



## PRINCIPLES AND GUIDELINES FOR THE IMPLEMENTATION OF BIOECONOMY STRATEGIES

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### ABSTRACT

The report examines existing bioeconomy strategies. The principles and guidelines of the individual countries for the implementation of the strategies are considered. A comparative analysis of the strategies was made. Based on this, the principles and guidelines for the implementation of the strategies for the bioeconomy of individual countries are derived.

**Key words:** biobased economy, bioindustry, biotechnologies, circular economy, policies

### INTRODUCTION

Interest in the bioeconomy is growing worldwide. A large number of countries have already adopted bioeconomy strategies with a focus on various areas.

Policy strategies and initiatives usually refer to the terms bioeconomy, bioindustry or biobased economy. (1) There is no general definition of the political concept of the bioeconomy; in addition, it develops over time. The bioeconomy therefore covers traditional sectors of the bioeconomy, such as agriculture, forestry, fisheries and aquaculture, as well as related processing and service industries such as food, paper, textiles, construction and building, chemistry and bio-pharmacy. Key activating and converging technologies, such as bio-, nano- and information technologies, are vital to a knowledge-based bioeconomy that uses biological technology-based processes and principles in engineering and industrial applications.

### METHODS

Many countries in Europe (19 countries), Asia (10 countries), North America (4 countries) and Oceania have adopted national strategies related to the bioeconomy. In a small number

of countries in Africa (10 countries) and South America (5 countries) there are also adopted plans for the development of a bioeconomy with a limited focus of action.

The report examines several strategies from all continents, proposing a common European Union (EU) bioeconomy strategy for Europe, with the aim of identifying the principles and guidelines of individual countries in the field of the bioeconomy and highlighting the similarities and differences between them, as well as the stage of development they have reached.

The official strategic documents in the field of bioeconomy of the USA, Canada, Argentina, China, Russia, EU, South Africa and Australia are considered. The main principle on which they are selected is their economic and political impact on the world economy and politics.

### RESULTS

#### The United States

In the United States, the government has been promoting the development of the bioeconomy for several decades. Published in 2012 The National Bioeconomy Plan, which covers all areas of the bioeconomy, including the health sector, promotes the growth of the bioeconomy in the United States through organic research, education, regulatory reform, and public-private partnerships.

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The United States uses a set of programs aimed at promoting the development of the bioeconomy in the agricultural and food sectors - "Farm Bill". (2) They are for the promotion of sustainable biomass and for renewable energy policies related to agriculture. These programs offer technical and financial assistance to producers to improve the efficiency of their activities, to produce a new "cash" crop and to process raw agricultural and forest raw materials with added value.

The innovation strategy from 2015 emphasizes the need to invest in new technologies for the development of future industries in the United States, such as the bioeconomy.

The strategic plan "Thriving and Sustainable bio-economy" 2016 follows the new direction of development of the bioeconomy in the United States and reflects the vision for a future clean energy economy.

In 2016 the government adopts the 'Billion Ton Strategy,' which is a framework for developing biomass products in the United States.(3) The strategy is aimed at sustainable production of 1 billion tons of biomass by 2030. The strategy is focused on sustainable development goals - in particular job creation, rural development, optimal land development, energy security and GHG reduction.

### **Canada**

At this stage, Canada does not have a strategy or vision for the bioeconomy. In 2006 adopts a strategy for renewable energy sources. In the Agrarian Strategy 2013-2018 the Canadian government has high hopes for the use of biotechnology in agriculture and forestry. In 2009 The National Biotechnology Association "Biote Canada" is preparing a strategic document "Blue print beyond moose and mountain" (4), which offers for political discussion the issue of a strategy for bioeconomy, but has not been formally adopted.

In 2017 a strategic document "A forest bio-economy Farmenoric for Canada" was adopted.

In May 2019 bioindustrial Innovation Canada, in partnership with several other companies, offers a strategy for Canada's bioeconomy, which presents the views of more than 400

industry representatives from across the country. Action is recommended in four main priority areas: creating flexible regulation and government policy; utilization of biomass supplies and their management; building strong companies and value chains and building strong, sustainable innovation biosystems.

Although no action has been taken at the national level in the field of the bioeconomy, action has been taken at the regional / federal level such as:

- in 2011 the Government of British Columbia appoints a bioeconomy council, the province focuses mainly on using its vast forestry and agricultural resources to provide bioenergy, but also recognizes the need to promote life sciences and clean technologies;
- Alberta, another example, is one of the strongest provinces in Canada in the agricultural sector and also pays special attention to the bioeconomy. In addition to agriculture, the regional strategy promotes the production of biological chemicals and materials, as well as bioenergy.

### **Argentina**

The Argentine government is hosting the annual Bioeconomía Argentina symposium to promote the country's bioeconomic development, although it does not have a specific bioeconomy strategy.(5) As one of the leading producers of biodiesel, Argentina's political focus is on providing a supportive regulatory framework for biofuel production. In addition, the bioeconomy is addressed in the national innovation strategy Argentina Innovadora 2020 (2012). Moreover, the ALCUE-KBBE project was launched under the European Commission's Seventh Framework Program for Research and Innovation, which aims to promote interregional cooperation for the development of the bioeconomy in Latin America and the Caribbean (LAC). In this context, the Argentine representatives played an important role in the development of the roadmap for the bioeconomy "Towards Latin America and the Caribbean, based on knowledge, the bioeconomy in partnership with Europe" (2014).

Argentina Innovadora 2020 represents the government's vision to promote research, technology and innovation by 2020. The strategy aims to exploit the full potential of

Argentina's research opportunities and promote business initiatives. This should lead to sustainable (biological) product innovations that further increase national competitiveness and quality of life.

The innovation strategy identifies six main areas in which innovation is needed - environment and sustainable development, social development, energy, industry and health, and agro-industry. In particular, agro-industry is considered extremely important for the development of the bio-economy in Argentina. Within the agro-industry, innovative technologies such as biotechnology, ICT and nanotechnology should support strategic development (Nucleos Socio Productivos Estratégicos) in crop and seed development, food chains and processing and the development and development of bio-refinancing. As part of the innovation strategy, the government envisions the development of four pilot biological refining plants close to the raw material production and processing areas. Therefore, the strategy intends to encourage the further development of agricultural and food techniques in order to strengthen sustainable plant production in the country. Additional development areas addressed in the innovation strategy include the improvement of new and traditional livestock, the development of horticulture and the forest and timber industries, as well as new methods for the production and processing of marine bio resources.

### **China**

In China, political interest in the bioeconomy is strongly linked to the development of biotechnology. China's research and technological landscape is one of the most complex and diverse in the world. At the end of 2012 The State Council of China has published a "Plan for the Development of the Bio Industry". Innovations in agriculture and in particular the published "12th Five-Year Plan for National Agriculture and Rural Economic Development" and "12thFive-year Plan (2011-2015) on Agricultural Science and Technology Development" are considered the leading policies for the development of the bioeconomy in China.

National strategies are designed to promote sustainable growth, economic renewal and boost domestic demand. Another important role of the plan is "smart urbanization" in

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China's fast-growing cities. (6) The bioindustry development plan addresses key societal challenges such as: healthy aging, food security, energy supply and environmental protection. The five-year development plan defines seven strategically emerging industries - energy saving and environmental industry, new generation of information technology industries, biotechnology industry, production of modern equipment, new energy industry, industry for new materials to support the production of electric vehicles. (7)

In addition to biotechnology, the problems related to the bioeconomy are addressed in some of the other strategic programs, such as energy efficiency, environmental technologies and innovation.

The plan defines twelve key projects that include biomedicine, agriculture, bioenergy and biobased industries.

Another major focus in China's bioeconomy is agricultural innovation to ensure food security. Agricultural biotechnology and specific GMOs are being promoted in a support program that was launched in 2008 for the next fifteen years. The Innovation Program in Science and Technology in Agriculture, which is being implemented from 2013-2025, should increase the effectiveness of political support for agricultural innovation. (8) The program encourages international cooperation, capacity building and the modernization of research infrastructures. It consists of eight "disciplines", which include practically the full breadth of agro-sciences from plant science to agro-engineering and agro-economics.

### **Russia**

The bioeconomy in Russia is based on both natural resources and the development of biotechnology. (9)

Russia relies heavily on its natural resources for its bioeconomic activities: forests, arable land and access to water. Biotechnology serves as a tool for further development. In 2011, a national strategy for bioeconomy was adopted, developed by the National Technology Platform Biotech 2030. The Ministry of Agriculture, the Ministry of Economy, the Ministry of Trade and the Ministry of Research participate in this platform. A number of research facilities are also available. Within the

platform there are six divisions: industrial biotechnology, forestry, ecology, agriculture, fisheries and "food for life". As part of the technology platform, the cooperation between the state, the free economy, scientific and research institutions is regulated and a total of 160 public and private organizations are involved. More than half of its members come from the economic sector. In 2012, the BIO 2020 program (Extensive Program for the Development of Biotechnology in Russia until 2020) was signed and the government adopted a roadmap for biotechnology for the period up to 2020. They also include a number of projects related to the bioeconomy.

### European Union

The EU is a key player in promoting the bioeconomy, focusing on the "knowledge-based bioeconomy" in areas such as agriculture, bioenergy, new materials and bio-refineries. In the context of the Europe 2020 strategy, which considers the bioeconomy to be a key element for Europe's sustainable, smart and green economic growth, while comprehensively addressing the challenges facing society with the adoption of the Bioeconomy Strategy in 2012 and its development plan. (10)

The strategy covers all areas and sectors involved in the production or use of bioresources. It is assisted by Commissioners for Research and Innovation, Agriculture, Entrepreneurship and Industry, Environment and Maritime Affairs and Fisheries. The key activities are: strategic research and innovation to support the transition to a bioeconomy; education and training to provide a skilled workforce; consolidation of bio-based sectors; creation of new markets and value chains; use of local opportunities; protection and restoration of natural resources; and monitoring progress. (11)

It expects the bioeconomy to be the engine of rural and coastal development. The EU's vision is based on the understanding that the bioeconomy is based on integrated systems and networks that use biological resources, maximize added value and ideally operate in closed circuits in terms of raw materials, water, nutrients and energy, i.e. "Bioeconomy web". The EU's bioeconomy strategy is in many ways a natural consequence of the EU's 2020 climate targets and the EU 2020 Strategy for Smart, Sustainable and Inclusive Growth.

Under the EU's Seventh Framework Program, approximately € 387 million for research and innovation goes to the bioeconomy. (12) The strategy sets five goals for the bioeconomy - food security; sustainable management of natural resources; reducing dependence on non-renewable resources; climate change mitigation and adaptation; creating jobs and maintaining the EU's competitiveness. The strategy is structured around three pillars of action: investment in research, innovation and skills; enhanced policy synergies and stakeholder engagement; strengthening the market development and competitiveness of the Bioeconomy sector. (13)

The EU Bioeconomy Strategy was revised in 2017 and while successful in mobilizing funding for research and innovation, additional investment is needed to introduce new products and technologies. In addition, the development of human capital in the bioeconomy remains limited. Also, while technologies are being researched and developed, it remains difficult to predict whether and when they will reach the market. The review of the strategy also shows that a higher level of policy coherence is needed. Based on the presented review in 2018. The EC presented an updated bioeconomy strategy and a new three-step action plan:

- scaling up and strengthening bio-based sectors;
- location of local bio-economies throughout Europe;
- better understanding of the ecological boundary of the bioeconomy.

### South Africa

The government has published a "Strategy for the Bioeconomy in South Africa" (2013) to promote the transition to a knowledge-based bio-economy. Building on the experience of two previous initiatives, the National Biotechnology Strategy (2001) and the Ten-Year Innovation Plan (2008), the new strategy seeks to guide investment in research and innovation in the life sciences, as well as high-level decision-making. (14)

The bio-economy must become an important driver of the South African economy by 2030 in terms of the contribution of share and growth to gross domestic product (GDP). The new strategy is not limited to promoting the biotechnology sector, but seeks to develop a comprehensive bio-economy. Information and

communication technologies (ICT), research and production of nanomaterials, bio-enterprise, social sciences, and intellectual property management have been specifically identified as important areas of knowledge to enhance the country's socio-economic development. It focuses specifically on the development of a green economy, which also strengthens the competitiveness of countries. The creation and growth of new industries must provide sustainable jobs and improve the food sector. Objectives mentioned in the strategy paper relate to the harmonization of research with national priorities and regulations, as well as the improved public understanding of technologies related to the bio-economy. To achieve these overarching goals, the strategy seeks to improve the innovation capacity of the bio-economy in South Africa. With regard to political support for economic sectors, the Ministry of Science and Technology prioritizes agriculture, health and bio-based industries. In the agricultural sector, the bioeconomy strategy envisages a sustainable intensification of agricultural production and processing. Biotechnology, including responsible genetic engineering, should generally help to improve the heat and drought resilience of crops and address the challenges of climate change, reduce water resources and land grazing, and halt the loss of biological resources diversity. Optimization of energy crops is also considered important to promote the development of the biofuels industry. Support for research and development in agricultural life sciences and technology is an integral part of the strategy. In addition, autonomy in the development of animal vaccines and local cultures is envisaged. The strategy also aims to make better use of the country's biodiversity and to cover niche markets for natural products. In the health sector, the strategy seeks to better address key challenges such as infant mortality, HIV and malaria. The development of the national health innovation system in South Africa includes three key interventions. Detection and bio-examination play a key role in the development of new drugs, vaccines, diagnostics and medical devices (especially in TB and HIV). The strategy further focuses on supporting research, development and innovation in biologically based chemicals and industrial biotechnology. Improving local capacity in industrial biotechnology. Given the significant problems with water scarcity, especially in arid areas, the strategy further

encourages improvements in wastewater treatment.

### **Australia**

There is no formal national bio-economy strategy in Australia, but the government provides policy guidance and support in several thematic areas of the bio-economy, in particular with regard to increasing the added value of agricultural, forestry and marine resources. (15) In terms of focus on intervention, most bioeconomy-related policies can be characterized as R&D strategies. In 2013, the Australian Government identified 15 strategic research priorities for the future, which also integrated key themes from the bio-economy, such as bioenergy, ecosystem monitoring and management, food optimization and health. The development of biotechnology is particularly encouraged by national biotechnology policies (2000) and communication strategies that raise awareness of the importance and benefits of modern biotechnologies for the agricultural sector (2008) and the industrial sector (2008). In 2011, the Australian Government launched two biological refinery studies to examine the potential of tropical and temperate biomass value chains. In the field of bioenergy development, several industry associations have published strategies and roadmaps, which, however, have not been formally adopted by public authorities. In 2011, the government agency Rural Research and Development Corporation published a national innovation strategy promoting the development of bioenergy ("Opportunities for primary industries in the bioenergy sector - a national R&D strategy"). In order to further guide and implement this innovation strategy, a work plan of the same name was developed in 2014 with a view to promoting research capacity in key areas of knowledge, such as biotechnology. In 2011, the government developed a "Strategic Roadmap for Australian Research Infrastructure". In 2015, the Minister of Industry and Science launched the "National Maritime Plan 2015-2025", which focuses on developing the added value of the "blue economy" while protecting the Australian oceans and marine resources. In addition to these national innovation strategies, South Australia has issued a regional strategy for the bio-economy, "Building a bio-economy in South Australia 2011-2015".

South Australia's strategy seeks to use local knowledge in the life sciences to develop new markets and increase exports of innovative products and services in the life sciences. The life sciences sector is considered key to fostering innovation in several key sectors in the region, such as medical diagnostics, wine, agriculture and renewable energy. The National Strategy for Research and Development in the Field of Bio Energy identifies three priority areas for innovation: identification and availability of raw materials, supply logistics and sustainability. The 2014 work plan builds on these areas of work and addresses their convergence by adding a fourth priority: integrated supply chains and industrial development, with a special focus on regional applications. Stakeholder consultations identified integrated supply chains as key to Australia, providing a way to develop many of the innovation activities set out in the strategy. The Marine Science Strategy outlines the so-called "10-year steps to success". The priority research areas are: creation of tools to support the scientific solution for politics and industry; construction of an oceanographic modeling system; development of national maritime bases and long-term monitoring programs; industrial and government partnerships; maritime scientific training in order to become more quantitative and interdisciplinary; investing in research vessels; conducting research, mapping and monitoring of the marine ecosystem; promoting national cooperation. The South Australian Bioeconomy Strategy is clearly business-oriented and identifies three strategic elements of intervention. First, providing access to venture capital. Second, the provision of critical infrastructure, e.g. for clusters. And third, offering business development assistance and marketing assistance for new business.

## CONCLUSION

The concept of the bioeconomy is evolving. It is widely acknowledged that it covers more than biotechnology or biofuels, as evidenced by the strategies presented. While earlier bioeconomy strategies were mainly driven by the demand for renewable resources as a substitute for fossil fuels, newer strategies focus on increasing the value of bioresources. Overall, these national bioeconomy strategies seek to help achieve sustainable development, with green growth being a path to economic growth that uses natural resources sustainably - as a key objective.

Policy and institutional coherence are prerequisites for achieving the full potential of the bioeconomy. Policies offering incentives for different economic uses of biomass - such as food, feed, bio-based products and bioenergy - need to be aligned and evaluated in the context of the strategic objectives of the bioeconomy. Regulatory frameworks may also need to be evaluated and revised, which is often necessary to increase the value generated by biomass and to stimulate the creation of value chains. Several national bioeconomy strategies aim to promote coherence across policy levels and areas by: investing in research, innovation and skills; promoting the participation management structure; facilitating informed public dialogue; monitoring progress; and strengthening cooperation at international, national and regional levels. In this regard, several countries have set up inter-ministerial working groups and policy advisory bodies. Some countries have also set up specialized bioeconomy councils or groups that involve various stakeholders to consult on the implementation process. These strategies are encouraging and are recommended to be disseminated so that other countries can learn from them. Bioeconomics is complex and involves interdisciplinary knowledge. Developing a skilled workforce for the emerging bioeconomy is a major challenge and development of expertise is one of the main concerns of almost all bioeconomy-related policy strategies. The review of national strategies reveals many commonalities, in particular the focus on research, innovation and technology, which are at the heart of all bioeconomy strategies, and the promotion of public-private partnerships. In addition to biotechnology, the opportunities arising from a wide range of new technologies, such as biotechnology, as well as the development and wider application of energy and water saving technologies, have been highlighted in most national strategies. Some strategies also mention the possibility of improving the quality of food and nutrients while reducing waste. Transferring the latest research results and approaches to best practices is key to the development of the global bioeconomy and the achievement of sustainable growth.

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