strategies.

Focus on ecologically sustainable development: With the rising concept of sustainable development, the transformation from the traditional industrial economy to the bioeconomy is an inevitable result of socio-economic development. The industrial economy was primarily based on chemical processes that used fossil energy as a fuel or raw material. However, this economic form has become increasingly unsustainable with changing resources and the environment. The new industrial system formed by the bio-economy uses bio-refinery technology. This technology produces bio-chemicals and bio-energy, radically reducing the dependence on fossil-based raw materials and energy. It makes agriculture, industry, and environmental protection more sustainable [17]. In addition, contemporary economic and social development faces five major global issues: food and nutrition, health care, resources, environment, and ecology. The development of bioeconomy is a fundamental initiative to combat climate change and reduce greenhouse gas emissions [18,19]. Therefore, countries focus on energy saving and emission reduction, economic transition to green, and quality of life improvement. The bio-economy is characterized by sustainability. Therefore, the bio-economy strategies introduced by countries and national organizations take sustainability as the starting point and destination of bio-economy development.

Moreover, this sustainability feature is reflected in the policies formulated by each country. For example, as early as 2012, the European Commission proposed to create conditions for the continuous development of innovative bioecological systems for the bioeconomy in the strategy "Bioeconomy for Sustainable Development in Europe: Strengthening the Links between Economy, Society, and Environment." In 2010, the German federal government adopted the (National Research Strategy Bio-economy 2030). The central aim of this

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strategy is to develop a sustainable bioeconomy. The European Commission's *Foresight scenarios for the EU bioeconomy in 2050*, published in 2021, also highlights the characteristics of sustainable development. This shows that when developing bioeconomy strategies, countries pay particular attention to the contribution of the strategies to sustainable development.

Conclusion

By sorting out the bio-economy strategies of various countries and international organizations and taking into full consideration the actual development situation in the world today, this paper believes that the bio-economy has excellent prospects in the following two aspects.

1. Biologization will become the mainstream of economic development in the future era

Biochemistry is based on the industrial utilization of biological resources. With the progress of life science and biotechnology, agriculture as the basis of biomass will be redefined, and biobased products will be commonly promoted because of their low price [20]. Just as information products are now cheap and familiar, which drives society into the information economy era, the future human economic society will also move into the bioeconomy era. Digitalization is now becoming the dominant mode of industrialization. Assuming that the biomass industry will be integrated and bio-based products will be ubiquitous in the future, biologization will also gradually replace digitalization through the green transformation of agriculture, industry, and even economic society. In other words, biochemistry will open the way to "Industry 5.0" [21].

2. Health and medical care is likely to become a leading field in the development of bio-economy

As a result of this global epidemic, health and medical care based on pharmaceutical biotechnology are very likely to develop into a pioneering field leading the bio-economy. The practice of Germany and other countries with developed bio-economy shows that abundant life science talent reserve, strong biotechnology, and medical device means are essential for effective response to the new crown epidemic. Health and medical care is the eternal theme of human economic and social development. Today, the alleviation of the problem of food and clothing in most regions of the world, the improvement of the human pursuit of quality of life, and the prominence of international public health and biosecurity issues. In this background, the importance of healthcare, including biopharmaceuticals, is becoming increasingly prominent in many areas of the bio-economy, coupled with the general increase in concern for healthcare issues in the global epidemic. In the face of this situation, health is likely to develop into a leading field of bioeconomy. It will drive the accelerated development of bio-manufacturing, bio-energy, bio-chemicals, and other fields.

It is clear from the above review that many developed countries worldwide have recently put forward their bio-economy strategies, taking into account their realities. In addition, the strategic planning and implementation details have been further clarified to promote the bioeconomy development effectiveness of each country. We hope that this study will contribute to the development of bioeconomy strategies.

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