



**International
Advisory Council on
Global Bioeconomy**



Global Bioeconomy Policy Report (IV):

**A decade of bioeconomy policy
development around the world**

A report from the International Advisory Council on Global Bioeconomy



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Preface

Over the past decade, the concept of the bioeconomy has become more visible and important in the policy process worldwide. Almost 60 countries around the world are pursuing bioeconomy-related policies. This study focuses on the dynamic development of 19 dedicated national and macro-regional bioeconomy policy strategies over the past decade. By adopting bioeconomy strategies, governments are laying the foundation for policy support and investment which in turn enables pioneering research, facilitates the development of new and advanced technologies, supports education and capacity building, drives forward industrialization processes, creates awareness and helps stimulate consumer demand.

In addition to national policy initiatives, we are witnessing the increasing engagement of macro-regional and international actors in bioeconomy development across the globe. New dynamics in bioeconomy policy development are evolving outside of governments, with stakeholder-driven and industry-driven strategies on the rise. These emerging initiatives represent excellent examples of the great extent to which the bioeconomy is gaining importance globally and is why this report devotes a special chapter to these new and emerging policy trends.

In 2015, the first Global Bioeconomy Summit in Berlin highlighted the essential contribution of a sustainable bioeconomy to achieving the UN Sustainable Development Goals and today we see this relationship solidified in many dedicated policy strategies around the world. In 2018, the second Global Bioeconomy Summit concluded that there is no one solution that fits all: Political strategies point to different opportunities and pursue key objectives depending on their prevailing industrial and economic profiles and natural resource potential. Now, we are observing the increasing recognition that the strength of the bioeconomy lies in its diversity.

Regional strategies that create synergies from local specialization are gaining momentum and national strategies continue to capitalize on thematic prioritization and specializations.

In 2020, the world is facing systemic climate, biodiversity, economic and health crises. We, the chairs of the International Advisory Council on Global Bioeconomy, along with many others around the world, see opportunities in the bioeconomy for helping to solve these global crises.

For the first time, the third Global Bioeconomy Summit will be held in an interactive and virtual format from 16th to 20th November 2020. The International Advisory Council on Global Bioeconomy has commissioned this report to provide an overview of existing bioeconomy policy strategies and instruments around the world that seek to stimulate, support and steer transformation dynamics towards a sustainable bioeconomy. It builds on and further develops key insights from three previous reports on bioeconomy policy strategies assembled by the Secretariat of the German Bioeconomy Council.^{1,2,3} Covering roughly a decade of global policy development, we believe that this report will help monitor bioeconomy policies, identify gaps in current strategies and programs, and above all, stimulate discussions as to how the bioeconomy can contribute to societal and economic transformation, and best serve to rebuild a healthy planet.

Berlin, November 2020,



Prof. Dr. Joachim von Braun Prof. Dr. Christine Lang
Co-Chairs of the International
Advisory Council on Global Bioeconomy

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Introduction

This report was conducted in preparation for the Global Bioeconomy Summit 2020. It brings together key insights from three previous reports on bioeconomy policy strategies assembled by the Secretariat of the German Bioeconomy Council^{4,5,6}, and provides one overview document of existing bioeconomy policy strategies and instruments

around the world. The report centers on countries with a dedicated bioeconomy strategy. The only report of its kind, it encompasses roughly a decade of global policy development and seeks to reveal how far we have come, where work still needs to be done, and where we are headed.

Understanding of the Bioeconomy

While the term bioeconomy has become mainstream in policy papers and strategies globally, currently there is no common definition for the political concept of bioeconomy. Furthermore, the bioeconomy is not a static notion and its meaning is continually evolving. For the purpose of this report, the bioeconomy has been defined in line with the Communiqué of the GBS2018 as “the production, utilization and conservation of biological resources, including related knowledge, science, technology, and innovation, to provide sustainable solutions (information, products, processes and services) within and across

all economic sectors and enable a transformation to a sustainable economy.⁷ The bioeconomy therefore encompasses the traditional bioeconomy sectors, such as agriculture, forestry, fisheries and aquaculture, as well as related processing and service industries, such as food, paper, textiles, building and construction, chemistry, and bio-pharma. Key enabling and converging technologies, such as bio-, nano- and information technologies, are vitally important to the knowledge-based bioeconomy which uses biobased processes and principles in engineering and across industrial applications.

Methodology

The methodology of this study relies on internet-based desk research of officially adopted policy strategies and roadmaps in the period from 2010 to 2020. The authors reviewed national, macro-regional and regional policy strategies on bioeconomy development. The report’s findings are based on publicly available government documents, such as publications from ministries, government agencies and affiliated councils, and research institutions. Secondary literature, for example, from international organizations and networks, conference material and presentations, has been used to cross-check and complement background information. In addition, we benefited from expert consultations with members of the International Advisory Council on Global Bioeconomy (IACGB).

While there is no universally agreed **definition of a policy strategy**, the authors drew from various sources⁸ to form a common contemporary understanding of the term as having four defining elements: 1) long-term consequences; 2) a significant relationship to a given mission or central purpose; 3) a defined acting subject; and 4) concerns actual choices and prioritization.

The report centers on countries with a **dedicated bioeconomy strategy**. In order to determine the alignment, credibility, relevance, purpose, design, specialization, and adaptability of the dedicated bio-

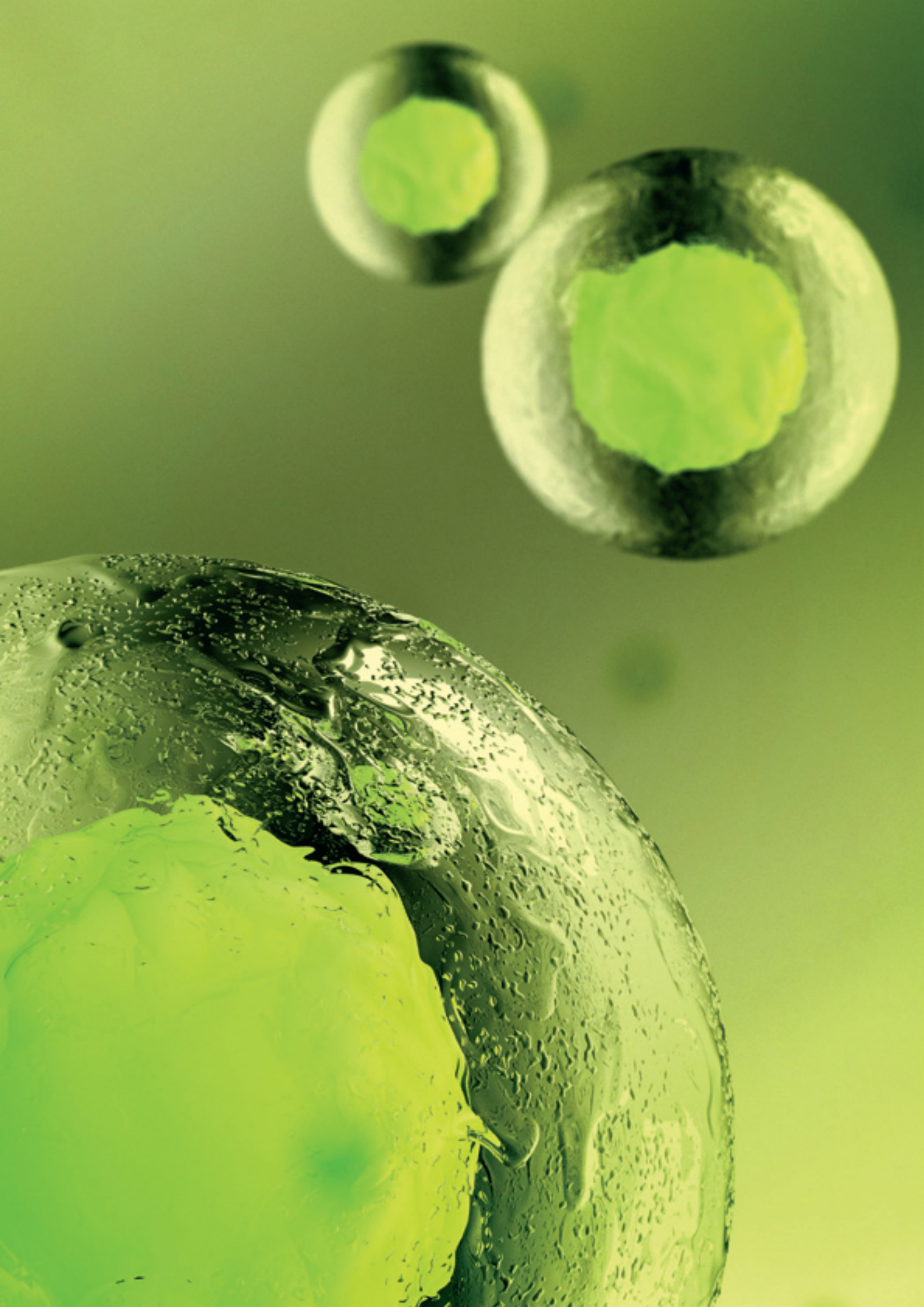
economy strategies, a number of review questions were adapted from Miedzinski, McDowall & Fahrenstock (2018).⁹ These review questions help illuminate the goals, qualitative and quantitative targets, and key priorities of bioeconomy strategies. Comprehensive approaches for promoting transformation in research and innovation policy tend to include a bundle of measures addressing the supply-side and demand-side of the economy.¹⁰ Using this framework, the authors categorized bioeconomy development into the supply-side measures of “promoting research and innovation”; “infrastructure development”; “capacity building and education”; and “supporting commercialization”. On the demand-side, measures related mainly to information campaigns and awareness building as well as to market stimulation by public lead-buyers and tax policies. Regulatory measures for improving the “framework conditions” can address the supply-side and the demand-side. Governments also increasingly propose measures to ensure “good governance” and also to support “international collaboration” in the bioeconomy. For each country reviewed, the authors sought to summarize and categorize the most important policy measures for promoting bioeconomy development in the dedicated strategies. The analysis seeks to illuminate the extent to which policy goals are translated into concrete measures and action plans. This study, however, can neither judge the degree of implementation of the strategies and measures nor their effectiveness.

Bioeconomy-related strategies can be understood as those with a strong link to bioeconomy development, namely in the areas of biotechnology, bioenergy, biomass, biobased economy/industry. To keep the scope of the study within workable limits, political strategies in the traditional bioeconomic areas, such as the primary production sector (agriculture/forestry/marine), as well as research and innovation strategies were only considered if they prioritized bioeconomy or innovative, biobased approaches. The same logic was applied to policy strategies relating to the overriding objectives of sustainability, green and blue growth, and circular economy. Bioeconomy-related strategies were characterized as have the following perspectives: **High-Tech** (i.e. strategies focusing on biotechnology or converging technologies); **Research and Innovation** (i.e. research and innovation strategies with a focus on the bioeconomy), **Bioenergy** (i.e. strategies focusing on “traditional” and “modern” bioenergy); **Blue Economy** (i.e. policy strategies relating to the ocean economy or marine biotechnology and innovation);

Green Economy (i.e. policy strategies focusing on biobased innovations in particular, such as “nature-based solutions”); **Biobased Economy** (i.e. policy strategies that specifically mention the biobased economy, or focuses on economic development in certain sectors of the bioeconomy); **Circular Bioeconomy** (i.e. policy strategies that focus strongly on the circular use of biobased/biological resources or directly refer to the term “circular bioeconomy”); **Forest Bioeconomy** (i.e. strategies that focus on converting renewable forest-based resources into value-added products and services); **Bioeconomy (holistic)** (i.e. strategies that holistically pursue bioeconomy development); **Bioeconomy** (i.e. bioeconomy documents other than strategies); **Bioeconomy (regional)** (i.e. regional bioeconomy strategies). It must be noted that there are no single, accepted definitions of these perspectives. Furthermore, this analysis does not by any means strive to be fully comprehensive, rather it seeks to provide a general overview document of existing bioeconomy policy strategies and instruments around the world.

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Overview & Emerging Policy Trends

Overview

An analysis of a decade of bioeconomy policy development shows that more and more countries worldwide have developing dedicated bioeconomy policy strategies. At the time of publication, **19 countries and macro-regions** (Austria, Costa Rica, EU, Finland, France, Germany, Ireland, Italy, Japan, Latvia, Malaysia, Nordic Countries, Norway, South Africa, Spain, Thailand, UK, US, East Africa)¹¹ have published **dedicated bioeconomy strategies**. Since 2018, **nine strategies** have been published (Austria, Costa Rica, EU, Germany, Ireland, Italy, Japan, Nordics, UK), **four** of which (EU, Germany, Italy, Japan) have **updated their strategy papers** since their initial publication.

In parallel, **macro-regional bioeconomy policy strategies** are gaining momentum and helping to foster national policy initiatives. The publication of the EU Bioeconomy Strategy in 2012 provided a decisive push for the development of national bioeconomy strategies in Europe. In East Africa, national efforts to develop dedicated bioeconomy policy initiatives were stimulated by the publication of the Regional Bioeconomy Strategy for Eastern Africa, e.g. in Kenya, Tanzania and Uganda. Macro-regional policy strategies are not only adding value and supporting national policy efforts, they also help create synergies by integrating national approaches, facilitate macro-regional collaboration, and provide a shared regional vision for bioeconomy development. In recognition of the local character of the bioeconomy, **regional strategies**, predominantly in Europe and Latin America, have also increased.

The bioeconomy continues to be advanced in many bioeconomy-related policies such as research and innovation, biotechnology, bioenergy, biobased and green economy strategies. Currently, **almost 60 countries around the world are pursuing bioeconomy-related policies**, however, the diffuse nature

of these initiatives and their dynamic development imply potentially higher numbers. This analysis, like its predecessors,^{12,13,14} is to be regarded as a living document that does not claim to be complete, but instead is continually evolving. Given the dynamic development of dedicated bioeconomy policy strategies over the past decade, this report concentrates on these holistic strategies as opposed to analyzing bioeconomy development in more fragmented bioeconomy-related strategies.

The dynamic development of the bioeconomy is thus not restricted to the development of holistic dedicated policy strategies. Some countries, such as Portugal, Canada, and Finland, have chosen to make use of their national comparative advantages by specializing in certain aspects of the bioeconomy such as the **“blue bioeconomy”** or the **“forest-based bioeconomy”**. Especially in European countries, but also in Asian and Latin American countries, bioeconomy development is increasingly linked to the concept of the **“circular bioeconomy”**. However, the relationship between these two concepts remains underdeveloped.

New dynamics in bioeconomy policy development are also not limited to national policy making. In some countries, it is **stakeholders from science, civil society and industry** who are leading the promotion of bioeconomy development and strongly promoting their country’s vision of the bioeconomy (e.g. Argentina, Canada, Portugal). Furthermore, bioeconomy development is increasingly driven by the engagement of **international actors** and international collaboration efforts. The following chapter summarizes these emerging policy initiatives beyond dedicated strategies and shows the extent to which the bioeconomy has gained importance around the globe.

Emerging Policy Trends

Stakeholder-driven Initiatives

Although stakeholder involvement has played a major role in bioeconomy development for many years, more recently, dedicated bioeconomy strategies have been developed outside of government. Just as more countries are taking the initiative to start developing national strategies at the request of stakeholders (e.g. from industry, science, and civil society organizations), we also see the emergence of stakeholder-driven and industry-driven strategies. These strategies do not represent official strategic government documents, but rather seek to provide a common vision for bioeconomy development and to raise awareness among political decision-makers. It remains to be seen how these approaches will be integrated into existing public policy frameworks.

Portugal uniquely developed the “Blue BioEconomy Roadmap for Portugal”¹⁵ in 2019, a stakeholder roadmap endorsed by the Ministry of Sea. With the roadmap, Portugal looks to be at the forefront of blue bioeconomy in Europe by 2030, contributing to the transition of the Portuguese economy towards a more competitive model focused on sustainable innovation. A new “Blue Bioeconomic Development Model” is proposed which is defined as the knowledge-based production and use of blue bioresources to provide products, processes, and services. The roadmap was developed by BLUEBIO ALLIANCE, a non-profit Portuguese association representing all players in the marine bioresources and blue biotech value chain, and CIIMAR, The Interdisciplinary Centre of Marine and Environmental Research in Portugal and funded through the BLUE and GREEN project under Horizon 2020. The action plan comprehensively covers the areas of science, technology and logistics, cooperation, communication and marketing, market and consumer demand, funding and cost of operations, and legal and regulatory, and proposes a short (2019/20), medium (2021/25) and long-term (2026/30) action plan depending on the urgency and complexity of the matter. How these actions will be taken up in the policy process is not clearly defined.

In **Argentina**, the long process to develop a national bioeconomy strategy resulted in the publication of a collective stakeholder strategy in 2019, “Bioeconomy

as a Strategy for the Development of Argentina,”¹⁶ from over 50 stakeholders representing academia, the public and private sector, and the territories. The strategy proposes a new geopolitical vision for the country with the bioeconomy at the core of its new development model. According to the document, the bioeconomy represents a new production profile, where the country is no longer exclusively a supplier of commodities, but more comprehensively uses its resources and capabilities to diversify and develop new value chains. It emphasizes the hierarchy of value-added production schemes versus quantity production schemes and recognizes that solving the problem of poverty is essential to environmental sustainability.

Canada has also taken a different path to developing its bioeconomy in the form of an industry-driven national strategy, “Canada’s Bioeconomy strategy”.¹⁷ Bioindustrial Innovation Canada (BIC) in partnership with BioDesign, an industry-led consortium of companies, associations, academic and research institutions from several sectors, developed the strategy and presented it to the Canadian government in May 2019. It represents the vision of more than 400 industry representatives from across the country and serves as a call to action for the government and industry to seize the opportunities of an industrial bioeconomy. The strategy focuses primarily on Canada’s competitive advantages in the agriculture and forestry sectors, and access to biomass, and links the bioeconomy to the challenge of climate change mitigation. It further recognizes the role of innovation clusters and ecosystems, a modern regulatory system, and commercializing innovation to enable the growth of larger companies. As a result of industry efforts, the Canadian government invested USD 200,000 in BIC, under the Canadian Agricultural Adaptation Program, to build the national bioeconomy strategy. The aim was to help establish clear roles for the government to provide the regulatory operating environment and infrastructure necessary for the adoption of biobased processes and products.¹⁸

Multilateral Policy Dialogue

Over the past decade, more and more multilateral bioeconomy policy initiatives have been launched under

the lead of supra- and international organizations as well as multi-stakeholder initiatives. Since 2015, three main attempts have been made to establish structures for multilateral policy dialogue to foster the development of a sustainable bioeconomy: the UN FAO International Working Group on Sustainable Bioeconomy (ISBWG), the European Commission's International Bioeconomy Forum, and the BioFuture Platform.

In 2016, the **BioFuture Platform**, a government-led, multi-stakeholder initiative, was launched during COP22 in Marrakesh with 20 signatory governments seeking policy cooperation and mutual learning in the development of a low-carbon bioeconomy.¹⁹ In 2019, the International Energy Agency (IEA) took over the role of facilitator (i.e. secretariat) after the government of Brazil's interim tenure expired. Since its inception, many ministerial level meetings and summits have been held, with the aim of promoting more consistent international collaboration and dialogue to fulfill the social and economic potential of advanced low carbon fuels and the new bioeconomy, facilitating the upscaling of markets, and promoting the recognition of their unique climate and environmental benefits.²⁰

In 2016, the European Commission initiated an **International Bioeconomy Forum (IBF)**, a mechanism for long-term R&D collaboration among global players in the bioeconomy.²¹ Co-chaired by Canada and the European Commission, the forum is organized in ad-hoc working groups which currently cover four areas: Plant Health, Information and Communication Technology in Precision Food Systems, the Forest Bioeconomy, and Microbiome.²²

In 2015, a UN FAO-led ISBWG was established to support countries with the development of sustainable and circular bioeconomy strategies, action plans and programs, in line with the Sustainable Development Goals and the Paris Agreement and other Multilateral Environmental Agreements (MEAs). The ISBWG represents an international, multi-stakeholder expert group which currently includes 35 members representing countries, regions, researchers and innovators, the private sector, NGOs and international organizations from all five continents. The first milestone of the group was the design and agreement of the Aspirational Principles and Criteria for a Sustainable Bioeconomy in November 2016.²³ The Working Group serves as a platform for international knowledge- and experience-

sharing concerning three main areas: 1) share lessons learnt and good practices on the potential benefits and risks of food system bioinnovations, e.g. on the use of food loss and waste, plastic alternatives, microbiome applications, and alternative proteins; 2) provide guidance to national and regional stakeholders in the development of sustainable and circular bioeconomy strategies, e.g. supporting Uruguay in the drafting of the National Bioeconomy Vision and Strategy; 3) supporting bioeconomy monitoring and evaluation, e.g. the European Commission uses the 10 aspirational principles and 24 criteria to build its bioeconomy monitoring framework.²⁴

In addition to these mechanisms, we observe the increasing role of **South-South and Triangular Cooperation** (SSC and TrC) in supporting multilateral cooperation in the bioeconomy. The 2030 Agenda on Sustainable Development explicitly called for enhanced SSC and TrC on access to science, technology and innovation, and knowledge-sharing.²⁵ SSC and TrC on the bioeconomy is increasing at the policy level with many developing countries working to define bioeconomy strategies, but also at the implementation level with a growing number of SSTC projects in the area of the bioeconomy.²⁶ The ISBWG is considered an important South-South and Triangular Cooperation (SSTC) platform within the UN FAO that supports the dissemination of sustainable bioeconomy in developing countries. The German Development Cooperation (GIZ GmbH), for example, is actively involved in bioeconomy policy development in Ecuador²⁷, Costa Rica²⁸, and in Africa with the BioInnovation Africa program.²⁹ The objective of the BioInnovation Africa program is to establish a European-African cooperation for biodiversity-based innovations and products, based on equitable benefit-sharing for biodiversity conservation. Policy dialogues on bioeconomy in Latin America, Asia and Africa are also supported by Sweden's innovation agency VINNOVA, as well as by the Swedish International Development Cooperation Agency (Sida), and are implemented by the Stockholm Environment Institute (SEI), the Research Institutes of Sweden (RISE) and the Gothenburg Centre for Sustainable Development (GMV).³⁰

More recently, the bioeconomy was recognized as a policy priority in the **Declaration of the G20 Meeting of Agriculture Ministers in Argentina in 2018** for its contribution to sustainable soil use, food security, ICT application, and meeting ambitious environmental

goals.³¹ However, many questions remain as to how the G20 can better promote a sustainable bioeconomy and stable food systems. Other international meeting activities also continue to address core issues for a sustainable bioeconomy, albeit in more fragmented policy fields, such as sustainable agriculture and forestry, and renewable energies. For example, the IPCC highlighted many bioeconomy-related response options to climate change, particularly referring to land management (agriculture, forests, soils, other ecosystems) and value chain management (demand and supply options).³²

Macro-regional Actors and Policy Initiatives

In addition to national and international efforts, an increasing number of regions are active in bioeconomy policy. In particular, macro-regional policy approaches have emerged among neighboring countries with similarities in their resource endowment and economic conditions.

In Eastern Africa, the **BiSEA project** was established to develop a regional, innovation-driven bioeconomy strategy. The project is implemented by the **East African Science and Technology Commission (EAST-ECO)**, the **African Technology Policy Studies Network (ATPS)**, the **Scinnovent Center**, **Bio-Innovations Ltd**, and the **Africa Centre of the Stockholm Environment Institute (SEI)**. The East African Regional Strategy, developed in close consultation with regional science councils and commissions, as well as relevant ministries and stakeholders from all BioInnovate countries (Ethiopia, Burundi, Kenya, Rwanda, Tanzania and Uganda and South Sudan), was published in October 2020.³³

In Europe, the European Union also encourages various cross-border initiatives. The **Central and Eastern European Bioregions Forum** was established as a follow-up to the European Bioeconomy Congress 2016 in Lodz, where Central and Eastern European Regions and stakeholders from business, academia and civil society published the Lodz Declaration of Bioregions.³⁴ The declaration presented a strategic document for bioeconomy development in local “bio-communities”, including biovillages, biocities and bioregions, such activities, however, have virtually

ceased. The Central-Eastern European Initiative for Knowledge-based Agriculture, Aquaculture and Forestry in the Bioeconomy (**BIOEAST**) is further promoting a strategic vision for bioeconomy development in Eastern Europe, including countries like the Czech Republic, Hungary, Poland, Slovakia, and Estonia, as well as in South East European countries like Bulgaria, Romania, Slovenia, and Croatia.³⁵ In 2020, a position paper on the “**Bioeconomy and Green Investments**”³⁶ was published which saw emerging opportunities linked to the local processing and biorefining of available biomass, including organic waste streams. In this macro-region, another initiative, the **Danube-INCO.Net project**, promotes the development of a macro-regional research, technology and innovation (RTI) strategy. The initial outcome of several strategy workshops and open innovation events was the publication of recommendations for the development of a Danube RTI-bioeconomy strategy in 2017.³⁷

The **Bioeconomy Strategic Working Group (BSW)** was established as a thematic working group under the Standing Committee on Agricultural Research (SCAR). It aims to facilitate informal exchanges between European Member States on regional, national and European activities, to implement strategies, and encourage research and innovation (e.g. needs, hurdles, challenges, organizational matters, etc.) in the broad area of the bioeconomy. BSW’s ambition is to be the central platform in Europe overseeing different initiatives at national and European level and translating this into actions.³⁸

In Northern Europe, the **Nordic Council of Ministers**, an official body for inter-governmental cooperation in the Nordic Region has also promoted bioeconomy development on a macro-regional level since 2012. The Nordic Council of Ministers consists of the Ministers for Nordic cooperation (involving Denmark, Finland, Iceland, Norway, Sweden, the Faroe Islands, Greenland, and Åland) and 10 ministerial councils which cover different sectors and are supported by 16 committees of senior officials.³⁹ The bioeconomy is high on the political agenda of several annual programs for the Presidency of the Nordic Council of Ministers. In addition, specific actions have been taken in the North-West Atlantic, the Arctic region, and the Baltic Sea Region.

In Latin America and the Caribbean, macro-regional bioeconomy development is increasingly driven by the

United Nations regional commission, the **Economic Commission for Latin America and the Caribbean (UN ECLAC)** which organizes joint events to promote exchange on policy making and successful private sector and research initiatives. UN ECLAC strives to better align existing initiatives and to further develop joint bioeconomy policies and programs.⁴⁰ It carries out technical assistance missions on the design of the national bioeconomy strategy in Costa Rica, Uruguay, and Argentina. The **Latin American Bioeconomy Network** was established in 2019 within the framework of the First Latin American Bioeconomy Symposium, organized by the Argentinian Ministry of Science, Technology and Productive Innovation, UN ECLAC, the International Labor Organization (ILO), the

United Nations Educational, Scientific and Cultural Organization (UNESCO), the **Inter-American Institute for Cooperation on Agriculture (IICA)** and the Interdisciplinary Center for Studies in Science, Technology and Innovation (CIECTI). It aims to promote the bioeconomy as a regional development strategy, generating an exchange of experiences and fostering collaborative projects.⁴¹ IICA is particularly involved in bioeconomy development in the region with its Bioeconomy and Production Development Program. IICA develops policy briefs and guidelines for action at country-level and specifically assisted Costa Rica, Uruguay, and Ecuador in their strategy development and, among other things, helped with the design and implementation of a bioeconomy observatory in Argentina.

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Bioeconomy Policies around the world



Africa



There is fast evolution of bioeconomy initiatives in Africa. South Africa published a dedicated bioeconomy strategy in 2013 and in 2020, a dedicated macro-regional bioeconomy strategy for Eastern Africa was published, the first of its kind on the continent of Africa.⁴² Seven eastern African countries (Burundi, Ethiopia, Kenya, Rwanda, Tanzania, South Sudan, and Uganda), with the support of the Bioresources Innovations Network for Eastern Africa Development (BioInnovate Africa), came together to develop a regional innovation-driven bioeconomy strategy that enables the pooling of resources to address shared regional priorities. The program is supported by Sweden and focuses on promoting bioinnovation policies that enable technology transfer and business development.

The BioInnovation Africa⁴³ program fosters equitable business partnerships that contribute to biodiversity conservation. In its first three-year phase, 2019 to 2022, BioInnovation Africa will focus on Cameroon, Madagascar, Namibia, and South Africa, countries rich in biodiversity, with support from Germany. The

German government also supports the BiomassWeb project⁴⁴ in Ethiopia, Ghana, Kenya, and Nigeria, which aims to increase productivity and efficiency across the whole system of producing, processing, and trading biomass.

While not covered in depth in this analysis, many other bioeconomy-related policy initiatives have emerged over the years. Most of the bioeconomy-related activities center on bioenergy/biofuel production (e.g. Ghana, Mali, Senegal, Nigeria, Mozambique, Uganda, Kenya).⁴⁵ Countries such as Kenya and Mauritius focus on bioprospecting policies in order to benefit from their unique biodiversity and on commercializing knowledge about traditional bioresources. The Eastern African countries Ethiopia, Kenya, Uganda, and Tanzania have adopted national biotechnology strategies. Mauritius has taken a different path and developed a comprehensive Ocean Economy strategy. Namibia has a research and innovation strategy which integrates key issues for bioeconomy development.

Country	Perspective	Document Name
East Africa	Bioeconomy (holistic)	The Eastern African Regional Bioeconomy Strategy (2020)
Ethiopia	High-Tech	Biotechnology Investment and Marketing Strategy (2017)
	High-Tech	National strategy and plan of action for pharmaceutical manufacturing development in Ethiopia (2015 – 2025) (2015)
	Bioenergy	Ethiopia Biomass Energy Strategy (BEST) (2013)
	Green Economy	Ethiopia's Climate Resilient Green Economy Strategy (2011)
	High-Tech	National Biotechnology Research and Development Goal (2009)
Ghana	Green Economy	Green Economy Strategy and Implementation Plan 2016 – 2030 (2017)
	Bioenergy	National Bioenergy Strategy in Ghana (2014)
Kenya	High-Tech	National Bioprospecting Strategy (2011)
	Bioenergy	Strategy for developing the Bio-Diesel Industry in Kenya (2008)
	High-Tech	A National Biotechnology Development Policy (2006)
Malawi	Bioenergy	Malawi Biomass Energy Strategy (2008)
Mali	Bioenergy	Strategie Nationale de Développement des Biocarburants en Mali (2009)
	Bioenergy	Stratégie Nationale pour le Développement des Energies Renouvelables (2006)

See further policy strategies on the next page →

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Mauritius	Blue Economy	Ocean Economy (2013)
Mozambique	Green Economy	Green Economy Action Plan 2013 – 2014 (2012)
	Bioenergy	Mozambique Biomass Energy Strategy (BEST) (2012)
	Bioenergy	Política e Estratégia de Biocombustíveis (2009)
Namibia	Research & Innovation	National Programme on Research, Science, Technology and Innovation (2015)
Nigeria	Bioenergy	Nigerian Biofuel Policy and Incentives (2007)
Rwanda	Green Economy	Green Growth and Climate Resilience - National Strategy on Climate Change and Low Carbon Development (2011)
	Bioenergy	Rwanda Biomass Energy Strategy (BEST) (2009)
Senegal	Bioenergy	Lettre de Politique de Développement du Secteur de L'Énergie (2008, 2012)
		National Biofuels Strategy (2006)
South Africa	Bioeconomy (holistic)	The Bio-Economy Strategy (2013)
Tanzania	High-Tech	Biomass Energy Strategy (BEST) Tanzania (2014)
		National Biotechnology Policy (2010)
Uganda	Bioenergy	Biomass Energy Strategy Uganda (2014)
	High-Tech	National Biotechnology and Biosafety Policy (2008)
	Bioenergy	The Renewable Energy Policy For Uganda (2007)

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South Africa



1

What have been the major developments in bioeconomy policy over the past decade?

Out of all the African countries, South Africa stands out with a dedicated bioeconomy strategy. The government published the “**South Africa Bio-Economy Strategy**”⁴⁶ in 2013 to foster the transition towards a knowledge-based bioeconomy. As a country well-endowed with natural resources and one of the highest levels of biodiversity in the world, South Africa focused early on biodiversity and uniquely included health and medical aspects in its strategy. Based on the experiences of two former initiatives, the “**National Biotechnology Strategy**” (2001)⁴⁷ and the “**Ten-Year Innovation Plan**” (2008), the dedicated bioeconomy strategy seeks to guide bioscience research and innovation investments, as well as decision-making, within a high-level framework. Many other policies seek to move the country towards a “green economy” and, more recently, policies have been adopting a circular-economy approach.

Starting in 2018, the Department of Science and Innovation (DSI), in partnership with its entity, the Technology Innovation Agency (TIA), and AfricaBio, has hosted a yearly **BioAfrica Convention** to showcase bio-innovations from the broader biotech community of the African continent.

With regard to policy recommendations, in 2018 the Academy of Sciences of South Africa⁴⁸ reviewed the regulatory and ethical issues as well as the impacts of genome editing, both in terms of breeding and in human genomics, and the National Advisory Council on Innovation (NACI) provided advice on the country’s bioeconomy strategy, most recently on the approach to monitor the performance of the bioeconomy.⁴⁹

Furthermore, the South African government is active in international collaboration. It is involved in the **Southern Africa Innovation Support Program** (SAIS), a regional initiative funded by the Ministry for Foreign Affairs of Finland, in partnership with STI Ministries of Botswana, Namibia, Tanzania and Zambia, and the Southern African Development Community (SADC) Secretariat, all supporting the growth of new businesses through strengthening innovation ecosystems and promoting cross-border collaboration (e.g. through pilot programs in South Africa, such a biotech startup incubator run by CiTI and TechVillage). Furthermore, the **Southern Africa Network for Biosciences** (SANBio), a regional initiative supported by South Africa and Finland, focuses on bio-innovations and a variety of capacity development and collaborative projects.

2 How is the dedicated bioeconomy strategy embedded into the wider policy context?

The South African bioeconomy strategy was officially launched in 2014 and it effectively replaced the National Biotechnology Strategy of 2001. The

bioeconomy strategy was very closely linked to the National Development Plan (NDP).

3 Who is the author of the strategy, and how were stakeholders consulted and engaged in the different phases of the strategy process?

South Africa's bioeconomy strategy was published by the Department of Science and Technology (now the Department of Science and Innovation DSI) in 2013. Although the ministry plays a crucial role in leading the implementation of the strategy, the policy was defined as an inter-agency effort. The Departments of Trade and Industry, Health, Agriculture, Forestry and Fisheries, and Environmental Affairs

are involved in this by coordinating their research, development and innovation activities. The strategy also aims to involve relevant non-governmental stakeholders, such as industry, community-based organizations, not-for-profit companies, academia, and science councils. No information is provided on the strategy development process.

4 How is "bioeconomy" defined in the main policy strategy?

The South African bioeconomy definition refers to "activities that make use of bioinnovations, based on biological sources, materials and processes to generate sustainable economic, social and environ-

mental development." It encompasses biotechnological activities and processes that translate into economic outputs, particularly those with industrial application.

5 What is the main purpose of the dedicated policy strategy, and how does it relate to the SDGs and the Circular Economy? How does it introduce visions, targets, milestones, and action plans?

The vision is for South Africa's bioeconomy to become a significant contributor to the country's economy by 2030, in terms of gross domestic product (GDP). The strategy further seeks to 1) make the country more competitive internationally (especially in the industrial and agricultural sectors), 2) create more jobs, 3) enhance food security, 4) and create a greener economy as the country shifts towards a low-carbon economy. The strategy often highlights the need to integrate both a technology push and a

market-pull approach, in order to enhance the country's socio-economic development.

The strategy is clearly built upon the lessons learned from existing programs and strategies, such as the National Biotechnology Strategy and 'Farmer to Pharma' concept (one of the "Grand Challenges" of the Ten-Year Innovation Plan of 2008), which were too narrowly focused. The new strategy looks to shift the focus from developing the biotechnology

sector to developing a bioeconomy, where the biotechnology sector joins forces with the ICT sector, environmental agencies and the social sciences to create holistic solutions for the agriculture, health and industrial sectors.

Published before the SDGs and proliferation of the circular economy concept, there is no direct connection made to these themes.

The strategy document provides strategic objectives, interventions and potential impacts for the three priority areas for research and development – agriculture, health and industry/the environment. There are no overall targets set, but targets are set on individual programs that are implemented in each of the sectors. No additional budget is specified.

6

What are the priority areas of the strategy?

The Bioeconomy Strategy identifies three priority areas for research and development – **agriculture, health and industry/the environment**.

Representing about 12 percent of the GDP, the agro-industrial sector is considered as having the highest economic impact among the three bioeconomy-related sectors. In the agricultural sector, the bioeconomy strategy foresees sustainable **intensifying agricultural production** and processing. Biotechnology, including responsible genetic engineering, should generally help to improve the heat resistance and drought tolerance of crops and address the challenges caused by climate change, diminishing water resources, and grazing land, as well as halt the loss of biodiversity. South Africa is currently leading the continent in agricultural biotech, with more than 80 percent of its maize and soya genetically modified. Optimizing energy crops is also considered important in order to foster the development of the **biofuel** industry. R&D support for agricultural biosciences and technologies is an integral part of the strategy. Furthermore, it is intended to strengthen autonomy in the development of animal vaccines and indigenous crops (such as fortified sorghum, rooibos and honey bush). The strategy also seeks to better capitalize on the country's **biodiversity**, and capture niche consumer markets for natural products.

In the health sector, the strategy seeks to better respond to key challenges, such as child mortality, HIV

and malaria infections. Discovery and **bioprospecting** play a major role in developing new drugs, vaccines, diagnostics, and medical devices (especially in TBC and HIV). This also includes exploring opportunities in **indigenous knowledge systems** (IKS). The largely informal market for natural and plant medicines should also be developed. This requires capacity-building in process engineering and manufacturing.

The strategy further focuses on support for research, development and innovation in **biobased chemicals** and **industrial biotechnology**. Improving the local capacity in industrial biotechnology, such as the local manufacturing of enzymes and biofuels, should increase the acceptance of more environmentally sustainable inputs and practices by South Africa's heavy industries. Given the significant problems related to water scarcity, especially in dry areas, the strategy further promotes improvements in **wastewater treatment**.

The bioeconomy strategy is not restricted to fostering the biotechnology sector but seeks to develop a comprehensive bioeconomy, which involves several cross-sectional technologies and knowledge areas. **Information and communication technology** (ICT), nanomaterial research and manufacture, bio-entrepreneurship, social sciences as well as intellectual property management are specifically mentioned as important knowledge areas.

7

What policy instruments are put forth in the strategy (and its action plan)?

While the strategy calls for a significant increase in additional resources, especially in research and development activities, no budget is provided. For the implementation of the strategy, the document refers to various funding programs, e.g. the Department of Higher Education and Training funding for academic institutions, as well as science-based innovation and patent support. In general, the various strategic interventions proposed represent a comprehensive approach to supporting the bioeconomy.

The strategy calls for a variety of investments in **research and innovation**. In order to enhance the innovation system, it calls for increased state investment in life science incubators, science parks and pilot facilities for demonstration purposes. The strategy points to funding for large research infrastructure and platforms to raise the country's production of patents in life sciences. In agriculture, for example, it seeks to establish a network of agro-innovation hubs to enhance technology transfer. With regard to industry, a number of RDI interventions have been developed as a result of the 2014 strategy. These are aligned with the strategic thematic areas of bio-products, bio-based chemicals, bio-based materials, bioenergy and bioremediation and include technology flagship programs relating to biomanufacturing and bioprocessing, biorefineries, biocatalysis, microbial bioprospecting and bio-based remediation technologies.

Infrastructure support is largely focused on the research environment. To de-risk the RDI value chain and to localize biomanufacturing capabilities, several upscaling and pilot demonstration infrastructures have been established, including the Bio-manufacturing Industry Development Centre (BIDC), Biorefinery Industry Development Facility (BIDF), Supercritical Carbon Dioxide Encapsulation Facility (SCEF), Industrial Biocatalysis Hub and Umbogintwini Bioprocessing Platform.

In particular, the strategy underlines the importance of having highly skilled labor involved in the development of its national bioeconomy. **Training and education** for scientists, engineers and technicians along bioeconomy value-chains is considered of

highest priority in order to create a sufficient knowledge base. Furthermore, it is considered necessary to develop “technopreneurs” who convert diverse technologies into innovative biobased products. Education and training should therefore become integrated into research and innovation policies.

In general, programs to enhance **commercialization** of technologies should be developed. The strategy defines that a Bio-Innovation Venture Capital Fund should be established as a mechanism to attract public and private capital. The fund would require about R2 billion, of which R300 million to R400 million (15 to 20 percent) would be provided by the government over a period of three years. While not directly dedicated to bio-innovations, more recently an Innovation Fund was established with an allocation of R1.5 billion (USD 90 million in 2020).

The strategy mentions the creation of an enabling environment for venture capital where the Technology Innovation Agency stimulates investment through venture capital and foreign investment. In early 2010, the biotechnology innovation centers were incorporated into the Technology Innovation Agency, which was established to address the “innovation chasm” and the fragmentation of funding instruments. The agency also incorporated the Innovation Fund.

The strategy suggests that private-sector funding as well as in-kind capital could be sourced through corporate social investment programs.

With regard to **demand-side** measures, the strategy supports initiatives to promote public understanding of the technologies underlying the bioeconomy. Activities include participation in, or hosting of, international conferences and other relevant forums, as well as electronic marketing through the creation of a South African bioportal that provides information on relevant technology skills, opportunities, products and linkages in the bioeconomy.

The strategy suggests that further legislation will help create demand for green products and facilitate the introduction of new bioproducts. In addition, un-

locking the value of indigenous crops, coupled with consumer demand for “natural” products, should help capture niche markets.

The document also mentions a variety of **bioeconomy-friendly framework** conditions. Intellectual property (IP) management is highlighted as a priority issue and calls for the country to implement a strategy in order to exploit expired, expiring or unenforceable patents to produce bioproducts locally at a fraction of the cost of importation. Other actions include expanding the National Intellectual Property Management Office (NIPMO) to improve intellectual property brokering and trading, both nationally and internationally.

The strategy calls for a review of regulations regarding new bioproducts, and the mechanisms and bodies responsible for the enforcement of these regulations. In addition, the regulatory landscape should address the ethical implications of all innovations (e.g. GMO usage, bioprospecting using indigenous knowledge, confidentiality of genetic information).

In order to support the pharmaceutical industry, the strategy employs an import-replacement technique, with the aim of replacing up to 25 percent of current imports within a decade of implementation. This would support programs, such as “Farmer to Pharma” one of the five Grand Challenges of South

Africa’s Ten-Year Innovation Plan. By capitalizing on natural biodiversity and applied biotechnologies, this program promotes the commercial use of local, indigenous and underutilized plants and animal breeds in ways that protect genetic resources, respect local communities’ intellectual property rights and support nature conservation. With regard to the smaller human vaccine sector, an import replacement target of 20 percent or more is suggested.

The strategy makes clear that its success hinges on coordination efforts, a key **good governance** measure. Committees have been created to oversee the Strategic Health Innovation Partnership (SHIP) programme and the Agricultural Bio-innovation Partnership Programme (ABIPP). A consortium committee is overseeing investments in the IKS arena. A committee is also currently being established for the Industry and Environment programme (Strategic Industry Bio-Innovation Programme - SIIP).

Fostering international partnerships that help expand and improve research and innovation is encouraged, however it is noted that this internationalization should not reduce research into local priority issues. In addition, emphasis is placed on social inclusions and working with Indigenous Knowledge Systems (IKS) as an important crosscutting contributor to the activities within these three sectors.

8

How is the implementation of the strategy monitored and evaluated?

DSI as the lead agent of the strategy is tasked with facilitating the strategy’s broad implementation, however it should be guided and monitored by interdepartmental stakeholder groups. This interdepartmental structure will function as a subcommittee of the Economic Sectors and Employment Sector Cluster of government. DSI will develop implementation frameworks, which will guide all associated stakeholders in developing implementation plans.

18 key quantitative output indicators (related to industry, market, knowledge transmission and application, as well as knowledge base and human resources) are provided to track and monitor the strategy. Although

the strategy envisions the bioeconomy being a significant contribution to South Africa’s GDP by 2030, the indicators only refer to knowledge and skills (full-time equivalent researchers, scientific publications, and bioeconomy-related publications) and financial support (gross expenditure on research and development as a percentage of GDP).

However, these systematic metrics have not yet been implemented. In 2018, the National Advisory Council on Innovation (NACI) developed a set of indicators that can be used to measure and monitor the bioeconomy’s contribution to South Africa’s GDP at both sectoral and national level. The new performance

indicators include: output, employment, exports, investment, and innovation.⁵⁰ The NACI study defines two high-level components: metrics for that portion of the economy resulting from the bioeconomy activities/sectors, and metrics for innovation that provide

a key input to the development of the bioeconomy.⁵¹ However, the DSI will still have to find appropriate social and environmental indicators. A new bioeconomy metrics report based on these recommendations is anticipated to be published in 2020.

9

Do dedicated regional bioeconomy policy strategies exist?

No

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Americas



Latin America and the Caribbean

In recent years, the concept of the bioeconomy has gained significant political importance in Latin America and the Caribbean. While various bioeconomy-related policy strategies are being developed, notably with the support of macro-regional organizations, this has only slowly translated into the adoption of dedicated national bioeconomy strategies in the region. Countries including Argentina, Brazil, Colombia, Ecuador, Puerto Rico, Uruguay, and Argentina have been working for years on dedicated strategies; however, the process of adopting these strategies has been slow. The first and only country to publish a dedicated national strategy was Costa Rica in August 2020. In Argentina, the culmination of a process to develop a dedicated national bioeconomy strategy resulted in the publication of a collective stakeholder strategy in 2019.

In general, policy strategies that refer to bioeconomy development are characterized mainly by capitalizing on the relevant country's large quantity of natural resources. Bioeconomy is promoted particularly as an alternative model for sustainable development and green growth. Latin America and the Caribbean (LAC) have also made important progress in areas such as bioenergy, agricultural biotechnology, low-carbon agriculture, the utilization of biodiversity, and ecosystem services.⁵² For example, Brazil and Argentina are among the leaders in bioenergy production and are among the top five users of genetically modified crops. Bioeconomy development in Brazil has been dominated by progress in the bioenergy sector. The largest Brazilian state, Amazonas, however, has made significant headway in advancing tropical forestry-based bioeconomy.⁵³

Other countries are making headway towards developing dedicated bioeconomy strategies. For example, a multisectoral process is underway in Uruguay to design a national Sustainable Bioeconomy Strategy (EBS) as part of the “Uruguay 2050” National Development Strategy, under the authority of the Office of the President. Colombia is devising a proposal to capitalize on the bioeconomy as part of its “Mission of Experts,” a group of 34 leading national and international experts, whose objective is to produce a roadmap and recommendations for prioritizing science and technology. Ecuador is currently in the process of consolidating its regulatory, institutional, and political framework in order to establish the conditions necessary for developing a public policy for the bioeconomy. Starting in 2017, a Working Group on Bioeconomy was set up within the Ministry of Environment which has assumed a strong biodiversity-based approach to the bioeconomy.⁵⁴

North America

The USA came to the forefront in 2012 with a holistic dedicated bioeconomy strategy which uniquely emphasized the role of biotechnology, the importance of biomedicine, and its application for defense purposes. Since then a more agricultural and bioresources-based vision developed, driven by individual federal agencies. While recent coordinating activity within the White House and bills in the house and senate look to strengthen America’s bioeconomy, this has not yet translated into a replacement for the 2012 National Bioeconomy Blueprint. Canada has taken a different path to developing its bioeconomy in the form of an industry-driven national strategy. The strategy focuses primarily on access to biomass in agriculture.

Country	Perspective	Document Name
Argentina	Bioeconomy (stakeholder)	La Bioeconomía como Estrategia para el desarrollo argentino (2019)
	Bioeconomy	Bioeconomía Argentina (2017)
	High-Tech	Biología argentina al año 2030: Llave estratégica para un modelo de desarrollo tecno-productivo (2016)
	Bioeconomy (regional)	Plan Provincial de Bioeconomía Buenos Aires (2016)
	Research & Innovation	Argentina Innovadora 2020 (2012)
Brazil	Bioenergy	Plano Decenal de Expansão de Energia 2023, 2029 (2014, 2020)
	Research & Innovation	Plano de Ação em Ciência, Tecnologia e Inovação em Bioeconomia / Action Plan in ST&I in Bioeconomy 2018 (2018)
	Research & Innovation	Estratégia Nacional de Ciencia, Tecnologia e Inovacao 2016 – 2019 (2016)/ National Strategy on Science, Technology and Innovation
	High-Tech	Biotechnology Strategy (2007)
Canada	Forestry	Canada's Bioeconomy Strategy Leveraging our Strengths for a Sustainable Future (2019)
		Growing Forward 2 (2018)
		A Forest Bioeconomy Framework for Canada (2017)
Colombia	High-Tech	Colombia Green Growth Roadmap (2018)
		Colombia Bio (2016)
		Plan nacional Dedesarrollo 2014-2018 (2015)
		Programa Nacional de Biocomercio Sostenible (PNBS) 2014 – 2024 (2014)
		Politica para el Desarrollo Commercial de la Biotecnología a partir del Uso Sostenible de la Biodiversidad (2011)
Costa Rica	Bioeconomy (holistic)	National Bioeconomy Strategy – Costa Rica 2020 – 2030 (2020)
Ecuador	Biobased Economy	Guidlines for the Promotion of Bio-Entrepreneurship (2019)
Mexico	Bioenergy	Estrategia de Transición para Promover el Uso de Tecnologías y Combustibles más Limpios (2016, 2020)
	Bioenergy	Estrategia Intersecretarial de los Bioenergéticos (2009)
Paraguay	High-Tech	Estrategia Nacional y Plan de Acción para la Conservación de la Biodiversidad del Paraguay 2015 – 2020 (2015)
	High-Tech	Politica y Programa Nacional de Biotecnología Agropecuaria y Forestal del Parauay (2011)
Uruguay	High-Tech	Estrategia Nacional de Desarrollo Uruguay 2050 (2019)
		Plan Sectorial de Biotecnología 2011 –2020 (2012)
		Uruguay Agro inteligente 2010 – 2015 (2010)
USA	Bioeconomy (holistic)	The Bioeconomy Blueprint (2012)

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Costa Rica

1

What have been the major developments in bioeconomy policy over the past decade?

Costa Rica is a frontrunner when it comes to sustainable development. Since the abolition of the army in 1948, the government of Costa Rica has promoted pioneering political reforms in environmental protection and conservation. Since the 1980s, further policies have been adopted to open up trade and to diversify production, along with internationally recognized initiatives in areas relevant to the bioeconomy, such as biodiversity, forestry, climate change, sustainable agriculture, clean energy, sustainable tourism, among others.

For example, in 1996, the country passed a **Biodiversity Law**⁵⁵ with the aim of promoting the conservation and ecologically sustainable use of biodiversity and the equitable sharing of the benefits arising from the utilization of genetic resources across all economic sectors and parts of society. The political focus on biodiversity conservation and protection has since been maintained by the adoption of **National Biodiversity Policies**.⁵⁶

In 2008, the Costa Rican government approved the **National Biofuels Program**⁵⁷ to promote the progressive substitution of fossil fuels by renewable energy sources with the aim of increasing social development and contributing to the reduction of greenhouse gases.

In 2010, the **Law for Integral Waste Management** was passed to encourage market development for

by-products, recoverable materials, and recyclable and biodegradable products, as well as to promote innovations and technological transfer for integrated waste management.

In 2015, the government published the **Strategy for Low-Carbon Livestock**,⁵⁸ to increase productivity of the country's livestock farmers while reducing greenhouse gas emissions.

By adopting the **Law on the Development, Promotion and Encouragement of Organic Agriculture**,⁵⁹ the government agreed to develop comprehensive training and education programs on good practices in organic agriculture, to support research in this area and to establish certification systems for national organic products.

With the publication of the **National Policy on a Knowledge-Based Society and Economy**⁶⁰ in 2017, the government looked to maximize well-being through the production, distribution and use of all types of knowledge. In addressing the knowledge-based economy, the document specifically referred to the term bioeconomy, which includes "economic activities based on innovation and biotechnology for the production of biological products and processes."

In addition, Carlos Alvarado, the current President, announced plans to fully decarbonize the country's economy and make it the first carbon-neutral na-

tion in the world. In order to support the country's contribution to the Paris Agreement, the government launched a **Decarbonization Plan**⁶¹ in February 2019. The ambitious plan aims to reduce the country's net emissions of carbon dioxide to zero by 2050 and promote the country's modernization through green growth.⁶²

In August 2020, the government published the **National Bioeconomy Strategy – Costa Rica 2020 – 2030**⁶³

at a launch event attended by the President, making Costa Rica the first country in Latin America and the Caribbean to adopt a dedicated national bioeconomy strategy. In parallel, the Ministry of Science and Technology signed a Memorandum of Understanding with UNDP with the aim of strengthening the mobilization of technical and financial resources to encourage the development of bio-businesses within the framework of the National Bioeconomic Strategy and the Finance for Biodiversity Initiative (BIOFIN).⁶⁴

2

How is the dedicated bioeconomy strategy embedded into the wider policy context?

The policy strategy explicitly highlights the wider context in which it emerges. It describes its relationship to superordinate and national policy development and outlines how far the strategy aligns with existing policy initiatives in related policy areas. It particularly aligns with Agenda 2030 for Sustainable Development, the Convention on Biological Diversity, the Paris Agreement on Climate Change, and the Convention to Combat Desertification. Furthermore, it aligns with various public policy frameworks, including the National Policy on Productive Development (Vision Costa Rica 2050), the National Development Plan 2019 – 2022, the National Biodiversity Strategy, the National Decarbonization Plan 2018 – 2050, the National Policy on Sustainable Production and Consumption 2018 – 2030, the National Science

and Innovation Strategy, and the National Digitalization Strategy 2018 – 2022, amongst others⁶⁵. It is further stated, that the new bioeconomy strategy provides a reference framework to complement the National Policy on Entrepreneurship 2030, which is also a guiding framework to promote a sustainable economic recovery.⁶⁶

For Costa Rica, the bioeconomy represents an opportunity to converge productive development policies and environmental policies developed over the last seven decades. It aims to reconcile the objectives for productive development and for the protection, knowledge and sustainable use of the country's biological wealth.

3

Who is the author of the strategy, and how were stakeholders consulted and engaged in the different phases of the strategy process?

The strategy was developed as an inter-ministerial effort and is based on a preceding multi-stakeholder development process, including various consultations of experts and representatives from science and technology, both public and private, and inter-organizational processes.

The process was coordinated by an inter-ministerial committee on bioeconomy (CIB), composed of representatives from the Ministry of Science, Technology

and Communications (MCTIC); the Ministry of Agriculture and Livestock (MAG); the Ministry of Environment and Energy (MINEA); and the Ministry of Economy, Industry and Trade (MEIC). The formulation process, which started in 2017, was supported by the Economic Commission for Latin America and the Caribbean (ECLAC) and the Inter-American Institute for Cooperation on Agriculture (IICA) and financial support was given by the cooperation program with the Federal Republic of Germany (ECLAC-BMZ/GIZ Program).⁶⁷

4

How is “bioeconomy” defined in the main policy strategy?

The strategy’s definition of the bioeconomy refers to the Communiqué of the Global Bioeconomy Summit 2018, in which the bioeconomy comprises “the production, utilization, conservation and restoration of biological resources, including related knowledge, science, technology, and innovation, to provide information, products, processes and services in all economic sectors aiming towards a sustainable bioeconomy.”

The definition represents a comprehensive understanding of bioeconomy, including the whole range of biological resources and knowledge to provide products and services in all sectors of trade and industry within the framework of an economic system fit for the future. In this respect, biological resources include: 1) cultivated and natural biomass, 2) residual biomass from the agricultural, fishing and aquaculture, forestry and agro-industrial sec-

tors, 3) biomass that can be recovered from urban residues, 4) waste-waters from livestock and human activities, but also 5) terrestrial and marine biodiversity, including biochemical elements, genes, proteins, and microorganisms of interest for research and commercial applications.

Scientific and technological development is recognized as a fundamental catalyst for the transformation of the country. The strategy therefore emphasizes the following three key elements of the bioeconomy: 1) the promotion and application of scientific knowledge in biological and life sciences, 2) the application of traditional and modern knowledge about biological resources, processes and principles in the development of new products, processes and services, and 3) the use of technologies applicable to knowledge, transformation and emulation of biological resources, processes and principles.



5

What is the main purpose of the dedicated policy strategy, and how does it relate to the SDGs and the Circular Economy? How does it introduce visions, targets, milestones, and action plans?

The bioeconomy policy strategy pursues a 10-year vision to promote high value-added sustainable production in all regions of the country, which is based on the fair and equitable use of biodiversity, the circular utilization of biomass and the country’s biotechnological progress.

Strategic objectives mentioned in the strategy include: 1) making Costa Rica a model country in sustainable development, taking advantage of its biological resources to promote social inclusion and equity, balanced territorial development, conservation, knowledge and sustainable use of biodiversity, and national competitiveness, 2) making the bioeconomy one of the pillars of the productive transformation of Costa Rica by promoting innovation, value creation, diversification and sophistication of the country’s economy, applying the principles of the circular bioeconomy and seeking to decarbonize production and consumption processes, 3) promoting the convergence between the country’s wealth in biological resources and the

use of national capacities in biological sciences for the valorization of that wealth.

The strategy is scheduled to be implemented in three phases: momentum (2020 – 2022); scaling up (2022 – 2026) and consolidation (2026-2030).⁶⁸ The strategy distinguishes between three types of goals: 1) short-term goals (2020 – 2022), including establishing an institutional basis for the development of the bioeconomy in Costa Rica, preparing action plans for the implementation of the strategy, identifying a set of strategic projects, and identifying and managing the resources to start the implementation of a set of the identified strategic projects; 2) mid-term goals (2022 – 2026), including consolidating the institutional and legal frameworks for bioeconomy development, expanding the scope of implementation of regional bioeconomy action plans, and identifying and implementing a second round of regional strategic bioeconomy projects and initiatives, focused on high value-added sec-

tors; 3) long-term goals (2026 – 2030), including consolidating the bioeconomy as a model for fossil decarbonization and the sustainable development of Costa Rica, and consolidating Costa Rica as a model country in the development of the bioeconomy in the context of high biodiversity.

Action plan development should start in 2020. Its main objective should be to implement the proposals set out in the strategy with a ten-year horizon (to 2030). The action plan should be carried out on the basis of a participatory process that includes all relevant bioeconomy stakeholders.

Moreover, the strategy reacts to the global Covid-19 pandemic and the associated global economic downturn and the challenges to many production systems by recognizing the potential of bioeconomy to produce more efficiently, to reinvent the country's economy, and to maintain value chains that sustain jobs and livelihoods, while ensuring the sustainable use and rehabilitation of nature in the face

of climate change.⁶⁹ The focus of the strategy is to increase the resilience and sustainable use of the country's biodiversity.

The strategy document further highlights the active involvement of societal actors. Its prioritization of gender equity and the creation of opportunities for the country's youth and indigenous communities presents a unique addition to bioeconomy policy-making.

Within the strategy, the bioeconomy is mentioned as a form of the circular economy, "which seeks the use of biological resources in the most productive and efficient way (...)" The strategy document uses the term "circular bioeconomy" to emphasize that the concept goes beyond seeking efficiency in the use of fossil resources, but rather aims to replace them. According to the strategy, a circular bioeconomy contributes to reducing the carbon footprint of production processes and generates new market niches for consumers concerned with minimizing their impact on the environment.

6 What are the priority areas of the strategy?

The strategy document defines five strategic axes with respective lines of action: 1) bioeconomy for rural development, 2) biodiversity and development, 3) biorefinery of residual biomass, 4) advanced bioeconomy, and 5) urban bioeconomy and green cities.

It recognizes that agricultural, fishing and forestry activities are fundamental to the **development of rural areas**. The strategy emphasizes the need to diversify production and to generate new value chains and networks. Priority should be given to promoting **sustainable primary industries** (e.g. through research and innovation in precision agriculture and sustainable aquaculture) and fostering new **value-added rural agro-industry** that produces food and ingredients by valorizing local resources.

With regard to biodiversity and development, the strategy highlights the government's efforts and commitment to environmental protection and conservation, while also emphasizing terrestrial and marine biodiversity resources as a new engine for

inclusive, sustainable development with high value-added and low greenhouse gas emissions. Interestingly, the role of **ecosystem services** is stressed (e.g. virtual tourism and sustainable eco-tourism in protected wildlife areas and biological corridors). Furthermore, the document considers the **sustainable use and commercialization of biodiversity**, for example through bioprospecting activities, as holding great potential for economic development, but also for biodiversity protection and conservation.

Within strategic axis three, "biorefinery and residual biomass," the focus is on promoting the **integral use and valorization of residual biomass** from agricultural, agro-industrial, forestry and fishing processes to produce energy and a wide range of bioproducts. **Biorefining** should contribute to generating new value chains and networks in primary production. The production of bioenergy based on residual biomass is highlighted as an alternative for private consumption on farms and rural households. Furthermore, the production of bio-inputs and biobased materials should be promoted,

i.e. to produce nutrients for biofertilizers and protein for animal feed, and to replace fossil-based products or those with a high environmental impact.

Strategic axis four, “advanced bioeconomy,” highlights the importance of **biotechnology, nanotechnology and digital technologies, as well as their convergence**. The strategy demonstrates the wide range of technologies, which can contribute to the sustainable use of biological resources, including the so-called omics technologies, synthetic biology, biochemical engineering, and green chemistry, as well as tools arising from interdisciplinary and technological convergence, such as bioinformatics, bio-diagnostics and biomonitoring.

The strategy seeks to promote synergies between the Costa Rican scientific capabilities in order to

encourage the development of new, innovative and sustainable products, applications and platforms.

The highly innovative approach of the strategy to promote **the urban bioeconomy and green and intelligent cities** is unique in comparison to other existing policy strategies. Costa Rica is one of the first countries in the world which intends to focus and further develop the concept of a **bioprincipled city**. The government intends to develop and experiment with the sustainable management and valorization of solid waste residues, inter-urban biological corridors, as well as urban design approaches inspired by biological principles, processes and systems. The strategy intends to identify intermediate and small cities whose municipalities might be interested in applying the concept of a bioprincipled city in their urban development plans.

7

What policy instruments are put forth in the strategy (and its action plan)?

The strategy document emphasizes the cross-cutting priority “**Research, Development and Innovation**” and the need to generate economies of scale and avoid duplication. In this respect, the strategy focuses on establishing shared platforms to encourage the collaboration between public and private sector R&D, to promote entrepreneurship (e.g. through incubation and accelerator programs), to support ventures in the piloting and development phases, and to foster collaboration for technology transfer. Interestingly, the strategy pursues a broad concept of innovation which spans technological, social and economic innovations.

Costa Rica’s strong commitment to investing in education and training is outlined within the cross-cutting priority “**Education and Capacity Development**.” The strategy highlights the importance of building a knowledge-based society, to ensure quality education and universal access. A focus is put on environmental education, e.g. through regional platforms for virtual tourism. Moreover, internship programs with companies and centers of excellence should be established for young people and women interested in biobusinesses.

The cross-cutting priority “Market Access” highlights the importance of promoting **commercialization** by stimulating local markets and guaranteeing access to international markets for bioeconomy goods and services, among others. The strategy document recognizes the need for new incentives, regulations and financing options for the different stages of the production chain. Special contests and fairs should contribute to fostering a favorable business climate for the bioeconomy.

The cross-cutting priority “Communication with Society” focuses on increasing the involvement and empowerment of the entire population, for example by supporting networks at the local, regional, national and international level. The **demand side** remains relatively unaddressed in the strategy document. The focus is on raising public awareness for through actions such as the promotion of the bioprincipled city concept.

In order to promote **bioeconomy-friendly framework conditions**, the strategy highlights the need to strengthen existing mechanisms for the management of ecosystem services, especially in the area

of forestry, biodiversity and eco-tourism (e.g. nationwide payment for the environmental services system, PES). In addition, legislation should be updated, e.g. with regard to promoting the sustainable use of biodiversity, fostering the use of residual biomass in primary industries and the agro-industry, and facilitating the use of biological materials and principles in construction. It further emphasizes the need to strengthen national capacities in IP management, licensing and other mechanisms for the protection of knowledge.

The government aims to promote **good governance** in terms of policy coherence and effectiveness within the strategy document. The Ministry of Science, Technology and Telecommunications (MCTIC), as the coordinator and initiator of the strategy, established an Inter-ministerial Bioeconomy Commission (CIB), for exchange among the four participating ministries (MAG, MEIC, MCTIC and MINEA). In addition, by creating a high-level National Bioeconomy Council, as the highest decision-making and monitoring body, the strategy further pursues a multi-stakeholder approach to promoting bioeconomy development.

8

How is the implementation of the strategy monitored and evaluated?

The strategy proposes the creation of a National Bioeconomy Council, as a multi-stakeholder body to support strategy implementation. The council will be supported by a technical secretariat and may establish ad-hoc working groups to address identified bottlenecks limiting the implementation of the strategy.

Moreover, the development of a dedicated 10-year action plan should ensure monitoring and evaluation of the strategy implementation. Comparative studies should further monitor the country's progress in terms of the bioeconomy development.

9

Do dedicated regional bioeconomy policy strategies exist?

No

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USA



1

What have been the major developments in bioeconomy policy over the past decade?

In 2012, the White House published a dedicated U.S. bioeconomy strategy, the “**National Bioeconomy Blueprint**,”⁷⁰ covering the entire bioeconomy portfolio and emphasizing biotechnology and biomedicine. With the release of this Blueprint, the United States became the first country to describe biotechnology as a key driver of the bioeconomy.

The agricultural strategy or updated “**Farm Bill**,” developed by the Department of Agriculture (USDA) and covering the period from 2014 – 2018, did not specifically relate to the bioeconomy, but promoted key subsegments in the areas of agriculture, bioenergy, and food, and expanded efforts to enable the procurement of biobased products (BioPreferred Program) and the BioRefinery Assistance Program (rebranded as the Biorefinery, Renewable Chemical, and Biobased Product Manufacturing Assistance Program), and the Biomass Crop Assistance Program.

The **BioPreferred program**,⁷¹ which works to increase the use of biobased products through a federal procurement program and a voluntary certification and labeling program, has developed into one of the U.S. bioeconomy’s main support tools. Since the launch of the program’s voluntary certification initiative in 2011, more than 3,000 bioproducts have been certified and labeled.⁷² However, in May 2018, the Obama era Executive Order compelling federal agencies to submit biobased procurement targets was revoked by the current Administration, potentially

setting back efforts to measure the success of the program. While federal agencies are still required to procure biobased products, they no longer are required to report targets.

In 2015, the U.S. government renewed the federal “**Strategy for American Innovation**,”⁷³ highlighting the need for investment in new technologies to develop future U.S. industries, such as the bioeconomy. Public R&D investment was considered highly relevant for the National Nanotechnology Initiative, the Materials Genome Initiative, the National Robotics Initiative, and the Big Data Research and Development Initiative.

Without a central document to replace the 2012 Bioeconomy Blueprint and its holistic view of bio- and high-tech innovation across all economic sectors, the U.S. entered a period marked by the more agricultural and bioresources-based vision put forth by individual federal agencies. Building on a series of opportunity reports named “**Billion-ton Report**” (2005, 2011, 2016),⁷⁴ an inter-agency vision to sustainably produce one billion tons of biomass by 2030 was adopted. The implementation of this billion-ton strategy is documented in the 2016 “**Federal Activities Report on the Bioeconomy**,”⁷⁵ which provides an overview of publicly funded bioeconomy activities. Subsequently, in December 2016, the government adopted the “**Strategic Plan for a Thriving and Sustainable Bioeconomy**,”⁷⁶ a strategy providing a

framework for biomass-derived product development in the United States. After a series of meetings and stakeholder activities, the Department of Energy's Bioenergy Technologies Office (BETO) would eventually receive congressional appropriations in 2017 to establish the first open, public biofoundry, **the Agile BioFoundry (ABF)**, a distributed consortium of nine DOE National Laboratories, which work to advance biomanufacturing and address precompetitive research challenges identified by industry.⁷⁷

The U.S. leads in many biotechnology arenas and in recent years has focused on modernizing the regulatory system. In 2017, the USDA released an **interagency task force report**⁷⁸ outlining the need to increase public acceptance of biotechnology products, modernize and streamline the federal regulatory system for biotechnology products, and expedite commercialization of biotechnology products. The White House also released an **"Update to the Coordinated Framework for the Regulation of Biotechnology,"**⁷⁹ aimed at streamlining regulatory processes and accelerating the translation of bioinnovations to market. In 2019, the administration signed an **Executive Order**⁸⁰ aiming to modernize how agricultural biotechnology products are regulated. The Order called for the development of an international trade strategy to remove unjustified trade barriers and expand markets, and the creation of a unified biotechnology web-based platform. It was aligned with the **USDA 2020 SECURE Rule**⁸¹ which creates a new process to regulate plants developed using genetic engineering.

In June 2019, the Engineering Biology Research Consortium (EBRC), a public-private partnership partially funded by the National Science Foundation, released its technical research roadmap, **Engineering Biology: A Research Roadmap for the Next-Generation Bioeconomy,**⁸² which outlines technical themes and application sectors for engineering biology.

In 2019, the Biomass Research and Development Board (BR&D Board) co-chaired by USDA and the U.S. Department of Energy (DOE) issued **"The Bioeconomy Initiative: Implementation Framework,"**⁸³ focused on innovative technologies to harness the nation's biomass resources for affordable biofuels, bioproducts and biopower. In 2020, the **USDA Science Blueprint: A Roadmap for USDA Science from**

2020 to 2025,⁸⁴ listed the bioeconomy as a key aspect of fostering value-added innovations and explicitly references the BioPreferred program as an important evidence tool.

In contrast to other countries, over the years the Department of Defense has invested significantly in the bioeconomy. In 2019, for example, it established biotechnology as an enterprise modernization priority.⁸⁵

While in May of 2019 some coordinating activity occurred within the White House, these events have not developed into a new strategy or Executive Order to replace the 2012 National Bioeconomy Blueprint. For the first time since 2009, in August 2019 the Administration identified the bioeconomy as a key area for federal agencies to focus R&D efforts,⁸⁶ in September it released a **request for information (RFI)**⁸⁷ to gather stakeholder input, and in October hosted the **White House Summit on America's Bioeconomy.**⁸⁸ This Summit marked the first gathering at the White House of the country's bioeconomy experts, federal officials, and industry leaders to discuss the U.S. bioeconomy and signaled an understanding of the bioeconomy as critical for "Industries of the Future" and as a science and technology priority.

In 2020 the National Academy of Sciences, Engineering and Medicine (NASEM) released a new report on **"Safeguarding the Bioeconomy,"**⁸⁹ which for the first time provided a comprehensive measurement of the U.S. bioeconomy and made a number of key recommendations to government for the appropriate promotion and protection of the bioeconomy. The report strongly recommended the establishment of a government-wide strategic coordinating body with a mandate to develop, adopt and regularly update a living bioeconomy strategy.

Other promising developments include **bills in the House of Representatives**⁹⁰ and the **Senate**⁹¹ to strengthen America's bioeconomy, including the establishment of a committee to coordinate research in engineering biology across the federal agencies.

Recently, in response to the Covid pandemic, a consortium of DOE National laboratories has come together to form the National Virtual Biotechnology Lab (NVBL).⁹²

2

How is the dedicated bioeconomy strategy embedded into the wider policy context?

While the dedicated strategy of the U.S., the National Bioeconomy Blueprint, released in 2012 emphasized the benefits of coordinating federal efforts, especially with regard to R&D and regulation, no single agency has a clear lead in advancing U.S. bio-

economy goals. Each U.S. agency and department has its own defined mission and associated scientific domain, with no central government agency mandated to holistically steer the bioeconomy.

3

Who is the author of the strategy, and how were stakeholders consulted and engaged in the different phases of the strategy process?

The White House published the Bioeconomy Blueprint in 2012 with Mary Maxon, the Assistant Director for Biological Research at the Office of Science

and Technology Policy in the Executive Office of the President, as the principal author.

4

How is “bioeconomy” defined in the main policy strategy?

The National Bioeconomy Blueprint describes the bioeconomy as “one based on the use of research and innovation in the biological sciences to create economic activity and public benefit.” Notably, this definition considers GM crops as part of the bioeconomy as opposed to all crops, as do many EU countries.

This holistic definition of bio- and high-tech innovation across all economic sectors would evolve over the decade. In 2016 the “Strategic Plan for a Thriving and Sustainable Bioeconomy” defined the bioeconomy as the “sustainable use of domestically produced renewable biomass for fuels, products, and power” reflecting a vision of a future clean energy economy.

In 2019 the “White House in its Summit on America’s Bioeconomy” referenced the following definition: “the bioeconomy represents the infrastructure, innovation, products, technology, and data derived from biologically- related processes and science that drive economic growth, improve public health, agricultural, and security benefits.” This represents a more comprehensive view and shift away from

the previous focus on agriculture and biomass to include more economic areas. In addition, we see an increasing value in the “security” benefits of the bioeconomy (e.g. protecting against biological threats and developing biotechnology for military use).

Given the significant advances that have occurred since the Blueprint first articulated the U.S. definition in 2012, the NASEM report on “Safeguarding the Bioeconomy” in 2020 recommended that the government adopt a more comprehensive definition that would enable a better assessment of the bioeconomy. The report recommended the following definition: “The U.S. bioeconomy is economic activity that is driven by research and innovation in the life sciences and biotechnology, and that is enabled by technological advances in engineering and in computing and information sciences.” This definition identifies four drivers of the bioeconomy (life sciences, biotechnology, engineering, and computing and information sciences), takes a broad understanding of the bioeconomy and places innovation in the foreground. Notably, under this definition forestry would not be included in the bioeconomy given that the use of biotechnology or the use of

produced biomass for fermentation in the industry is not thought to be significant at this point. According to this definition, the bioeconomy contributed

nearly USD 960 billion in 2016 alone – more than 5 percent of the country's GDP.⁹³

5

What is the main purpose of the dedicated policy strategy, and how does it relate to the SDGs and the Circular Economy? How does it introduce visions, targets, milestones, and action plans?

The Obama administration's Bioeconomy Blueprint positions itself as a response to a world shifting to an innovative and technology-fueled economy. The bioeconomy should produce technical innovations to secure the future competitiveness and sustainability of the U.S. economy. Emphasis is placed less on using biomass for energy and more on non-energy applications (see also adaptation of the Biorefinery Assistance Program to biobased materials in the Farm Bill).

The Bioeconomy Blueprint lays out five strategic objectives: supporting R&D investments, improving commercialization of bio-inventions, reforming regulatory processes, updating workforce training programs for new bioeconomy careers, and building new bioeconomy public-private partnerships. It provides no quantitative targets, time limits or action plan. No new dedicated bioeconomy strategy has since replaced the Bioeconomy Blueprint.

6

What are the priority areas of the strategy?

The Obama administration's Bioeconomy Blueprint covers the entire bioeconomy portfolio, explicitly including the **health sector**. It specifically highlights the role of biomedical research and its impact on health. Particular weight is given to three "foundational technologies:" **genetic engineering, DNA sequencing, and automated high-throughput manipulations of biomolecules**. Other areas that are mentioned are synthetic biology, proteomics and bioinformatics. In addition,

applied research, cross-cutting technologies and technology transfer, including easier access to market, are particularly important.

Lastly, federal agencies are encouraged to prioritize procurement of **biobased and sustainable products** where appropriate and cost-effective. Increased attention is paid to biobased consumer goods for sports, leisure time, health care, ecosmetics, etc.

7

What policy instruments are put forth in the strategy (and its action plan)?

The Bioeconomy Blueprint provides measures relating to the promotion of innovation, infrastructure, commercialization, demand-side instruments, and political framework conditions. It not only defines traditional R&D funding in life-sciences, but also provides for measures to ensure improved and accelerated technology transfer. Some of the measures to

facilitate this transfer include simplifying the procedure for forming clusters and start-ups, adapting to regulatory mechanisms, and eliminating obstacles to innovation. Particularly in the health sector, approval processes should be accelerated and be more efficient. A further package of measures aims at the reform of education and training courses, as well as

enhanced involvement of industry in the qualification of employees.

While no new dedicated bioeconomy strategy has been released since the Bioeconomy Blueprint in 2012, a number of key policies and actions over the past few years have helped steer the U.S. bioeconomy. Below are key measures from the latest initiatives, the Bioeconomy Initiative: Implementation Framework (2019) and the USDA Science Blueprint (2020).

With regard to **research and innovation**, the Science Blueprint provides a vision for the USDA's scientific research through 2025 and in the area of the bioeconomy looks to strengthen food, agricultural and forest production, processing, manufacturing, utilization, and marketing through new technologies, innovation, and data analysis to create jobs and economic opportunities in rural areas. It specifically calls for the development of a bioeconomy research roadmap with near-, mid-, and long-term goals and annual progress reports.

At least 25 agencies and departments in the U.S. support research and development (R&D) in areas of the life sciences. The Bioeconomy Initiative Framework builds upon previous federal investments in basic research and applied R&D and provides a guiding document for federal agencies. The Framework specifically proposes building a national feedstock network including USDA, DOE, NSF, DOI, and industry with improved public accessibility.

Stimulating public-private partnerships is also a priority for the Bioeconomy Initiative Framework. It refers to the existing public-private partnership model, the Commercial Aviation Alternative Fuels Initiative (CAAFI), which develops alternative jet fuels for commercial aviation. Other prime examples include the Manufacturing USA program, a collection of 14 manufacturing institutes, each a public-private partnership that works to develop and advance manufacturing-related technologies. Several of these institutes connect directly to the bioeconomy, including those working on biofabrication and regenerative medicine, biopharmaceuticals, robotics, and digital technologies (e.g. the Advanced Regenerative Manufacturing Institute (BioFabUSA), the National Institute for Innovation in Manufacturing Biophar-

maceuticals (NIIMBL), the Advanced Robotics for Manufacturing Institute (ARM), and Manufacturing Times Digital (MxD)).⁹⁴

Support for **infrastructure** is mostly focused on research facilities. The Science Blueprint sets the objective of optimizing biorefining and processing systems that leverage economies of scale to promote biobased product competition and market access.

With regard to **commercialization**, the Bioeconomy Initiative Framework places significant emphasis on technology transfer. Investment in this area is mostly through federal public funding of innovation, and programs such as the Small Business Innovation Research (SBIR) program and the Small Business Technology Transfer (STTR) program to bridge the gap between basic science and commercialization. (Aviation Alternative Fuels Initiative). In addition, both the Bioeconomy Initiative Framework and the Science Blueprint aim to build on the successful USDA BioPreferred program.

With regard to good governance measures, the Bioeconomy Initiative Framework ultimately aims to facilitate coordination among federal government agencies that affect the research and development (R&D) of biofuels, bioproducts, and biopower and includes a number of initiatives to ensure better coordination of programs. In addition, it provides for increased sustainability R&D, for example by identifying relevant metrics and indicators to facilitate evaluation of environmental, societal, and economic effects. The Science Blueprint also sets the objective of gathering data to quantify and inform the valuation of the bioeconomic ecosystem.

The Bioeconomy Initiative Framework also sees the expansion of the bioeconomy as limited by technology uncertainty and investment risk for biorefineries. While federal agencies support industry in developing the U.S. bioeconomy through direct financial assistance via grants, loans, cooperative agreements, technology transfer activities, and incentives (e.g. biofuels mandates and tax credits, as determined by Congress), the Framework also looks to increase private sector involvement.

The Bioeconomy Initiative Framework refers to the need for **education** and job-training initiatives. For

example, through the Agricultural Biotechnology Education and Outreach Initiative, which calls upon the U.S. Food and Drug Administration (FDA) to provide education and outreach to the public on agricultural biotechnology and food and animal feed ingredients derived from biotechnology.⁹⁵

With regard to **demand side instruments**, the Bioeconomy Initiative Framework seeks to make scientific knowledge and data available to the biomass community and the public. Actions include improving existing federal online portals, hosting meetings and webinars, and publishing technology innovation success stories. In addition, the Initiative should revamp the federal bioeconomy stakeholder engagement and communications strategy and develop additional public-private partnership models (e.g. the Commercial Aviation Alternative Fuels Initiative). In

addition, both the Bioeconomy Initiative Framework and the Science Blueprint aim to build on the successful USDA BioPreferred program.

With regard to **good governance** measures, the Bioeconomy Initiative Framework ultimately aims to facilitate coordination among federal government agencies that affect the research and development (R&D) of biofuels, bioproducts, and biopower and includes a number of initiatives to ensure better coordination of programs. In addition, it provides for increased sustainability R&D, for example by identifying relevant metrics and indicators to facilitate evaluation of environmental, societal, and economic effects. The Science Blueprint also sets the objective of gathering data to quantify and inform the valuation of the bioeconomic ecosystem.

8

How is the implementation of the strategy monitored and evaluated?

The Bioeconomy Blueprint provides no action plan and does not put in place mechanisms to monitor or evaluate strategy implementation.

9

Do dedicated regional bioeconomy policy strategies exist?

No state-level dedicated bioeconomy strategies exist in the USA. There are, however, innovative international cooperation projects.

In October 2019, the **State of Maine and Finland** signed a five-year **Memorandum of Understanding (MOU)** to foster an exchange of information and cooperation in developing a bioeconomy that is based on forests and the use of wood.⁹⁶

In May 2020, a new set of policy recommendations under the title **“Built With Biology: California’s Biostrategy 2020: The Greenprint for Biomanufacturing and Sustainable Supply Chains in a Post-COVID World,”**⁹⁷ was released for California Governor Gavin Newsom’s Business Recovery Task Force. “Built

With Biology” is a five-point plan to rethink and rebuild the economy using biomanufacturing and lays out a 50-year strategy to create more prosperous, sustainable, and equitable economy in the state of California, the fifth largest economy in the world. The report was drafted in consultation with over 100 leading entrepreneurs, investors, startups, large and small corporations, scientists and engineers, and input from the Lawrence Berkeley National Lab, the Engineering Biology Research Consortium, and the advocacy organizations the Californian Life Science Association (CLSA) and the Biotechnology Innovation Organization (BIO).

The five main recommendations include 1) almost USD 900k to create a Built With Biology initiative;

2) over USD 8.5 million to better equip schools and universities with courses and lab facilities to prepare for future biomanufacturing jobs; 3) USD 100 million per site to build five biomanufacturing opportunity zones that could rapidly make a variety of biobased

products 4) introduce a California BioPreferred Stimulus Program inspired by the USDA BioPreferred Program; and 5) create a USD 100 million Bio-Bridge Matching Investment Fund for synthetic biology and biomanufacturing startups.

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Asia/Pacific



Three countries in the Asia-Pacific region, Malaysia, Thailand and Japan, have adopted dedicated bioeconomy strategies. Some of the emerging economies in Asia are rated among the most innovative countries in the world. It is therefore not surprising to find that bioeconomy development in Asia is generally strongly oriented towards high-tech and industrial innovations. Innovations in the bioeconomy are seen as particularly important for improving human health in the medical sector, working closely with bioindustry to develop innovative biobased products (e.g. marine biodegradable plastics) and creating centers of excellence for bioeconomy research and experimentation.

While not analyzed in the following section, a number of bioeconomy-related strategies also reflect the high-tech vision and focus on biotechnology in the region (e.g. China, India, Russia, South Korea, Sri Lanka).⁹⁸ Large industrial economies such as China and India see biotechnology as a nascent field of innovation in which they can quickly compete. South Korea is a leader in marine biotechnology policy. Bioenergy is an important focus in Indonesia, India, and New Zealand. In Australia, the federal state of Queensland has a dedicated roadmap for bioindustry development, whereas New Zealand continues to concentrate on further growth and value-creation in the primary industries.

Country	Perspective	Document Name
Australia	Research & Innovation	National Collaborative Research Infrastructure Strategy (2018)
	Bioeconomy (regional)	Queensland Biofutures 10-Year-Roadmap and Action Plan (2016)
	Blue Economy	National Marine Science Plan 2015 – 2025 (2015)
	Research & Innovation	National Collaborative Research Infrastructure Strategy (2013)
	Bioenergy	Opportunities for Primary Industries in the Bioenergy Sector: National Research, Development and Extension Strategy (2011) + Workplan (2014)
	Research & Innovation	Strategic Roadmap for Australian Research Infrastructure (2011)
	Bioeconomy (regional)	Building a Bioeconomy in South Australia (2004)
China	Research & Innovation	13 th FYP for Science, Technology and Innovation (2016)
	High-Tech	13 th FYP for Strategic Emerging Industries (2016)
	High-Tech	13 th FYP on Bioindustry Development (2016)
	High-Tech	12 th FYP on Bioindustry Development (2012)
	Research & Innovation	12 th FYP (2011-2015) on Agricultural Science and Technology Development (2012)
	High-Tech	12 th FYP for National Strategic Emerging Industries (2012)

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See further policy strategies on the next page →

Country	Perspective	Document Name
India	Bioenergy	National Biofuel Policy 2018 (2018)
	High-Tech	National Biotechnology Development Strategy (2007, 2014, 2015)
	High-Tech (regional)	Biotech Policy 2015 – 2020 – Government of Andhrapradesh (2015)
	High-Tech (regional)	Tamil Nadu Biotechnology policy (2014)
Indonesia	Bioenergy	Strategic Plan of the Indonesian Ministry of Agriculture 2015 – 2019 (2015)
	Bioenergy	National Energy Policy (2014)
Japan	Bioeconomy (holistic)	Bio-Strategy Japan (2020)
	Bioeconomy (holistic)	Bio-Strategy Japan (2019)
Malaysia	Bioeconomy (holistic)	Bioeconomy Transformation Programme (BTP) (2012)
New Zealand	Research & Innovation	AgriTech Industry Transformation Plan (2020)
	Research & Innovation	Primary Sector Science Roadmap – Te Ao Turoa (2017)
	Research & Innovation	Biological Industries Research Fund (2013)
	Bioenergy	Bioenergy Strategy (2010)
Russia	High-Tech	Russian Government Roadmap for Development of Biotechnology (2013)
	High-Tech	Comprehensive Program for the Development of Biotechnology in Russia by 2020 (BIO2020) (2012)
South Korea	Research & Innovation	3 rd Basic Plan for Science and Technology (2013)
	High-Tech	Strategy for Promotion of Industrial Biotechnology (2012)
	Blue Economy	Blue-Bio 2016 Plan (2008)
	Biobased Economy	2020 Vision and Strategy of Bio-industry (2007)
	High-Tech	2 nd Framework Plan for Promotion of Biotechnology, Bio-Vision 2016 (2006)
Sri Lanka	High-Tech	National Biotechnology Policy (2010)
Thailand	Bioeconomy (holistic)	Bio-Circular-Green Economy (BCG) in Action: The new Sustainable Growth Engine (2019)
	Biobased Economy	Measures for the Development of Bio-Industry in Thailand 2018 – 2027 (2018)

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98 For the purposes of this report, Russia has been included in this continental grouping.



Japan



1

What have been the major developments in bioeconomy policy over the past decade?

While initially the term “bioeconomy” was rarely used in Japan, the country has a long history of promoting the production and industrial use of biomass. As an example, the first biomass strategy, **Biomass Nippon Strategy**,⁹⁹ was developed in 2002 with the aim of generating a sustainable economy by efficient use of biological resources. The strategy was then revised in 2006 to also focus on bioenergy, as well as to accelerate the promotion of “Biomass Towns” (biobased, environmentally friendly and disaster-resistant communities which utilize biomass comprehensively). From 2005 to 2011, the central government encouraged the development of “Biomass Town” plans and a total of 318 municipalities participated.

Many of these advancements or “zero-waste” Japanese municipalities can be attributed to other laws such as the **Fundamental Plan for Establishing a Sound Material-Cycle Society**,¹⁰⁰ first enacted in 2000, that helped establish “regional circular and ecological spheres’ and advanced household and municipal waste approaches.

In the case of biotechnology promotion, in 2002 Japan launched the Biotechnology Strategy Council (BTSC), presided over by the Prime Minister, and a comprehensive set of **Biotechnology Strategy Guidelines**, containing 200 detailed action plans to foster Japan’s biotechnology sector.¹⁰¹ The Japanese government then established the Government-Industry Council for Biotechnology Strategy Promotion in 2008

and published a new strategy, “**Dream BT Japan**”,¹⁰² to promote and realize the “Biotechnology Strategy Guidelines” issued in 2002. Given its importance for medicine and pharmaceuticals, chemistry, agriculture, and environmental protection, biotechnology is considered a key sector in the Japanese government’s strategies to stimulate the economy. In Japan, it has been permitted to import genetically modified (GM) plants under certain conditions for a long time. With respect to biotech-related regulation, an expert panel released rules in 2019 governing genome-edited agricultural and marine products, in which Japan decided to exempt SND-1 type modifications from GMO regulation under the Japanese Cartagena Act.¹⁰³

In 2009, the “**Basic Act for the Promotion of Biomass Utilization**”¹⁰⁴ was passed. It outlined the principles of biomass utilization and specified government responsibilities, political stakeholders, and funding measures as well as appointing the National Biomass Policy Council. **The National Plan for the Promotion of Biomass Utilization**¹⁰⁵ followed in 2010, setting quantitative utilization targets for 2020 at national, prefectural, and district level (e.g. fixed quotas for biofuels). The plan took into account the entire value-added chain from the recycling of residues to biorefining.

Difficulties regarding the commercial success of businesses involved in the “Biomass Town” plans would ultimately lead to the formulation of a new policy in

2012, the **Biomass Commercialization/Industrialization Strategy**,¹⁰⁶ and in 2013, the “Biomass Industrial City/Region” scheme, an expansion of the biomass town concept to promote biomass industrialization. As of 2020, 90 municipalities were recognized as Biomass Industrial Cities. Following the great eastern earthquake and the Fukushima nuclear power plant disaster in 2011, the new 2012 biomass strategy also sought to support green industry (e.g. through biobased materials and conversion technologies) and achieve autonomous and decentralized energy production. Topics included biorefineries, research on microalgae, and biofuels.

Following a change in government, the Abe Cabinet passed a revitalization strategy for Japan in 2013 with the aim of research and technology moving Japan towards new growth. On this basis, the Cabinet adopted the **Comprehensive Strategy on Science, Technology and Innovation** in June 2013 which focuses, among other things, on a clean energy system and revitalization of the regional economy. The **4th and 5th Science and Technology Basic Plan** (2011 – 2015) and (2016 – 2021) also promote green innovation in the field of energy and environmental technologies.¹⁰⁷

Over the years, the Japanese government has also actively promoted the market entry of environmentally friendly products through legislation, tax breaks, reduced-interest loans or consumer-oriented labeling of such products (e.g. the biodiversity label, Eco Mark, or GreenPla and BiomassPla for bioplastics). The first edition of the “**Act on Promoting Green Purchasing**” appeared in 2001 and requires that government agencies apply green purchasing criteria when procuring products in a wide array of categories.¹⁰⁸

The **national strategy and action plan for biodiversity (2012 – 2020)**¹⁰⁹ also promotes aspects of the bioeconomy by living in harmony with nature and emphasizing traditionally managed regions or so-called Satoyama, farmed agricultural and forestry areas that maintain and restore the resilience and efficiency of the ecosystem. The strategy also strives to revitalize rural regions which are suffering from the migration of younger people to urban areas.

Private stakeholders are also increasingly active in bioeconomy policy development in Japan. In 2016, the Japan Bioindustry Association (JPA) developed a **Vision Document**¹¹⁰ for Japanese biobased industry, in which key innovations were expected from advances in genome editing and synthetic biology.

Japan has also been active in efforts to solve marine plastic waste issues. In advance of the G20 Summit in 2019, the Minister of Economy, Trade, and Industry (METI) published a **Roadmap for Popularizing Development and Introduction of Marine Biodegradable Plastics**¹¹¹ and, during the summit, Japan launched an international framework on marine waste, the “**MARINE Initiative**.”¹¹²

In June 2019, Japan adopted its first dedicated **Bioeconomy Strategy**,¹¹³ based on a report of the Working Group for Bio-Strategy and in June 2020 it was updated.¹¹⁴ With a strong bioindustry and research setting, the strategy strongly focuses on high-tech aspects of the bioeconomy. It is one of the most comprehensive representations in a national strategy worldwide of the bioeconomy in relation to digitization, AI, and robotics. Nonetheless, the strategy seeks to holistically span a range of topics from the circular economy to sociopolitical considerations.

2

How is the dedicated bioeconomy strategy embedded into the wider policy context?

In 2018, the **Integrated Innovation Strategy** documented the growing interest in the bioeconomy around the world and called for the formulation of a new bioeconomy strategy by the summer of 2019. It further launched the **Integrated Innovation Strategy**

Promotion Council, which consists of the secretariats of each innovation-related headquarters and relevant ministries and agencies, and approves AI, bio, quantum, and environmental strategies.¹¹⁵

3

Who is the author of the strategy, and how were stakeholders consulted and engaged in the different phases of the strategy process?

The strategy was developed under the Council of Science, Technology and Innovation (CSTI)¹¹⁶ of the Cabinet Office which established a Working Group for Bio-Strategy. The Working Group met multiple times, starting in 2017, to review previous strategies for the advancement of biotechnology and to discuss and formulate a new bioeconomy strategy.

An interim report of the Working Group's discussions and analysis was issued in June 2018.¹¹⁷ The Ministries of Economy, Trade and Industry (METI), Agriculture, Fishery and Forestry (MAFF), and Ministry of Health and Welfare (MHLW) also contributed to the strategy.

4

How is "bioeconomy" defined in the main policy strategy?

The strategy refers to the bioeconomy as a "concept that expands a sustainable and renewable circular economy and society by using biotechnology and renewable biological resources." Throughout the document, the strategy refers to a bioeconomy that

covers all sectors including agriculture, industry, health, and medicine. The definition is strongly influenced by the 2009 OECD report which defined the bioeconomy as involving the integration of biotechnology across all sectors, including health.

5

What is the main purpose of the dedicated policy strategy, and how does it relate to the SDGs and the Circular Economy? How does it introduce visions, targets, milestones, and action plans?

The Bioeconomy Strategy positions itself in response to global changes in international power structures, social issues, such as the rapid population and economic growth in Asia and Africa, worsening environmental problems, as well as the increasing demand for goods. The strategy seeks to overcome social issues, such as climate change, conservation of the environment, and an aging population in Japan. It sees biotechnology, including renewable bio-resources and utilization of waste, as essential tools of the bioeconomy that can address these issues while also maintaining economic growth. Rapid technological innovation and the fusion of biotechnology with digital technologies such as big data and AI, provide a major impetus for the strategy. At the same time, it admits to the need to strengthen the relationship between science and society. It seeks to shift from a conventional strategy of utilizing biotechnology to one in which the bioeconomy is an indispensable element of a new sustainable socioeconomic system.

The strategy seeks to align itself with the SDGs and global trends of conservation and restoration of the environment (CO₂ reduction, improvement of soil and water quality, etc.), the creation of a recycling-oriented society, food security as well as environmental, social, and governance (ESG) investment.

The overall objective is for Japan to achieve the world's most advanced bioeconomy society by 2030. Such a society is defined by one in which three elements are realized: 1) bio-first concept which looks to conceive business that can be accomplished with biotechnology or biomass use as first choice; 2) biocommunities which looks to build a strong bioeconomy society that resonates both domestically and internationally; 3) biodata-driven, to realize the goal of becoming a leading country in the world in terms of integrating biological and digital technologies.

Five basic principles help guide the strategy and reflect the lessons learned from previous strategies: 1) establishment of targeted market domains, back-casting roadmaps, and continuous commitment. This is a response to past overemphasis on seed-oriented thinking, incapability of identifying applied fields for new technology, and a lack of commitment to the strategy; 2) integration of biology and digital technology in response to inadequate data management in the past; 3) encouragement of international hubs, local networking, and investment in response to insufficient resources for startups and the lack of an international strategy; 4) enhancement of international strategies in response to the low priority on harmonization of standards and regulations; 5) response to ethical,

legal, and social issues due to a lack of actions on ethical, legal, and social implications (ELSI).

The strategy rests on four so-called societal visions: 1) greater circularity in society and industry; 2) satisfying diversified need by sustainable primary production; 3) biobased feed stock and sustainable production; 4) healthy longevity and social participation through health and medical care.

The heart of the strategy calls for the formulation of target-driven roadmaps for the nine market domains which at the time of publication were still in the process of being written. A number of first general actions are proposed. However, no overall timeline with targets or a budget is provided ahead of the roadmaps.

6

What are the priority areas of the strategy?

The strategy targets nine market areas that are expected to attract significant investment from inside and outside the country.

As a leader in the accumulation of biological resources (microbes, plants, etc.), Japan focuses on high-performance **biomaterials** (lightweight, durable, safe). The need for light and strong biomaterials, especially in the fields of health and medicine, and mobility, is expected to expand significantly and the strategy seeks to take advantage of Japan's strengths in material technology and application (e.g. automotive industry). The strategy supports **bioplastics** as a substitute for commodity plastics. Given the rise in global marine plastic pollution, the strategy focuses on using Japan's know-how in plastic handling and 3R (Reduce, Reuse and Recycle) management.

A sustainable **primary production** system (e.g. smart farming technology, optimal use of fertilizer, water, waste, and labor) is furthered to address climate change and improve agricultural productivity to meet the rising demand for food (better tasting and healthier) in Asia and Africa.

Organic waste and organic wastewater treatment are prioritized. This builds on Japan's advanced biobased

resource recycling system that converts waste into high-value substances.

The strategy focuses heavily on **healthcare, functional foods, and digital health** in order to realize the creation of a **food-based healthcare** industry. With the rise in life-style-related diseases and expansion of digital health, the strategy looks to develop healthy, "tailor-made" food to improve health as well as to advance concepts like the AI Hospital System and modern diagnostics. Priority is also given to **biopharmaceuticals, regenerative medicine, cell and gene therapy**.

Biofoundries or "bio-production" and the associated areas of **engineered biology, microbes, and fermentation** for food production and biobased products are supported. Japan has a strong history of fermentation research and a well-funded biofoundry to push ideas to commercialization. Biofoundry support is also tied to systematic **SME** support. **Biological analysis**, measurement, and experimental systems, including **robotics**, are prioritized.

And lastly, the strategy promotes large **wooden architecture** and **smart forestry** in order to capture CO₂ and expand Japan's international market share of wooden houses.

7

What policy instruments are put forth in the strategy (and its action plan)?

With regard to **research and innovation**, overall funding for basic scientific research is advanced, as is the funding of inter-agency cooperation for subject-driven research and innovation (e.g. competitive projects in the field of biotechnology). The strategy looks to establish rules to promote open innovation through data collaboration among national research institutes, universities, and companies. Collaborative research between industry, academia, research, and development that contributes to the development of market areas is also promoted. The strategy looks to have the world's most advanced development base for bio-production systems (i.e. biofoundry) and bio-related analysis, measurement, and experiment systems.

More specifically, the strategy sets out to create two international biocommunities or clusters (e.g. potentially one near Tokyo and the other near Osaka) to attract scientists and investors through the establishment of an advanced research incubation center and the promotion of biofoundries. The research center will not only support advanced research through a global incubation system and increased university-industry collaboration, it will also include startup support with the help of global investments, IP management, regulation support, human resources, wet lab support, and hospital collaboration. A feasibility study is set for 2020.

Furthermore, the strategy looks to promote international and regional collaboration through demonstration projects. With regard to regional activities, the strategy emphasizes the sharing of best practices such as the regional recycling Biomass Town initiative. The promotion of international research and demonstration includes standardization, international regulatory harmonization, and stabilizing biomass supply.

Infrastructure promotion centers on the provision of research facilities.

Capacity building and education is supported through a comprehensive package of support for young researchers to strengthen research capabilities, as well as staff training and securing biodata scientists who are in charge of integrating biotechnology and digital technology. It remains unclear which measures the package includes.

Commercialization is mostly advanced by strengthening the business and investment environment by establishing a global incubation system (e.g. the presence of hospitals, clinical sites, and expensive wet facilities for R&D) to support biotech startups.

Japan was one of the first countries in the world to introduce a system for labeling the functionality of foods.

Demand-side measures point to providing solutions for marine plastic waste by introducing bioplastic research roadmap and market introduction roadmap. New functional food labeling based on scientific findings (e.g. immune system enhancement) is also promoted.

The strategy calls for the protection of intellectual property and genetic resources by identifying the market segments that require database, IP, and genomic material protection (both human related and plant and animal data) and providing **framework conditions** for the bioeconomy.

A range of **good governance** actions are advanced. One of the very first steps in the strategy includes developing a data platform that can gather information involving data from all bio-related fields (e.g. a health/medical, biomaterial, and breeding and fermentation data platform). A user-friendly and internationally-compatible system design should be formulated by 2020. The strategy further addresses Ethical, Legal and Social Issues (ELSI) by creating international regulatory harmonization of basic research and clinical tests on fertilized human embryo genome editing, as well as increasing the social acceptance of genome editing by scientists/sociologists.

Another key component of the strategy is to strengthen the so-called "strategic command post function," in other words the transition from a decentralized to a more centralized and connected approach where resources are brought together to produce a synergistic effect. Examples include the promotion of health and medical and biostrategies in tandem.

Lastly, the Japanese government looks to strengthen the international strategy by reviewing key countries and regions and accumulating market, policy and regulations trends from investors and funding agencies.

8

How is the implementation of the strategy monitored and evaluated?

The Bio-Strategy Taskforce is responsible for promoting and following up the strategy. This ongoing discussion mechanism will allow for continuous support, including the introduction of new measures each year. Implementation will be supported by analyzing policy, market, and regulatory trends in Japan and abroad, and with the participation of industry, universities and other stakeholders, including Japan Science and Technology Agency (JST), New Energy and Industrial Technology Development Organization (NEDO), National Institute of Technology and Evaluation (NITE), Japan Agency for Medical Research and Development (AMED), National Agriculture and

Food Research Organization (NARO), Japan External Trade Organization (JETRO), and Japan International Cooperation Agency (JICA).

By the end of 2019 (as of publication in 2020, this had not yet been completed), a roadmap will be developed for each market segment with Key Performance Indicators (KPIs). The strategy also calls for the development of systems that enable evaluation and verification of the biotechnology field. The strategy notes that there will be a wide range of support from multiple ministries and agencies and the private sector.

9

Do dedicated regional bioeconomy policy strategies exist?

No

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Malaysia

1

What have been the major developments in bioeconomy policy over the past decade?

Malaysia is the first country in Asia to develop a holistic policy program fostering the development of the bioeconomy. Historically, the term bioeconomy has been strongly related to industrial upgrading and the application of biotechnology.

Malaysia's path to developing its bioeconomy began with the launch of a comprehensive **National Biotechnology Policy (NBP)** in 2005.¹¹⁸ The Malaysian Government recognized biotechnology as one of the key strategic drivers to propel the country's social and economic development, in pursuit of the status of a developed nation. The policy is a 15-year plan aimed at making biotechnology a key contributor to economic growth in three consecutive stages, focusing on capacity building in phase 1 (2005 – 2010), commercialization of R&D in phase 2 (2011 – 2015), and internationalization in phase 3 (2016 – 2020). It is focused on the development of three major biotechnology sectors, namely agriculture, healthcare, and industrial manufacturing. In ensuring the proper execution of the NBP, the Malaysian Biotechnology Corporation (now renamed as the Bioeconomy Development Corporation) was set up in 2005 as an

agency under the Ministry of Science, Technology and Innovation (MOSTI).

Launched by the Malaysian Prime Minister in October 2012, the **Bioeconomy Transformation Programme (BTP)**¹¹⁹ made Malaysia the first country in Asia to initiate a comprehensive plan to develop the bioeconomy. At the **BioMalaysia & Asia Pacific Bioeconomy 2016**,¹²⁰ a biotech event first established in 2003, the Biotechnology Corporation was rebranded to Bioeconomy Corporation and its roles and functions expanded to uplift the strategies and programs of Malaysia's bioeconomy agenda and help develop a competitive and diverse end-to-end value chain of the bioeconomy ecosystem.

The **National Biomass Strategy 2020**¹²¹ was updated in 2013. While the first edition of the **National Biomass Strategy (2011)** focused on agricultural biomass valorization (mainly palm oil), the second edition explored the development of higher value-added downstream opportunities from the country's biological resources in general, with special consideration of residues.

2 How is the dedicated bioeconomy strategy embedded into the wider policy context?

The Malaysian government through the Bioeconomy Transformation Programme (BTP) and the Bioeconomy Corporation has set national goals and developed multiple programs, in line with the national agenda, to create a coherent supportive bioeconomy policy framework and implementation programs. The BTP is at times referred to as a complement to the National Biotechnology Policy and the shift in focus onto the bioeconomy as a necessary move, as the country enters the third phase of the National Biotechnology Policy.¹²²

It is also seen as one of the implementation strategies under the Economic Transformation Programme

(ETP) through the various relevant national key economic areas (NKEAs).¹²³ Furthermore, it is in line with the 11th Malaysia Plan 2016 – 2020 and its six strategic thrusts,¹²⁴ which has been developed to propel the country into a high-income economy.¹²⁵ The six thrusts include enhancing inclusiveness towards an equitable society, improving well-being for all, accelerating human capital development for an advanced nation, pursuing green growth for sustainability and resilience, strengthening infrastructure to support economic expansion, and re-engineering economic growth for greater prosperity.

3 Who is the author of the strategy, and how were stakeholders consulted and engaged in the different phases of the strategy process?

The BTP was developed under the guidance of the Ministry of Science, Technology and Innovation (MOSTI) and endorsed by the government.

The Bioeconomy Corporation is owned by the Ministry of Finance, governed by the National Bioeconomy Council (NBC) and advised by the Bioeconomy International Advisory Panel (Bio-IAP), chaired by the Prime Minister. The Bio-IAP assists the government in formulating strategies to drive the growth and development of the biotechnology industry in Malaysia,

including the NBP.¹²⁶ It is not clear, however, what the concrete output of the panel is.

The Bioeconomy Corporation is tasked with achieving all the objectives set out in the national bioeconomy policy and with identifying the needs of industry and research, providing financial and commercial support. Furthermore, it has developed many of the programs jointly with the private sector. It is also responsible for achieving the objectives of the National Biotechnology Policy.¹²⁷

4 How is “bioeconomy” defined in the main policy strategy?

According to the Bioeconomy Corporation, the bioeconomy refers to “all economic activity that is derived from the continued commercial application of biotechnology” and encompasses “the production of renewable biological resources and their conver-

sion into food, feed, chemicals, energy, and healthcare wellness products via innovative and efficient technologies.” This includes agriculture, forestry, fisheries, food production, healthcare, chemicals, and renewable energy.¹²⁸

5

What is the main purpose of the dedicated policy strategy, and how does it relate to the SDGs and the Circular Economy? How does it introduce visions, targets, milestones, and action plans?

The BTP acts as a platform provided by the government for the private sector to channel and maximize commercial opportunities in bio-based industries. It is designed as a transformation program based on biotechnology's potential to cut across various different industries and transform Malaysia into a high income, inclusive and sustainable economy. It seeks to promote a knowledge-based bioeconomy through the establishment of a sustainable ecosystem of R&D and commercialization in the areas of agriculture, healthcare, and industrial biotechnology. It therefore focuses not only on bio-based industry but also on other industries and economic sectors that produce manage and utilize biological resources, including agriculture, forestry, fisheries, food production, healthcare, chemicals, and renewables.

BTP aims to increase Malaysia's GNI up to RM 3.6 billion with a total investment of RM 10 billion by 2020. It looks to do this by further enhancing domestic biotechnology and biobased industries, while also creating new job opportunities and enabling Malaysia to become a high-income nation by year 2020. In addition, it promotes the "Green Economy" by contributing towards Malaysia's tar-

get of a 40 percent reduction in its carbon footprint and emissions, and improving the health and well-being of the people through reduced health-care treatment costs, early disease detection and cheaper, accessible medicines. It also seeks to help enhance productivity, yield, and quality of outputs throughout the entire supply chain. No reference is made to the circular economy or the SDGs.¹²⁹

BTP targets to secure RM 48 billion (USD10.9) of GNI, create 170,000 new job opportunities, and capture an investment of RM 50 billion (USD11.4) by the year 2020.

Malaysia does not have an action plan and rather implements bioeconomy with "Entry Point Projects (EPPs) and Trigger Projects." During the launch of the program, 10 Entry Point Projects (EPPs) were identified to develop the national biobased industry and private sector-driven Trigger Projects chosen. As of 2017, it had been expanded to 13 EPPs in the areas of BioIndustrial, Agbiotech, and Healthcare Bio, and 77 Trigger Projects (e.g. 35 Trigger Projects in BioIndustrial, 34 in Agbiotech and 8 in Healthcare Bio).¹³⁰

6

What are the priority areas of the strategy?

The BTP has three focus areas: **agriculture**, **healthcare** and **industry**. Within the agriculture sector, there are four EPPs: 1) biobased **farm inputs** (e.g. animal vaccines, livestock, aquaculture biofeed, and biofertilizers and biopesticides), 2) high-value **bioingredients** (e.g. biobased fragrances, bioflavors, natural products, functional foods), 3) high value **food varieties** (e.g. high-tech livestock breeding, high-tech aquaculture, genetically modified crops and organisms, novel plant breeding techniques), and 4) high-value **horticulture inputs** (e.g. micropropagation of forestry species and ornamental plants). The largest number of projects were in **high-value food varieties**.¹³¹

Within bioindustry, the first EPP, **biobased raw material for industrial input** (e.g. biogas, feedstock plantation for industrial application), is strongly supported. For example, the production of palm oil is vital for the Malaysian economy and the country is the second-largest producer in the world, after Indonesia. The National Biomass Strategy of 2011 was strongly focused on palm oil biomass and higher-value uses such as wood products, energy pellets, bioenergy, biofuels, and organic-based bioproducts. Interestingly, no reference is made in the BTP to the issues of sustainable forest management and biodiversity protection/conservation.

Other industrial EPPs are biobased **chemicals** (e.g. petrochemical substitutes and production of industrial sugar), **biomaterials** (e.g. bioplastics, biodegradable packaging, and biodegradable compostable materials), and **bioremediation** (e.g. waste treatment and environmental management).

Although a significantly smaller field, innovative bio-healthcare products and services are prioritized, including EPPs in **biopharmaceuticals**, biobased **materials** (e.g. tissue engineering, drug delivery systems), **medical devices** (e.g. biocompatible implantable devices), **molecular screening** (e.g. personalized medicine), drug discovery, and **stem cell and regenerative therapy**.



7

What policy instruments are put forth in the strategy (and its action plan)?

The BTP as well as the National Biotechnology Policy advance a number of measures to support the bio-economy.

With regard to **research and innovation**, BTP looks to establish a sustainable ecosystem of R&D. It does so through the development of regional clusters in the country's five economic corridors, namely the Northern Corridor Economic Region (NCIA), the East Coast Economic Region (ECERDC), Iskandar Malaysia (IRDA), Sarawak Corridor of Renewable Energy (SKOR) and Sabah Development Corridor (SEDIA). The Bioeconomy Corporation also established a partnership with the California Institute for Quantitative Bioscience (Qb3), based in San Francisco, with projects running until 2020.^{132,133}

In addition to BTP, the National Biomass Strategy (NBS) through the national innovation agency, Agensi Inovasi Malaysia (AIM), laid out a BioHub concept. It encompasses the complete and holistic planning and development of various complementary clusters that serve as platforms for various waste streams to enhance the economics of various projects.¹³⁴

Infrastructure support mostly comes in the form of cluster development/bioparks/biohubs, a strategically located office with centralized utilities and shared laboratory space. This "plug-and-play" model also supports biorefineries and biochemical plants, such as the first commercial biorefinery in Segamat, in Johor State, which utilizes empty fruit bunch fiber (EFB), a waste product from palm oil production.^{135,136}

Education and capacity measures referring to the development of talent and entrepreneurship to help

the sector prosper are a key element of the program. For example, the BioAcademy focuses on developing a skilled workforce in the biotech industry. The SCIENSATIONBIO program seeks to promote understanding of biotechnology and life sciences in public schools.¹³⁷ The Bioeconomy Community Development Programme (see below) also is designed to support rural farmers by increasing their skill as bio-agropreneurs.

Commercialization measures play a large role in the BTP. Incentive programs such as 'BioNexus' award a special status to qualified international and Malaysian biotechnology companies undertaking value-added biotechnology and/or life sciences activities. These companies are granted fiscal incentives, tax incentives (up to ten years of exemptions), legal advisory services, and other privileges.¹³⁸ One privilege is access to shared facilities and laboratories to help companies with R&D and commercialization of their biobased products and services. As of 2018, a total of 283 companies have been awarded the special status.¹³⁹

The Bioeconomy Community Development Programme (BCDP) focuses on supporting the upstream portion of the industry value chain through the creation of secure, local, high-quality sources of raw materials for capacity expansion. It involves enlisting farmers to cultivate raw materials on idle lands to produce inputs for biotechnology companies and projects that are part of BTP. Farmers and producer associations obtain additional sources of income through the contract farming mechanism with guaranteed buyback and the bioindustries receive a constant supply of raw materials to produce

bioproducts. The Bioeconomy Corporation acts as the facilitator and provides advisory services. The projects are targeted to local conditions and needs. They seek to increase economic opportunities in the areas in which they operate and are focused on strategic subsectors, such as high-value herbs, seeds, mushroom farming, dairy, bee keeping, and aquaculture. Examples of related technologies include tissue culture, DNA fingerprinting, the extraction of active compounds, and selective breeding.¹⁴⁰

In addition, BioShoppe, a market access platform, aims to enhance market access and commercialization of natural-based products produced by companies with BioNexus status, particularly in the area of biocosmeceutical and pharma nutrition.¹⁴¹

Lastly, the private sector can access the Biotechnology Commercialisation Fund (BCF 2.0) with a total approved fund of RM 100 million. It is administered in collaboration with Malaysian Industrial Develop-

ment Finance Berhad (MIDF) and helps finance the commercialization of biobased products and services, providing assistance to expanding biobased businesses. Two funding schemes exist: one for working capital (up to RM 600,000) with a tenure of up to 2 years, and one for business expansion capital (up to RM 3 million including 'zero entry financing cost') with a tenure of up to 7 years.¹⁴²

Demand-side measures include raising awareness of the bioeconomy through Bioeconomy Day in conjunction with BioMalaysia & ASEAN Bioeconomy Conference.

Good governance measures have focused on monitoring and measuring the bioeconomy in Malaysia. The Bioeconomy Contribution Index (BCI) methodology is one such tool. The BCI specifies five indicators: Value-added, Productivity, Investment, Exports, and Employment as identifiers of bioeconomy performance.¹⁴³



8

How is the implementation of the strategy monitored and evaluated?

The public agency responsible for implementation of the bioeconomy strategy (Bioeconomy Corporation) publishes progress reports on the country's

Bioeconomy Transformation Program.¹⁴⁴ However, it is not clearly stated to what extent implementation of the program will be monitored and evaluated.



9

Do dedicated regional bioeconomy policy strategies exist?

Although there are no dedicated regional bioeconomy policy strategies, as part of the National Biomass Strategy Plan, the state governments of **Sabah and Sarawak** developed a **Biomass Industry Development Plan** in 2016.¹⁴⁵ Both states account for more

than 50 percent of biomass resources in Malaysia. Ongoing efforts with the Sabah and Sarawak state governments and Agensi Inovasi Malaysia (AIM) exist to establish a local task force and implement a biomass action plan.¹⁴⁶

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Thailand



1

What have been the major developments in bioeconomy policy over the past decade?

Bioeconomy development in Thailand was initially driven by the “**National Biotechnology Policy Framework**” (2004, 2012).^{147,148} The policy framework provided a holistic view of biotechnology as a knowledge-based industry with diverse applications across the medical, agricultural, aquatic, and industrial fields.

Bioplastics were specifically fostered as a new biobased industry via the “**National Roadmap for the Development of Bioplastics Industry**” (2008)¹⁴⁹ and renewable energies have been promoted within the “**Alternative Energy and Development Plan**” (2012, 2015),^{150,151} which supports bioenergy and biofuels based on the country’s vast agricultural feedstock, specifically by-products and residues.

The Thai government actively promotes the country’s transition to a value-based, innovative, and technology-driven economy. The bioeconomy plays a key role in this transition process which is reflected, for example, in the announcement of the **Thailand 4.0 program** (2015).⁶ This innovation strategy identifies 10 future industries that will drive economic development (five existing industries that will most likely be subject to substantial innovation, e.g. agriculture and food, and five new industries). The bioeconomy is considered as one of these new S-curve industries and includes biofuels & biochemicals.¹⁵³

To accelerate bioeconomy development in Thailand, the National Reform Assembly Steering Committee

published a reform proposal in March 2016, which suggests placing the bioeconomy on the national agenda and developing a dedicated national policy strategy. These recommendations were considered by 23 key industrial and policy stakeholders who signed a memorandum of understanding, the so-called “**Pracharath**” **Bioeconomy Roadmap**, to drive bioeconomy development in Thailand. The roadmap included a dedicated 10-year action plan which foresaw an overall investment of THB 365 billion (about USD 12 billion), which should be co-financed by private and public stakeholders over three project periods.¹⁵⁴

In 2017, the Ministry of Industry drafted “Measures for the Development of Bio-Industry in Thailand 2018 – 2027” to promote Thailand as a biohub in the ASEAN region with a focus on the bioplastics, biochemicals, and biopharmaceuticals industry. These measures were approved by the Thai cabinet in July 2018 and included 1) measures to eliminate investment barriers; 2) measures to accelerate domestic investment in the three key industries; 3) measures to stimulate demand in domestic markets by creating awareness and promoting capacity building and training in manufacturing, and 4) measures to foster networks in the form of a Center of Bio-Excellence (CoBE).¹⁵⁵

As a result of the Global Bioeconomy Summit 2018, attended by the Thai Minister of Science and Tech-

nology, a workshop on the Thai bioeconomy to which more than 100 bioeconomy experts were invited was organized under his initiative. The workshop resulted in a **White Paper on the Bio-Circular-Green (BCG) Economy Model**, a new economic model for promoting inclusiveness, sustainable growth, and competitiveness in Thailand. The white paper presented an advancement of the previous bioeconomy policy documents by also integrating the Sustainable Development Goals, ecosystem, and biodiversity protection. Furthermore, the industry focus had evolved to include the following economic sectors and their related ministries: 1) food and agriculture; 2) medicine and wellness; 3) bioenergy, biomaterials, and biochemicals; 4) tourism and creative economy.¹⁵⁶

In November 2019, around 500 experts from the private and public sector met with the Prime Minister to discuss the Bio-Circular-Green Economy Model. As a result, the **Roadmap “Bio-Circular-Green Economy (BCG) in Action: The new Sustainable Growth Engine”** was adopted and a national BCG committee, chaired by the Prime Minister, was established. In June 2020, the Minister of Higher Education, Science, Research and Innovation brought together representatives from government agencies, academia, industry, and business to further promote the BCG Model and to drive forward the national agenda on food security, public health security, energy security, job security, environmental sustainability, and social inclusiveness.¹⁵⁷

2

How is the dedicated bioeconomy strategy embedded into the wider policy context?

The BCG in Action policy is aligned with the Thai Sufficiency Economy Philosophy¹⁵⁸ which is also a key principle of Thailand’s social and economic development. It further builds on the future industries’ strat-

egy by envisioning the transformation from Thailand 3.0 to Thailand 4.0 by focusing on four out of ten targeted S-curve industries.

3

Who is the author of the strategy, and how were stakeholders consulted and engaged in the different phases of the strategy process?

The BCG in Action Policy is a result of an expert consultation process led by the Thai Minister of Science and Technology. The BCG Policy Board of Directors, which is chaired by the Prime Minister, coordinates the strategy and a dedicated BCG Economic Pro-

motion Agency oversees its implementation. The Agency is divided into different sub-units, including agriculture, food, medical and wellness, energy, material and biochemical, tourism and creative economy, circular economy, and digital platform.

4

How is “bioeconomy” defined in the main policy strategy?

The BCG model is an integration of the bioeconomy, circular economy and green economy, with the bioeconomy defined as involving “(...) the production of renewable biological resources and the conversion of these resources into value added products.¹⁵⁹

While no clear definition of the bioeconomy is provided in the BCG in Action policy, the bioeconomy is roughly defined as an economic model that promotes four major sectors, namely food and agriculture, medical and wellness, bioenergy biomaterial and biochemicals, and tourism and creative econo-

my. The bioeconomy is said to transform agricultural products and diversity to high-value products for competitiveness by using innovation and technology, and to utilize bioresources and diversity as ecosys-

tem services. This is a more holistic approach than Thailand's previous bioeconomy policies which focused on the industrial bioeconomy.

5

What is the main purpose of the dedicated policy strategy, and how does it relate to the SDGs and the Circular Economy? How does it introduce visions, targets, milestones, and action plans?

The BCG in Action strategy aims to distribute economic prosperity and highlights biodiversity and biotechnology as drivers for the BCG economy. The strategy further pursues a transformation of the country into a value-based and innovation-driven economy and aims to increase the countries competitiveness.

It addresses particular challenges the country is facing in the agriculture sector (e.g. volatile crop prices and low incomes of farmers, deteriorating natural resources), the medical and pharmaceutical sector (e.g. aging society, dependence on import of medical equipment and pharmaceutical products), the energy sector (e.g. energy security, dependence of energy imports), and the tourism sector (e.g. over-tourism, deteriorating natural resources).

The goal of the BCG model is to address the UN's Sustainable Development Goals (SDGs) and pro-

mote inclusive and sustainable growth. The circular economy is integrated into the BCG model itself.

Furthermore, the BCG in Action policy intends to re-brand Thailand after the Covid-19 crisis¹⁶⁰ and to create 300,000 new jobs for graduates and unemployed workers affected by covid-19 with the help of a community development campaign.¹⁶¹

While it provides no clear action plan with timelines and targets, the BCG in Action policy provides for both public and private investments. It is envisaged that the public-private investment ratio will be set at 30:70 in the first three years of 2021 and that this ratio will gradually decrease in subsequent years (to 15:85 in 2030). In this respect, the strategy will be supported by an overall investment of THB 3.75 billion (about USD 120 million), increasing to THB 7.5 billion (about USD 240 million) in 2025, and THB 10 billion (about USD 320 million) in 2030.¹⁶²

6

What are the priority areas of the strategy?

Priority areas of the BCG Model include food and agriculture, medical and wellness, bioenergy and high-value biochemical materials, and tourism and creative economy. These four S-curve industries already combine an economic value of THB 3.4 trillion (about USD 109 billion) (pre-Covid-19) and account for 21 percent of the Thai GDP. It is expected that the BCG in Action policy will raise this number to THB 4.4. trillion (about USD 141 billion) in the next five years.¹⁶³

Within the **food and agriculture** sector, the focus lies on developing high value and novel food

products and functional ingredients, but also on biorefinery development, waste reduction, improvements in resources and land-use efficiency, and on smart and precision farming (e.g. new plant breeding techniques for coping with drought, flood and insect resistance).

In the **medical and wellness** sector, the emphasis is on precision medicine, omics, the development of vaccines and biopharmaceuticals, the promotion of biosimilars and medical devices, herbal extraction for medicine and cosmetics, fostering bioactive

compounds, and platforms to facilitate the utilization of genetic data.

In order to promote **bioenergy and high-value biochemical materials**, the policy promotes energy produced from renewable resources, such as refuse-derived fuel (RDF) and biogas, the establishment of community-based power plants with distributed renewable energy resource systems (including biomass and biogas) and their connection through blockchain-enabled smart microgrids. Furthermore, the strategy highlights research on energy storage systems and the development of cutting-edge technologies to convert biomass and agricultural by-products to high value commodities, such as bioplastics, fibers, and pharmaceuticals.

In the **tourism and creative economy sector**, the strategy particularly fosters the development of the

digital infrastructure and supports the further promotion of culinary tourism and sustainable tourism (e.g. through national guidelines for tourism).

The BCG in Action strategy further highlights **area-based developments** in 1) the Northern Economic Corridor (promotion of food safety and agricultural health standards, the agro-industry, and food processing); 2) the North-Eastern Economic Corridor (resolving major health issues, and promoting insect farming as an alternative protein source); 3) the Eastern Economic Corridor (focus on fruit production and the development of future industries); 4) the Southern Economic Corridor (focus on precision aquaculture and innovative halal foods), and 5) the Central Thai region (reducing waste, promoting an active aging society, and enhancing new and innovative cultural tourism).¹⁶⁴



7

What policy instruments are put forth in the strategy (and its action plan)?

With regard to policy instruments promoting the BCG in Action policy, the strategy highlights four so-called enablers, namely research and innovation, infrastructure development, education and capacity building, and bioeconomy-friendly framework conditions.

In order to promote **research and innovation**, the focus is on promoting research on complex microbiota, omics technologies, bioprocessing engineering, gene editing and synthetic biology, AI and high-performance computing, and advanced digital technologies. International research collaboration should be strengthened through the establishment of a BCG global Forum. Furthermore, the shift from traditional industries to S-curve industries should be enabled through actions such as promoting BCG start-ups and innovation-driven enterprises. In addition, a bioeconomy-friendly innovation ecosystem should be fostered by boosting the private investment ratio and by promoting funding for integrated research projects (instead of individual projects) that will advance the transfer of research to the market.

The promotion of **infrastructure development** is envisaged through the establishment of a National Biobank to support the collection, preservation, and utilization of bioresources. Furthermore, a Genomics Thailand network should be established to support human genome research and to enable advancements in precision medicine. Other infrastructure projects include the establishment of regional science parks to foster local economy development and the promotion of pilot plants (particularly biomass power plants, biorefinery pilot plants, and hydrogen power plants).

Thailand is currently establishing the Eastern Economic Corridor of Innovation (EECi), a hub linking innovation and investment across the country for Thailand's target industries. The National Science and Technology Development Agency (NSTDA) invested THB 3.4 billion (about USD 109 million) in a pilot biorefinery in the EECi to further promote Thailand as a hub for biotechnology in Southeast Asia. The biorefinery will be certified with Good Manufacturing Standards for the production of consumer goods, such as nutrients and medical foods, and biochemi-

cals and bioplastics.¹⁶⁵ As part of the project, the German company Glatt Ingenieurtechnik has been commissioned to plan a biorefinery pilot plant. The aim of the so-called Biopolis complex is to provide technology that is freely available under patent law and can therefore be widely used by companies and organizations as well as by local and international universities. The facility should enable users to validate and scale prototypes and to conduct technical and economic feasibility studies before investing in their own production line.¹⁶⁶

Another so-called enabler of the BCG in Action policy is in **education and capacity building**. The strategy highlights the need to develop labor in the various fields of the four S-curve industries, particularly in system biology, bioinformatics, life sciences, computer engineering, and data science. Furthermore, BCG career paths should be developed with their

respective curriculums and non-degree programs should be fostered.

With regard to **demand-side measures**, it is envisaged to adapt and improve quality and safety standards for food and functional food, and to introduce carbon pricing and green tax measures to boost eco-friendly products.

To provide appropriate political **framework conditions** for advancing the BCG Model in Thailand, the strategy focuses on long-term investments, particularly shifting from annual project funding to multi-year funding. Financial and tax measures should be promoted to incentivize the private sector to engage in capacity-building projects, e.g. for small farmers. The Thailand Board of Investment, for example, is also offering a corporate tax holiday of up to 13 years to investors in bioeconomy ventures.¹⁶⁷

8

How is the implementation of the strategy monitored and evaluated?

It is not stated to what extent the implementation of the strategy will be monitored and evaluated.

9

Do dedicated regional bioeconomy policy strategies exist?

No

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Europe



In Europe, the European Union can be seen as the key driver of national bioeconomy policy strategies. Support for bioeconomy development dates back to 2007 when Janez Potocnik, the former EU Commissioner for Research, Science and Innovation, presented the concept of a knowledge-based bioeconomy.¹⁶⁸ During the Presidency of the EU Council in 2007, Germany enhanced the concept and highlighted the importance of biological resources as primary feedstock and biorefineries as important production facilities. Germany was the first country to publish a dedicated national bioeconomy research strategy in 2010, followed by a policy strategy in 2013. In 2012, the European Commission presented the first dedicated macro-regional bioeconomy strategy, sparking the development of dedicated bioeconomy strategies across individual EU Member States. The Horizon 2020 program (2014 – 2020) would provide the basis for further development of national research and innovation strategies across Europe. In 2014, Finland published a dedicated policy strategy on the bioeconomy, propelling it to become a leading bioeconomy nation in Europe.

The international political landscape changed significantly in 2015 with the adoption of the UN's Agenda 2030 and the 17 Sustainable Development Goals leading to important discussions on the bioeconomy's contribution to sustainable economies. Since 2015, 9 dedicated bioeconomy policy strategies have been adopted in Austria, France, Ireland, Italy, Latvia, Norway, the Nordic Countries (including Denmark, Finland, Iceland, Norway, Sweden, Faroe Islands, Greenland), Spain and the UK.

In addition, a number of strategies have been updated, including the EU, Italy, and Germany, with Finland due to update its strategy in 2021. In the updated strategies, the concepts of sustainability, circular economy, and the need to understand the ecological limits of the bioeconomy became more integral parts of the bioeconomy concept. With this increasing complexity, bioeconomy strategies in Europe recognize a broad set of goals and increasingly seek to maximize impact by better aligning with other policy priorities.

Many other European countries have adopted bioeconomy-related strategies such as research and innovation strategies (e.g. the Netherlands and Sweden have adopted holistic bioeconomy/biobased economy research and innovation strategies). In Belgium, a regional bioeconomy strategy for Flanders was developed. Furthermore, the bioeconomy in European countries is often treated within the wider context of green or blue growth strategies, and most recently within strategies focusing on the circular economy. Interestingly, in its most recent roadmap, Portugal is fostering the blue bioeconomy as a new economic model, focused on the knowledge-based production and use of blue bioresources to provide products, processes, and services.

At the regional level, the funding framework of the European Structural and Investment Funds (ESIF), including regional (ERDF) and agriculture and rural development funds (EAFRD) as well as Smart Specialization Strategies (RIS3), an ex-ante conditionality for the use of ESIF funds, have significantly contributed to supporting the development of rural bioeconomies in Europe. Several regions in the European Union have coupled bioeconomy development with their research and innovation RIS3 strategies and many have now developed regional bioeconomy strategies, such as in Spain (Extremadura, Andalucía, Basque and Castilla León), Norway (Innladet, Rogaland, Trondelag, Ostfold), France (Haute-de-France, Grand Est) and Germany (Baden-Wuerttemberg).

Country	Perspective	Document Name
Austria	Bioeconomy (holistic)	Bioeconomy – A Strategy for Austria (2019)
Belgium	Bioeconomy (regional)	Bioeconomy in Flanders (2014)
Croatia	Bioeconomy	Rural Development Programme 2014-2020 (2016)
Czech Republic	Bioeconomy	Bioeconomy concept in the Czech Republic from the perspective of the Ministry of Agriculture 2019 – 2024 (2019)
	Bioenergy	Action Plan for Biomass in the Czech Republic 2012 – 2020 (2012)
Denmark	Research & Innovation	Research 2025 – promising future research areas (2018)
	Circular Bioeconomy	Strategy for Circular Economy (2018)
	Green Economy	Growth Plan for Water, Bio and Environmental Solutions (2013)
	Green Economy	Growth Plan for Food (2013)
European Union	Bioeconomy (holistic)	A sustainable Bioeconomy for Europe: strengthening the connection between economy, society and the environment (2018)
	Bioeconomy (holistic)	Innovating for Sustainable Growth: A Bioeconomy for Europe (2012)
Finland	Bioeconomy (regional)	Roadmap Towards Oil-Free and Low-Carbon North Karelia by 2040 (2017)
	Bioeconomy (holistic)	The Finnish Bioeconomy Strategy (2014)
France	Bioeconomy (regional)	Grand Est Regional Plan for the Bioeconomy (2019)
	Bioeconomy (regional)	Master Plan de la Bioéconomie en Hauts-de-France (2018)
	Bioeconomy (holistic)	A bioeconomy strategy for France: 2018 – 2020 Action plan (2018)
	Bioeconomy (holistic)	A Bioeconomy Strategy for France (2017)
Germany	Bioeconomy (holistic)	National Bioeconomy Strategy (2020)
	Bioeconomy (regional)	The Baden-Württembergs Government's Sustainable Bioeconomy Strategy (2019)
	Bioeconomy (holistic)	National Policy Strategy on Bioeconomy (2013)
	Bioeconomy (holistic)	National Research Strategy BioEconomy 2030 (2010)
Ireland	Bioeconomy (holistic)	National Policy Statement on the Bioeconomy (2018)
Italy	Bioeconomy (holistic)	Implementation Action Plan (2020 – 2025) for the Italian Bioeconomy Strategy BIT II (2020)
	Bioeconomy (holistic)	National Strategy for Bioeconomy – BIT II (2019)
	Bioeconomy (holistic)	Bioeconomy in Italy: A unique opportunity to reconnect economy, society and environment (2017)
	Bioeconomy (regional)	The smart specialisation Strategy and the Bioeconomy Cluster in the Basilicata Region (2016)
Latvia	Bioeconomy (holistic)	Latvian Bioeconomy Strategy 2030 (LI-BRA) (2017)
Lithuania	High-Tech	National Industrial Biotechnology Development Programme (2007 – 2010)
Netherlands	Bioeconomy	The position of the bioeconomy in the Netherlands (2018)
	Green Economy	Groene Groei: voor een sterke, duurzame economie (2013)
	Biobased Economy	Groene Groei – Van Biomassa naar Business (2012)

Country	Perspective	Document Name
Nordic Countries	Bioeconomy (holistic)	Nordic Bioeconomy Programme: 15 Action Points for Sustainable Change (2018)
Norway	Bioeconomy (regional)	Strategy for Bioeconomy in Rogaland 2018 – 2030 (2018)
	Bioeconomy (regional)	Bioeconomy Strategy for Innlandet 2017 – 2024 (2017)
	Bioeconomy (holistic)	The Government's Bioeconomy Strategy: Familiar resources – undreamt of possibilities (2016)
	Bioeconomy (regional)	Strategy for Bioeconomy in Østfold (2016)
Portugal	Blue Economy	Blue Bioeconomy Strategy (2019)
	Bioenergy	National Plan for the Promotion of Biorefineries (2017)
	Circular Bioeconomy	Circular Economy Action Plan (2017)
	Blue Economy	Estratégia Nacional para o Mar (2013)
Slovenia	Green Economy	Framework Programme for the Transition to a Green Economy (2015)
Spain	Bioeconomy (regional)	Castilla y León Agrifood Bioeconomy Strategy (2019)
	Circular Bioeconomy (regional)	Andalusian Circular Bioeconomy Strategy (2018)
	Bioeconomy (holistic)	Spanish Bioeconomic Strategy: "Horizon 2030 – Action plan 2018"
	Bioeconomy (regional)	Marco Regional de Impulso a la Economía Verde y Circular en Extremadura (2017)
	Bioeconomy (holistic)	Spanish Bioeconomic Strategy: "Horizon 2030" (2016) + The 2016 Action Plan (2016)
Sweden	Forest Bioeconomy	Sweden's National Forest Programme (2018)
	Research & Innovation	Swedish Research and Innovation Strategy for a Bio-based Economy (2012)
United Kingdom	Bioeconomy (holistic)	Growing the bioeconomy: a national bioeconomy strategy to 2030 (2018)
	Circular Bioeconomy (regional)	Making Things Last: a circular economy strategy for Scotland (2016)
	Bioeconomy (regional)	Biorefinery Roadmap for Scotland: Building a Sustainable Future (2015)
	High-Tech (regional)	National Plan for Industrial Biotechnology: Driving Progress to 2025 (2013)

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Austria



1

What have been the major developments in bioeconomy policy over the past decade?

In the last decade, the Austrian government has taken several steps to develop bioeconomy-related policies which have been predominantly research-oriented. Political commitment to supporting a bioeconomy research initiative was first laid out in the **coalition agreement of 2013** and largely based on the comprehensive policy paper on bioeconomy published by BIOS Science Austria and the Austrian Union for Agricultural Research (ÖVAF)¹⁶⁹ in 2013,

One year later, the government published the **Research, Technology and Innovation Strategy (RTI Strategy) for Biobased Industries (2014)**¹⁷⁰. An inter-ministerial working group then reviewed the current bioeconomy-related RTI activities in Austria in the RTI Status Quo Report.¹⁷¹ The report defined relevant research areas and was used to elaborate a comprehensive **National RTI Strategy on Bioeconomy**,¹⁷² which was published in 2018.

In November 2018, three ministries published a **Mission Statement**¹⁷³ which provided a SWOT analysis

of the bioeconomy in Austria and laid the foundations for the development of a national bioeconomy policy strategy.

In 2019, the Austrian Government adopted the **dedicated national bioeconomy strategy “Bioökonomie: Eine Strategie für Österreich”**¹⁷⁴ to address key questions as to how society can use natural resources in a sustainable and responsible way while also running a thriving economy.

At the beginning of January 2020, the new Austrian government alliance of the Austrian People’s Party (ÖVP) and the Greens published its **government program**¹⁷⁵ which names the bioeconomy as a central pillar for climate protection. The new government confirmed its commitment to implementing the national bioeconomy strategy and an associated action plan (not yet published), and to establishing a bioeconomy cluster and an associated office within the existing resources in the administration.

2 How is the dedicated bioeconomy strategy embedded into the wider policy context?

The Austrian Bioeconomy Strategy was adopted by the Council of Ministers on 13 March 2019. It has been developed as an essential cornerstone of the Austrian Climate and Energy Strategy “#mission2030” and is aligned with the EU Bioeconomy Strategy of 2012, its revision of 2018, as well as

with the United Nations Agenda 2030 and the Paris Climate Agreement. The strategy is also integrated into the policy framework of the Austrian Forest Strategy 2020+ and the Resource Efficiency Action Plan (REAP).

3 Who is the author of the strategy, and how were stakeholders consulted and engaged in the different phases of the strategy process?

The national bioeconomy strategy is the result of inter-ministerial collaboration. Three ministries were involved in its development and publication, including the Federal Ministry for Sustainability and Tourism; the Federal Ministry of Education, Science and Research; and the Federal Ministry for Transport, Innovation and Technology.

The strategy was developed with the help of a public consultation process which has been overseen by the University of Natural Resources and Life Sciences in Vienna since 2014. The process included, for example, two online consultations, a conference

to inform the public about the status of the development process, and a public web survey to confirm and partially quantify the operational objectives.

The European Forum Alpbach also played a decisive role in the strategy process. Since 2015, it has invited representatives from countries that already have dedicated bioeconomy strategies, such as Finland, South Africa, Italy, Germany, and the United States. The aim was to learn from the different strategy processes, the different priorities, and the countries' general experience of developing a dedicated bioeconomy strategy.¹⁷⁶

4 How is “bioeconomy” defined in the main policy strategy?

In Austria, the bioeconomy stands for an “(...) economic concept that aims to replace fossil resources (raw materials and energy sources) with renewable raw materials in as many areas and applications as possible.” It highlights that the bioeconomy covers all industrial and economic sectors that produce,

process, handle or use biological resources. The focus is on raw material sources from agriculture and forestry, water management, and waste, as well as the use of these biobased raw materials for food and feed, chemicals, materials, and energy.

5

What is the main purpose of the dedicated policy strategy, and how does it relate to the SDGs and the Circular Economy? How does it introduce visions, targets, milestones, and action plans?

The national bioeconomy strategy envisions an economy that reconciles technology and ecology. By providing a dedicated national bioeconomy strategy, the Austrian government's main aim is to meet global societal challenges, such as climate change, food and water shortages, and increasing environmental pollution. At the same time, the strategy is intended to contribute to achieving the goals of the Paris Climate Agreement and to promote the decarbonization of Austrian society and the economy. The bioeconomy is expected to significantly contribute to reducing greenhouse gas emission by 2030. In comparison to other (European) bioeconomy strategies, the Austrian strategy is thus very climate- and environment-oriented in its objectives.

The strategy introduces a series of goals and qualitative targets. For example, the country's dependence on fossil fuels and energy sources should be reduced, i.e. by significantly increasing the share of renewable resources in total raw material by 2030.

Furthermore, the strategy pursues regional value creation and looks to secure jobs for the future, i.e. by accelerating the existing growth of "green jobs" and creating additional jobs in the bioeconomy by 2030.

The Austrian Government aims to enter new markets, domestically and abroad, and to strengthen the country's economic development and competitiveness. With the dedicated bioeconomy strategy, Austria should be positioned globally as a bioeconomy RTI competence location and as an exporter of high-value, innovative biobased products and services.

The Government further aims to mobilize private capital for bioeconomy development and to strengthen the position of Austria as a financial

location. Private investment in bioeconomy enterprises of all sizes should be significantly increased by 2030.

By 2030, a national accounting system should be established that includes not only monetary variables but also other measures. This should help to better reflect value creation in the bioeconomy in several dimensions, including economic performance but also social and natural capital.

Moreover, the government is striving for sustainable social transformation. To do this, it aims to disseminate knowledge about the bioeconomy among the general public by 2030 so that people will be able to form a qualified judgement about bioeconomy-related topics and issues. Bioeconomy topics should also be comprehensively anchored in education and research by 2030.

The Austrian bioeconomy strategy is based on guidelines aligned with the UN SDGs. These guidelines form the framework for designing implementation measures to cope with potential goal conflicts and to optimize synergies with other Agenda 2030 objectives.

The circular economy is highlighted as essential for the utilization of biobased resources. While circular concepts are a central pillar of the strategy, reference is also made to the EU's circular economy package and the EU bioeconomy strategy.

The strategy document notes that an action plan is currently being developed with the participation of all stakeholders. To this end, numerous workshops with enterprises, regions, and other stakeholders were held in autumn 2019. However, the action plan has not yet been published. Its publication is expected at the beginning of 2021. In addition, there is no reference to budgetary resources.

6

What are the priority areas of the strategy?

The national bioeconomy strategy addresses four thematic areas. In the first, “**sustainable consumption**” is pursued by combining the goals of “sufficiency” (changing use and consumption behavior), “efficiency” (using raw materials as fully as possible) and “consistency” (recycling management and circular economy). The strategy emphasizes the urgent need for changes in behavior and values, both for producers and consumers. Interestingly, the Austrian government is committed to **reducing per capita consumption** and fostering sustainable services in the interest of sustainable resource management.

The second thematic area, “**resources of the bioeconomy**,” focuses on the sustainable production and utilization of biological resources in agriculture and forestry, i.e. through precision farming, the development of new value-added and production concepts, and the use of digitalization and data management. Interestingly, **water management** is also addressed, i.e. through the development of new raw material sources in closed production systems, such as algae production (energy and material use), protein production by insects (for animal feed), vertical and urban farming, and the sensible use of unused nutrients in sludge from biogas or sewage plants.

The third thematic area, “**technologies of the bioeconomy**,” focuses, for example, on sustainable and improved agricultural cultivation, processing and harvesting technologies, improved transport and

logistic concepts, and new conversion processes and technologies, including the evaluation and optimization of existing biorefinery concepts.

The thematic area, “**products of the bioeconomy**,” points to further promoting the existing strengths of the Austrian forest-based bioeconomy in the paper and pulp industry, the construction, insulation and wood sector, the basic chemical industry, and the bioenergy sector. Focus is on developing new and advanced materials based on cellulose, lignin, wood fiber, wood wool, and fiber plants but also on new and sustainable products based on biobased platform chemicals and biobased plastics or second generation (or higher) biofuels. Furthermore, the strategy highlights the food and animal feed sector and the need to ensure more conscious, climate-compatible and healthy diets and a high quality of food. Promoting organic agriculture and reducing food losses and waste are also emphasized as key areas of action.

In addition to these priority areas, the strategy highlights **digitalization** and **new communication** technologies as a cross-cutting theme which, in conjunction with technological developments such as artificial intelligence, will bring about significant changes in production processes towards so-called “**biodigitization**.” Initiated by the Austrian government’s digitization strategy, this should contribute to the long-term success of the domestic economy.

7

What policy instruments are put forth in the strategy (and its action plan)?

To promote innovation beyond the boundaries of disciplines, sectors and institutions, the strategy specifically addresses cooperation between business, science, administration, and society by fostering technological and social innovations as well as open innovations.

Policy measures proposed to foster bioeconomy **research and innovation** include instruments that support basic research at university research insti-

tutions, promote cooperation centers and platforms for science and industry, and funding programs for applied/industrial research. New and existing clusters should be promoted for the development of economic partnerships across production chains. In addition, international networking and cooperation between research institutions and innovation-oriented companies should be strengthened, i.e. by further supporting international networks such as the European Bioeconomy University, Austrian mem-

bership in the Biobased Industries Joint Undertaking (BBI JU), the IEA Technology Collaboration Program (TCP) and the international “Mission Innovation” alliance. Furthermore, targeted measures should be developed to support the establishment of companies in biobased industry.

With regard to **infrastructure** investments, the strategy document focuses primarily on the development of research infrastructure and support for logistics infrastructure for the biobased economy.

To support **commercialization**, the strategy provides for the development of targeted measures to strengthen the biobased market. For example, the Environmental Technology Export Initiative should be further promoted to improve the global positioning of Austrian combustion technologies. Bioeconomic products should also be given priority in terms of market access through appropriate funding instruments. However, the strategy document does not yet specify any measures.

Measures proposed to address the **demand side** focus mainly on supporting the consumers’ conscious decision to buy biobased products and replacing fossil products, for example, by introducing national and European certificates and labels. In addition, targeted information campaigns, such as the “Buy consciously” initiative, should be promoted. Besides the promotion of new consumption concepts (e.g. sharing economy, cradle-to-cradle), innovative and sustainable public procurement policies for biobased products should also be developed.

In addition to research and innovation, the strategy recognizes **education** as one of the key growth drivers for modern economies. In view of the complexity of the bioeconomy, the strategy highlights the need for comprehensive educational programs. Educational institutions that strive to improve and develop educational structures and processes related to bioeconomy will be supported by the Innovation Foundation for Education. Education. Capacity building should be further promoted by integrating the bioeconomy into school and academic education as well as into vocational training programs.

Interestingly, Austria strongly promotes bioeconomy education and capacity building within and across European borders. For example, the University of Natural Resources and Life Sciences in Vienna was one of the founding members of the European Bioeconomy University, a new alliance of the six leading European universities in bioeconomy research, which will act not only as a think tank for knowledge generation, but also as a creative hub for knowledge transfer.¹⁷⁷

Some policy measures mentioned in the policy strategy are intended to create political **framework conditions** that are favorable to the bioeconomy. These include promoting compliance with internationally recognized sustainability standards in agriculture, forestry and water management; compensating companies for additional costs of biobased production; and regulatory measures such as bans (e.g. for new installations of fuel oil boilers, or the use of plastic). Furthermore, benchmarks and standards for the use of secondary raw materials should be strengthened and additional measures should be developed to achieve the recycling quotas for 2025. Environmental and social standards should ensure fair competition for biobased products and feed quotas should be reduced. In addition, laws and standards in the construction sector should be harmonized and the rate at which buildings are renovated should be increased to promote the trend of living with natural materials. To accelerate the development and utilization of bioenergy, there should be further strengthening of the Renewable Energies Expansion Act of 2018 and promotion of incentives for early withdrawal from fossil fuels. At the same time, there should be an increase in the admixture of liquid biofuels.

With regard to **good governance** measures, the strategy often emphasizes that cooperation between the Austrian Government and the provinces should be expanded in the future, by promoting networking activities of regional clusters for example. An Austria-wide initiative for a joint cooperation approach was planned for in 2019.

8

How is the implementation of the strategy monitored and evaluated?

The three ministries involved in development of the strategy are also responsible for its implementation. With the new government in January 2020, the responsibility for implementation moved to the Austrian Federal Ministry for Climate Action, Envi-

ronment, Energy, Mobility, Innovation and Technology. The strategy's implementation should involve relevant stakeholders from science, business, and civil society.

9

Do dedicated regional bioeconomy policy strategies exist?

No

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EU



1

What have been the major developments in bioeconomy policy over the past decade?

The European Union can be seen as the key driver of national bioeconomy policy strategies. In 2012, the European Union presented its first dedicated Bioeconomy Strategy and Action Plan, “**Innovating for Sustainable Growth: A Bioeconomy for Europe**,”¹⁷⁸ with a focus on three pillars: (1) investments in skills, research and innovation; (2) coordination of policy and engagement with stakeholders, and (3) market development and competitiveness. Implementation was funded mainly via EU Research and Innovation funding under Horizon 2020 (2014 – 2020). Funding dedicated to the bioeconomy would nearly double from EUR 1.9 billion in the 7th Framework Programme (2007 – 2013) to EUR 3.85 billion in Horizon 2020.

One of the largest investments was dedicated to an innovative public-private partnership (ppp), the “**Bio-Based Industries Joint Undertaking (BBI JU)**,” between the EU and the Bio-based Industries Consortium (BIC). The BBI JU aimed to invest EUR 3.7 billion in biobased innovation between 2014 and 2020: EUR 975 million was committed by the European Commission and EUR 2.7 billion by the private sector. As of June 2020, BBI JU had invested over EUR 700 million in 123 projects creating over 100 new biobased value chains and materials in 37 countries.¹⁷⁹

Several other Horizon 2020 programs supported bioeconomic innovations, specifically under Societal Challenge 2 (food security, sustainable agriculture and forestry, marine, maritime and inland water research

and the bioeconomy), such as the 2014 call for proposals “Innovative, sustainable and inclusive Bioeconomy” (ISIB) with a budget of EUR 44.5 million, “Sustainable Food Security” (EUR 138 million) and “Blue Growth” (EUR 100 million). Other important initiatives under Horizon 2020 included a ppp with the chemical industry, Sustainable Process Industry (SPIRE), and a clean energy initiative, the “European Industrial Bioenergy Initiative” (EIBI).¹⁸⁰

Policy coherence was furthered in the Strategy via the **Bioeconomy (Stakeholders) Panel** (established in 2013 and renewed in 2016), an expert committee of 29 members tasked with providing cross-sectoral and interdisciplinary policy advice. EU-wide coordination of bioeconomy-related public research funding was also advanced with the help of ongoing ERA-Net activities (e. g. see the report on “Bioeconomy ERA-NET Actions” 2014) and Joint Programming Initiatives of member states. In addition, the **Bioeconomy Observatory**, led by the Joint Research Center (JRC), was established in February 2013 to inform policy-making by scientifically guiding the development of the EU bioeconomy with the help of statistical monitoring and modeling studies. In July 2017, the European Commission launched the **Knowledge Center for Bioeconomy (KCB)**, also hosted by the Joint Research Centre, to provide data and relevant publications on the bioeconomy in the member states to ensure better knowledge-sharing. To ensure cooperation at international level, in November 2017 the EU Commission launched the “International

Bioeconomy Forum,” a platform for multilateral R&D collaboration in areas of common interest.

Under the third pillar of the Strategy, activities were implemented that related mainly to research on standardization and coordinating the respective implementation activities, including the development of measurement methods, and standards and labels for different biobased products in the European Committee for Standardization (CEN).

Beyond the Strategy, the EU Commission also set up the **European Innovation Partnership for Agriculture (EIP-AGRI)**¹⁸¹ in 2012 to promote sustainable intensification in agriculture and forestry and contribute to providing the right quality and amount of biomass for food, feed, and the production of new biomaterials. The EIP was also backed by Horizon 2020 and Regional Development funds to foster the work of “operational groups” which facilitate hands-on communication and interactive knowledge transfer in agriculture and forestry. It also supported pilot projects and cooperation initiatives targeting improved supply chains, food security, climate or environmental protection.

In December 2015, the EU Commission adopted a circular economy strategy, **“Closing the loop – An EU action plan for the Circular Economy,”**¹⁸² to promote resource efficiency across industries and member states. Biomass and biobased products were among the five priority areas of intervention and the biobased sector was seen as an integral part of the circular economy. Consequently, bioeconomy and the use of biological resources was increasingly linked to the circular economy concept.

In November 2017, the Commission presented an expert review of the 2012 Bioeconomy Strategy and determined that the policy context in which the bioeconomy operates had changed significantly and a Strategy update was necessary. An updated Bioeconomy Strategy and Action Plan, **“A sustainable Bioeconomy for Europe: strengthening the connection between economy, society and the environment,”**¹⁸³ was released in October 2018 and set new priorities for the bioeconomy’s contribution to climate protection and sustainable development in Europe.

In addition to the updated Bioeconomy Strategy, two other important EC communications that year helped

define the bioeconomy as an important element in overarching policy debates: the EU Communication on **“A Clean Planet for all – A European strategic long-term vision for a prosperous, modern, competitive and climate neutral economy,”**¹⁸⁴ which highlights how the bioeconomy can contribute to achieving the Paris Climate Agreement goals, and the reflection paper **“Towards a Sustainable Europe by 2030,”**¹⁸⁵ which emphasizes the function of the bioeconomy as a positive driver for several SDGs. It specifically identified the transition to sustainable food systems as a key contribution of bioeconomy to reaching the SDGs.

In December 2019, the new president of the EU Commission, Ursula von der Leyen, published a first **communication on the European Green Deal.**¹⁸⁶ It presented a comprehensive approach to tackling urgent environmental challenges, including those the continent is facing in the area of agriculture and forestry, and renewed political relevance for the bioeconomy. It highlighted the essential and increasing role that the bioeconomy must play in reducing GHG emissions and created many synergies with and links to the bioeconomy and many policies of the Green Deal (e.g. Circular Economy Action Plan, Farm to Fork Strategy, EU Biodiversity Strategy).

In March 2020, the Commission published the **“Circular Economy Action Plan (CEAP)”**¹⁸⁷ with the hope of accelerating the change required by the European Green Deal, while also building on the 54 circular economy actions implemented since 2015. Important references are made to the biobased sector, especially with regard to circularity in production processes, plastics, and food, water and nutrients, however, bioeconomy development is lacking in important areas such as urban development, packaging, textiles, and construction and building. The **EU Industrial Strategy (2020)**¹⁸⁸ also envisions the physical, digital, and biological worlds coming together.

The Green Deal also focuses on the **Farm to Fork Strategy**¹⁸⁹ which looks to address the challenges of sustainable food systems and sees the deployment of a circular and sustainable bioeconomy as providing business opportunities, for instance, in making use of food waste and in advanced biorefineries that produce biofertilizers, protein feed, bioenergy, and biochemicals. As referenced in the European Green Deal, an **EU Biodiversity Strategy for 2030**¹⁹⁰ was released in

May 2020 which outlines a 10-year vision to restore and protect the union's ecosystems with a budget of at least EUR 20 billion a year. It lays out measures to transform the agriculture sector by promoting agro-ecology practices (e.g. supporting organic farming and crop genetic diversity, reducing chemical pesticides, soil erosion, and water depletion). In addition, "nature-based solutions"¹⁹¹ play a major role and should be systematically integrated into urban planning.

The European Forest Strategy (2013),¹⁹² which promotes the multifunctional role of forests, the principles of Sustainable Forest Management, and cascade use of wood products, is set to be updated in 2020. It is

unclear, however, how it will relate to the biodiversity strategy. The European Commission's **Green Recovery Plan** in response to the Covid crisis and the EU's new seven-year budget, including the next research and innovation program, Horizon Europe 2021 – 2027, and its funding for the bioeconomy, have not been finalized at the time of publication, leaving a string of unknown consequences for future investments in the bioeconomy. While the financing is not yet clear, Horizon Europe will begin in 2021 with a largely approved preliminary structure, with the bioeconomy falling under pillar 2 in the Food, Bioeconomy, Natural Resources, Agriculture and Environment Cluster and a redesigned BBI JU program.¹⁹³

2

How is the dedicated bioeconomy strategy embedded into the wider policy context?

The 2018 Strategy explicitly aims to maximize impact by aligning with other European priorities, especially those laid out in the renewed Industrial Policy, the Circular Economy Action Plan, and the Clean Energy for All European Package.

With regard to the overarching goals of the European Green Deal, the areas of action most relevant to the bioeconomy include the "Farm to Fork" Strategy (2020) for a fair, healthy and environmentally friendly food system, with legislative measures to reduce the use of chemical pesticides, fertilizers, and antibiotics; the EU Biodiversity Strategy (2020); the not yet

published EU Forest Strategy to help preserve and restore ecosystems and biodiversity; and the mobilization of research and fostering of innovation.

In general, the 2018 Bioeconomy Strategy uses a systemic approach that embraces multiple sectors and policies related to the bioeconomy and seeks to interlink them and facilitate coherence. Whereas the Circular Economy Action Plan sees the implementation of the Bioeconomy Strategy as an integral part of its strategy, the Green Deal and Biodiversity Strategy do not explicitly reference the Bioeconomy Strategy.

3

Who is the author of the strategy, and how were stakeholders consulted and engaged in the different phases of the strategy process?

The 2018 Bioeconomy Strategy was published by the European Commission, Directorate-General for Research and Innovation. In February 2018, the Commission published a roadmap for the Communication, updating the 2012 Strategy, and received public consultation (92 in total) from the public and private sectors. The Communication was developed jointly across different DGs (RTD, AGRI, ENV, MARE, GROW, JRC, CLIMA).

The 2018 Strategy and its corresponding Action Plan reflect conclusions drawn from the Review of the 2012 European Bioeconomy Strategy (2017).¹⁹⁴ The Review report built on input from an external expert group, composed of 14 experts from the public and private sector, as well as the Bioeconomy Stakeholders Panel, with representatives from large and small companies, NGOs, biomass producers, regions and academia from across

Europe, and related stakeholders' conferences. A key document published in November of 2017 by the Stakeholder Panel was a Manifesto¹⁹⁵ providing guidelines

for developing a sustainable bioeconomy in Europe. In addition, a coordinators' survey and an open public consultation were conducted for the BBI JU projects.

4

How is “bioeconomy” defined in the main policy strategy?

The 2012 Bioeconomy Strategy defines the bioeconomy as encompassing “the production of renewable biological resources and their conversion into food, feed, biobased products and bioenergy. It includes agriculture, forestry, fisheries, food, and pulp and paper production, as well as parts of the chemical, biotechnological, and energy industries. Its sectors have a strong innovation potential due to their use of a wide range of sciences (life sciences, agronomy, ecology, food science, and social sciences), enabling industrial technologies (biotechnology, nanotechnology, information and communication technologies [ICT], and engineering), and local and tacit knowledge.”

The updated 2018 Strategy makes an explicit effort to more clearly define the bioeconomy and uses a more comprehensive definition: “The bioeconomy covers all sectors and systems that rely on biological resources (animals, plants, micro-organisms and derived biomass, including organic waste), their functions and principles. 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, biobased products, energy and services. To be successful, the European bioeconomy needs to have sustainability and circularity at its heart.”

According to the new 2018 definition, the bioeconomy now includes all systems based on biological

resources in addition to economic sectors. While the 2012 Strategy emphasized the cascading use of biomass, the new Strategy goes further and describes the bioeconomy as a sub-sector of the circular economy. Similar to 2012, biotechnology plays a key role in the bioeconomy, but health biotechnology and biological medicines are not included in the definition.

According to a study conducted by nova-Institute on behalf of the Bio-based Industries Consortium (BIC) in 2020, the entire EU bioeconomy, including the primary sectors of agriculture, forestry, fishery, food products, beverages, and tobacco products, totaled EUR 2.4 trillion and employed 18.5 million people in 2017. Excluding the above-mentioned sectors, the biobased economy had a turnover of EUR 750 billion with the largest sectors being forest-based industry (26 percent), paper products (26 percent), and pharmaceuticals (19 percent), and employed EUR 3.6 million, 43 percent of whom were from the forest-based industry.¹⁹⁶

It is important to note that the broader definition in 2018 also includes bioeconomy services (e.g. restoration, waste treatment, food retail trade, and research into and repair of biobased products) which poses new methodological challenges for measuring jobs and wealth creation. While estimation of the biobased content of biobased products is appropriate for determining the biobased share of manufacturing sectors, it is less relevant for certain service sectors.¹⁹⁷

5

What is the main purpose of the dedicated policy strategy, and how does it relate to the SDGs and the Circular Economy? How does it introduce visions, targets, milestones, and action plans?

The 2018 Bioeconomy Strategy and its Action Plan make clear that the bioeconomy needs to have sustainability and circularity at its heart. In turn this will help achieve the new EU priority goals: the renewal of industries, the modernization of primary production systems, job creation (estimated as up to 1 million new jobs by 2030), protection of the environment, and biodiversity.

The five objectives referenced in the 2012 Strategy remain valid: 1) food and nutrition security; 2) sustainable resource management; 3) reduced dependence on fossil fuels; 4) climate change mitigation; 5) job creation and competitiveness. While the revised Strategy includes these same objectives, it also goes beyond them. One of the central aims of the updated Strategy is to adapt objectives so that they align better with overall European priorities, especially with regard to the EU Circular Economy, the Paris Climate Agreement, and the 2030 Agenda for Sustainable Development. Consequently, the Strategy places increased emphasis on

the concept of a sustainable and circular bioeconomy. The focus is on green transformation, an economically sensible and ecologically sustainable reorientation of the economy and society, and a systemic change in the production and consumption of resources.

The 2018 Strategy is based on three key objectives: 1) strengthening and scaling-up the biobased sectors; 2) rapidly deploying local bioeconomies across Europe; 3) protecting the ecosystem and understanding the ecological boundaries of the bioeconomy.

In the 2012 Strategy, there is no clear direct link between objectives (referred to as societal challenges) and the measures listed in the Action Plan. An overarching goal of the revised 2018 Strategy is to make measurable contributions, and thus 14 concrete policy measures are defined in the Action Plan which are to be implemented starting in 2019. Unlike many other bioeconomy strategies, the Action Plan sets milestones for some individual actions.

6

What are the priority areas of the strategy?

The updated 2018 Strategy strives to move beyond research and innovation with a systematic approach to the deployment of biobased innovations in the bioeconomy. There is an identified need for further **mobilization of investments** and increased predictability of the **regulatory environment**.

Attention is placed not only on conventional biobased products from biomass, such as wood, cork, paper, textiles, etc., but also **new products** such as biobased chemicals, plastics etc., which can either replace fossil-based products or have completely new functionalities and potential for new markets (e.g. cellulose-based products, biobased plastics that are fit for industrial composting and biodegradable in the natural environment or “green” chemicals). The Strategy specifically mentions using

advances in the life sciences and **biotechnology** to modernize and strengthen Europe’s traditional industries. At the same time, innovations resulting from the convergence of physical, digital and biotechnologies should create entirely new sources of future economic growth.

There is a strong focus on sustainability and circularity, where **cities** should become major circular bioeconomy hubs. Job creation, particularly in coastal and rural areas, is of central importance. The Strategy notes that the potential for the use of biological resources and residues has not yet been exhausted in European regions and municipalities (especially in Eastern Europe). It further supports the modernization of the EU industrial base by capitalizing on advances in life science and biotechnology.

7

What policy instruments are put forth in the strategy (and its action plan)?

The revised Strategy is funded through the bioeconomy cluster of the new research framework program “Horizon Europe” 2021 – 2027 which identifies seven intervention areas: environmental observation; biodiversity and natural resources; agriculture, forestry, and rural areas; seas, oceans, and inland waters; food systems; biobased innovation systems in the EU bioeconomy; and circular systems. For the new research framework program “Horizon Europe” 2021 – 2027, the Commission has planned a significant increase in the budget from EUR 3.85 billion to EUR 10 billion (“Food and Natural Resources” cluster), it remains open, however, whether these funds will be changed.

The revised Strategy provides for 14 concrete policy measures which this analysis has categorized under the promotion of research and innovation, commercialization, infrastructure, demand-side instruments, and good governance.

With regard to **research and innovation** investments, the Strategy in Action 1.6 focuses on plastic-free oceans and calls for research on the development of substitutes for fossil-based materials that are biobased, recyclable and marine-biodegradable and on bioremediation methods. Action 3.4 promotes research and innovation in the areas of agroecology, microbiome-based solutions, pollinators, etc. to enhance the benefits of biodiversity in primary production.

Pilot actions are supported through Action 2.2 which plans to implement five pilot projects in the first round in the following thematic areas: marine bioeconomy, urban bioeconomy, “carbon farming”, and “living labs” to support local bioeconomy development. July 2019 saw the publication of the urban bioeconomy call, “Pilot circular biobased cities,” which provides funding for at least five EU cities (and/or clusters of cities) to draft urban circular bioeconomy strategies fostering the sustainable production of biobased products from urban biowaste and wastewater. In the longer term, financial support will be extended to up to 30 bioeconomy cities across Europe.

With regard to strengthening and scaling-up the biobased sector through **commercialization**, the Action Plan singles out BBI JU as a successful tool to

kick-start demonstration and deployment of biorefineries and new value-chains. However, it determines that funding of high-risk investments is still not well supported. The 2017 Review identified the need to: 1) make investment opportunities more appealing, transparent, secure and visible, and 2) help EU regions evaluate their investment readiness level for the production of more sustainable chemicals. Action 1.1 therefore calls for the development of a toolbox of solutions, including financial advisory and strategic deployment support for biobased solutions, with special attention paid to new technologies, such as artificial intelligence and blockchain. Action 1.3 seeks to study and identify obstacles and factors promoting market development for biobased products by 2021.

Action 1.2 launched a EUR 100 million Circular Bioeconomy Thematic Investment Platform, called the European Circular Bioeconomy Fund (ECBF), to help de-risk private investments for both bioeconomy projects scaling-up from the pilot to demonstration phase as well as from the demonstration to industrial scale phase. The new fund will provide access to finance, in the form of equity, debt or quasi-equity, to innovative circular bioeconomy companies and projects of various sizes. Focus is placed on projects in the biobased industries, the marine bioeconomy, and closely related sectors such as agriculture and forestry. ECBF is a joint initiative of the European Commission and the European Investment Bank (EIB) and has a target fund volume of EUR 250 million.¹⁹⁸

Infrastructure is strongly supported in the Strategy. By 2024, Action 1.5 calls for the development of a roadmap for deploying an estimated 300 new biorefineries that must be built by 2030 to meet growing demand. A strong focus is placed on small-scale and decentralized biorefineries (especially sustainable chemicals).

With regard to **demand-side** measures, by 2025 Action 1.4 will promote and further develop existing standards and labels and the development of public procurement guidelines for biobased products. For example, to increase consumer acceptance of new products, reliable and comparable information on the environmental performance of products should be available to consumers (e.g. using the Product Environmental Footprint (PEF) method).

Education and capacity building are furthered through Action 2.4, the adaptation of education and training to the needs of the bioeconomy (e.g. by piloting vocational and higher education curricula and entrepreneurship programs). Vocational training is strongly emphasized, as is stimulating entrepreneurship, e.g. through a potential “Bioeconomy Innovation Bootcamp” for researchers to help develop, new business approaches; examples of positive synergies with local communities; and bioeconomy and ecosystem-based principles. Furthermore, the Strategy looks to support projects under the Blueprint for Sectoral Cooperation on Skills that address digital, green and maritime skills

A number of **good governance** measures are prominent in the Strategy. An essential finding of the 2017 Review and a pillar of the revised Strategy is to encourage the adoption, updating and coherence of national and regional bioeconomy strategies throughout Europe. To this end, Action 2.1 calls for the development of an implementation concept by 2021, the Strategic Deployment Agenda (SDA), to strengthen local bioeconomies. The focus is primarily on the use of by-products from agriculture, aquaculture and biobased materials. The Strategy notes that the utilization potential of biomass and biological residues has not yet been exhausted, especially in Eastern European regions and municipalities. Policy coherence and support is further provided through Action 2.3 which sets up an EU Bioeconomy Policy Support Facility (with a focus on Central and Eastern Europe) and a European Bioeconomy Forum for Member States.

Under the theme of understanding the ecological boundaries of the bioeconomy, a number of actions

contribute to good governance measures. Action 3.1 seeks to enhance the knowledge based on the bioeconomy, including biodiversity and ecosystems, and make it accessible through the Knowledge Centre for Bioeconomy (KCB) which boasts a library of over 3,016 resources (publications, datasets, news, events, etc.).¹⁹⁹

Another key finding of the 2017 Review was the need for better monitoring of the bioeconomy as a whole and of the Strategy itself, including indicators. Action 3.2 thus introduces an EU-wide monitoring system to track progress towards a sustainable bioeconomy and document its impact on biodiversity, ecosystems, climate change, etc. The BioMonitor project, a consortium of universities, statistical and standardization institutes, consultancies, and data modelling experts, has already begun setting up a monitoring and assessment framework for the European bioeconomy.²⁰⁰

Knowledge gained from these actions will then be used in Action 3.3 to provide voluntary guidance for operating the bioeconomy within safe ecological limits.

Lastly, in order to enhance the benefits of biodiversity in primary production, Action 3.4 proposes the development of microbiome-based solutions, a roadmap for action to support agroecology, and tools for the integration of pollinators into value chains.

The Strategy also emphasizes that all measures should be implemented in close connection with global developments. Specifically, the “International Bioeconomy Forum” and the “Global Bioeconomy Summit” should be used to identify synergies with like-minded partners.

8

How is the implementation of the strategy monitored and evaluated?

By introducing an EU-wide monitoring system with indicators, the updated 2018 Strategy seeks to better

track economic, environmental, and societal progress, and highlight trade-offs and synergies.

9

Do dedicated regional bioeconomy policy strategies exist?

The deployment of the bioeconomy at regional level in the EU is quite advanced. The existence of a national

or regional **Smart Specialisation Strategy (RIS3)** was one of the ex-ante conditionalities of the funding pe-

riod 2014 – 2020 for the approval of a Regional/National Operational Program. As a result, all regions in the EU have a strategic RIS3 document and the vast majority of these strategies foresee support for bioeconomy R&I. Most of them are under the heading of agrifood or energy R&I. However, with regard to specific measures and funding modalities, RIS3 strategies propose a wide array of measures.²⁰¹ The **European Structural and Investment Funds (ESIF)** are an important funding source for bioeconomy related activities for many RIS3 strategies. In particular, the European Regional Development Fund (ERDF), the European Agricultural Fund for Rural Development (EAFRD), and the European Maritime and Fisheries Fund (EMFF) are used by the regions and countries. Overall, the ESIF Funds made more than EUR 450 billion available for the period 2014 – 2020.²⁰² Mapping in 2017 revealed a number of subregions in the EU that had coupled bioeconomy development with their RIS3 strategies,

including the Central Hungarian region, the Island of Crete (Greece), the Spanish regions of Extremadura, Galicia and the Basque country, the Haute de France region (France), Lapland (Finland), the Lodzkie region (Poland), North Denmark, the Norte region (Portugal), Olomouc and South Bohemia (Czech Republic), Upper Austria, Värmland and Skåne regions (Sweden), Weser-Ems region (Germany), West Romania, and the Emilia Romagna (Italy).²⁰³

In addition, a number of collaboration initiatives surrounding the bioeconomy seek to exploit synergies from different regions, i.e. the Smart Specialisation Platform S3, European Regions Research and Innovation Network (ERRIN), European Regions for Innovation in Agriculture, Food and Forestry (ERIAFF), and The Vanguard Initiative.²⁰⁴ Furthermore, a number of regional “bioeconomy ecosystems or clusters” have blossomed over the years.²⁰⁵

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Finland

1

What have been the major developments in bioeconomy policy over the past decade?

Beginning in 2009, Finnish Innovation Fund Sitra published three documents which can be seen as milestones on the path toward the development of a Finnish bioeconomy strategy. The **Natural Resource Strategy** of 2009²⁰⁶ was developed to promote the sustainable and innovative use of natural resources by addressing six key areas, one of which covers the bioeconomy. Alongside economic and ecological aims, the document “**Distributed Bio-Based Economy – Driving Sustainable Growth**” of 2011²⁰⁷ also pursues social aims, with the intention of helping to face the challenges of climate change and the scarcity of natural resources. The paper further presents a vision of an almost self-sufficient Finnish society in respect of nutrients, food, and energy. Within the report, “**Sustainable Bio-economy: Potential, Challenges and Opportunities for Finland**” (2011),²⁰⁸ Sitra highlighted the importance of bioeconomy in relation to sustainable food production and the replacement of fossil natural resources.

In 2014, Finland published its first comprehensive policy strategy on the bioeconomy, “**The Finnish Bio-economy Strategy – Sustainable growth from bio-economy.**”²⁰⁹ The importance of the 2014 Finnish Strategy is undisputed. As one of the first national bioeconomy strategies in Europe, it presented an ambitious list of measures, propelling it to become the leading bioeconomy nation in Europe.

In 2016, Finland was one of the first countries worldwide to present a **Road Map to a Circular Economy**

2016 – 2025.²¹⁰ Two of the five topics prioritized are closely linked to the bioeconomy, namely sustainable food systems and forestry cycles. In 2019, Sitra launched an updated road map, “**Critical Move – Finland’s Road Map to a Circular Economy 2.0,**” with the goal of plotting Finland’s development to 2025, raising the level of ambition, and connecting it to climate change mitigation.²¹¹

The **Energy and Climate Strategy** in 2016²¹² set out to increase the share of biofuels in road transport to 30% by 2030 and to increase the proportion of electricity generated from biomass.²¹³ In addition, the **National Forestry Strategy 2025** (originally drafted in 2015 and then updated in 2019), the **National Biodiversity Strategy** (2012 – 2020),²¹⁴ and a **National Strategy for Aquaculture 2022**²¹⁵ also interlock strongly with the country’s bioeconomy strategy.

In 2018, the Ministry of the Environment published the **Plastics Roadmap for Finland**,²¹⁶ which proposes, among other things, the establishment of a national program to develop new value networks for solutions, materials and technologies to replace plastics, and a New Plastics Finland knowledge network of expertise to promote biomaterials.

Under the government program of Prime Minister Rinne (June to December 2019) and the current Prime Minister Marin, Finland has ambitiously pledged to become carbon neutral by 2035.²¹⁷ In July 2019, Finland took over the EU

Presidency and presented a program with a strong emphasis on sustainability and circularity, and on implementing the European Commission's updated bioeconomy strategy. A major event under Finland's Presidency included the **European Bioeconomy Scene 2019** conference in Helsinki. Other major bioeconomy related events hosted by Finland include the Koli Forum, the World Bioeconomy Forum (2018, 2019, 2020), the World Circular Economy Forum, and Food Economy 4.0 (2017).

In addition to Sitra, the state owned VTT Technical Research Centre of Finland has been supporting the bioeconomy transition with a number of important publications.²¹⁸ In 2017, VTT expanded operation of the Bioruukki pilot centre, one of VTT's biggest investments, from thermochemistry to novel ways of biomass utilization, recycling of textile fibers, and green chemistry technologies.²¹⁹

Finland has entered into international partnerships with the U.S. State of Maine and Michigan to further develop the bioeconomy. In October of 2019, the State of Maine and Finland (coordinated through the Ministry of Agriculture and Forestry of Finland) signed a five-year Memorandum of Understanding (MoU) to foster an exchange of information and co-operation to develop a bioeconomy that is based on forests and the use of wood.²²⁰ In March of 2020, the Finnish Minister of Economic Affairs and the Governor of Michigan signed an MoU on clean technology development, particularly in the areas of intelligent transport, including the car industry and maritime, battery technology, and bioeconomy. The focus of the MoU is initially on the R&D side, but the goal is to build valuable long-term partnerships in support of market access and bilateral investment opportunities.²²¹

2

How is the dedicated bioeconomy strategy embedded into the wider policy context?

The Finnish strategy, published in 2014, appeared to hold a strategic position in the government and was given priority in the program of the subsequent regime. In the program of Prime Minister Juha Sipilä's Government (2015-2019), a total of EUR 323 million was allocated to the priority area Bioeconomy and clean solutions between 2016 and 2018.²²² This strategic priority area

set four objectives (energy and climate, deregulation, job creation, and economic viability of food production), chose five key projects (these projects were partially based on the 2014 Finnish Bioeconomy Strategy), and appointed a ministerial working group to oversee its work. More recent policy developments in the country have prioritized circular economy proposals.

3

Who is the author of the strategy, and how were stakeholders consulted and engaged in the different phases of the strategy process?

The Finnish bioeconomy strategy of 2014 was developed under the responsibility of the Ministry of Employment and the Economy, and in cooperation with the Prime Minister's Office and other ministries, including the Ministries of Agriculture and Forestry; Environment; Education and Culture; Social Affairs and Health, and Finance. The public VTT Technical Research Centre and the Finnish Innovation Fund SITRA were also involved in this project. The strategy development was preceded by stakeholder consultations (including five workshops, three regional bio-

economy forums and eight sectoral hearings) with regional representatives and economic operators.

In 2018, the National Audit Office (NAOF) published an audit of the 2014 Strategy and determined that "the preparatory process provided, as a whole, a good basis for achieving the objectives laid out for the strategy." It found the drafting process was properly organized and involved a large number of stakeholders. However, documents were not properly archived, leading to a lack of transparency.²²³

4

How is “bioeconomy” defined in the main policy strategy?

The Finnish bioeconomy definition refers to “an economy that relies on renewable natural resources to produce food, energy, products, and services.” The definition is expansive and cuts across traditional sectoral boundaries linking wood processing, chemistry, energy, construction, technology, food, and wellbeing solutions.

According to the latest statistics from 2018, the bioeconomy accounted for 12 percent of Finland’s gross added value or EUR 25.2 billion, with the largest sector, forestry (EUR 9.1 billion), followed by construction (EUR 4.4 billion), food (EUR 3.9 billion), and other industries (EUR 3.5 billion). It has an output of almost EUR 73 billion (almost 17% of total output) and employs more than 300,000 people, a slight decrease from a peak in 2011.²²⁴

5

What is the main purpose of the dedicated policy strategy, and how does it relate to the SDGs and the Circular Economy? How does it introduce visions, targets, milestones, and action plans?

The Finnish bioeconomy strategy was designed as a growth strategy and therefore envisions sustainable bioeconomy solutions as drivers for Finnish well-being and competitiveness. According to the vision, sustainable bioeconomy solutions should be the foundation of wellbeing and competitiveness in Finland in 2025. The vision contains both quantitative and time-related goals. The document contains four strategic goals listed in its “action plan”.

The strategy sets out a detailed list of actions and measures and identifies the bodies responsible for implementing each of these, with most predicted to start by the end of 2014. The first goal is to create a competitive operating environment for the bioeconomy by promoting a climate favorable to investment and entrepreneurship. In order to coordinate the various stakeholders in the bioeconomy

sector, it establishes a national bioeconomy panel. Secondly, the strategy targets the generation of new bioeconomy businesses which should be promoted, for example, by means of new funding solutions and exemplary pilot and demonstration projects. Thirdly, expanded research and the training of experts should foster the creation of a strong bioeconomy competence base. Fourthly, the strategy aims to ensure the accessibility and sustainability of biomass.

These key goals are specified by numerous measures which do not mention concrete quantitative targets but should collectively contribute to an increased bioeconomy output of up to EUR 100 billion by 2025 (up from EUR 60 billion in 2011).²²⁵ It should also create about 100,000 new jobs.

6

What are the priority areas of the strategy?

As Finland is home to a vast number of forests (almost 80% of Finland’s total area is forestry land), the core element of the country’s bioeconomy is the **forestry industry**. According to the strategy, the forestry industry has great potential to contribute to economic growth in Finland, for example by strengthening the timber market or due to the diversification of wood

products. Wood is also of particular importance for energy purposes. Wood-based transport fuel, for example, is increasingly used in Finland.

The strategy considers the greatest opportunities for growth to be found in **new products and materials**, particularly in forestry, chemical and energy indus-

tries. Strong Finnish competence areas also include biochemical methods, pulping technologies, and enzyme production for refining biomass.

The strategy highlights the possibilities that arise from Finnish expertise in **biotechnology**, in the health sector, for example, by developing health technologies and pharmaceutical research. Interestingly, the Finnish bioeconomy strategy underlines the importance of water as the prerequisite for a successful bioeconomy. **Clean water** is mentioned as a critical resource which is commonly used within the bioeconomy. There is therefore a need for improved technologies for water efficiency and water recycling. The Finnish forestry industry is already leading by example

in this area by developing and using processes with low water consumption.

In addition to products, the Finnish bioeconomy strategy focuses on **services** and their importance for the value chain. By reflecting emerging trends related to increasing service intensity, services (such as **nature tourism**) are seen as new business opportunities.

Based on the assumption that the Finnish bioeconomy will increase in the future and therefore more biomass resources will be needed, the strategy also focuses on **evaluation methods**. This represents a first attempt to measure bioeconomy activities related to sustainability.

7

What policy instruments are put forth in the strategy (and its action plan)?

For each of its measures, the strategy identifies which ministries and other public bodies (e.g. TEKES, SITRA, the Academy of Finland, and Team Finland) are responsible for leading on implementation. The Strategy is largely policy-led and some measures are implemented solely by national public bodies (e.g. mapping policy steering instruments, developing criteria for sustainable public procurement). The most important state funding agencies include Finland's state-owned development bank Finnvera, the Research and Development Fund SITRA, the ELY centers, and Business Finland, created in 2018 by merging two organizations: the trade promotion organization, Finpro, and the technology and Innovation Promotion Agency, Tekes.

Measures call for allocating public **research and innovation** funding to the bioeconomy by encouraging Finnish actors to take part in international research networks, launching a collection of information on biomass resources and ecosystem services, as part of a national system for natural resource accounting and developing statistics systems on the bioeconomy, and developing and funding cooperation platforms (e.g. Strategic Centres for Science, Technology and Innovation or SHOKs, Finland's Innovative Cities Programme or INKA) to bring together actors in various sectors. The Academy of Finland and Tekes provide opportunities for research to work with companies

within these SHOKs. One of these Centres or SHOKs, CLIC innovation Ltd, is an open innovation cluster with the mission of creating solutions in the bioeconomy, circular economy, and energy systems.

Experimental, smart, green, urban regions, aimed at developing, testing and demonstrating new ideas, are also supported and partly delivered through existing cooperation models such as SHOK Centres and INKA programme projects (which focused on 12 cities and five themes, including the bioeconomy and sustainable energy). Measures also call for funding for pilot and demonstration projects of new bioeconomy solutions.

With regard to **infrastructure** development, while not highlighted in the 2014 strategy, Finland has made great progress in implementing the bioeconomy with an impressive number of biorefineries operating commercially (e.g. Metsä Group in Äänekoski) and very active, world-renowned industry players (e.g. Stora Enso, Metsä, Neste, UPM).

Commercialization is fostered in a number of ways. Measures call for increasing equity financing in the bioeconomy by ensuring the availability of risk financing for companies. An open international biorefinery competition, launched in 2014, also sought to accel-

erate commercialization and boost new biorefinery investments in Finland.²²⁶

New developments, not cited in the strategy, include the Bio and Circular Finland program run by Business Finland, which provides a number of services/funding to support the development of competitive bio and circular economy solutions and ecosystems. A central aim is to increase exports of bio and circular economy solutions.²²⁷ In addition, the BioNets program (2016-2018) funded and supported an array of bioeconomy projects, creating new networks and ecosystems and pilot solutions.²²⁸

Demand-side instruments include promoting the standardization and certification of bioeconomy solutions, and developing criteria for sustainable public procurement. Further communication and the promotion of public discussion is also encouraged. For example, an exclusive website on the bioeconomy was launched in 2012 to provide information about recent developments.²²⁹

Beyond increasing awareness of the bioeconomy among young people, measures to support **education and capacity** building seek to update qualifications and retraining, and deepen cooperation between universities and research institutes.

Framework conditions include the promotion of intangible value creation (e.g. brand management, intellectual property rights, and design). In addition, measures call for mapping of the opportunities for nature tourism and other service activities which rely on natural values. Lastly, they encourage the promotion of exports of biobased products and technologies.

With regard to **good governance** measures, the strategy employs a number of tactics. In 2015, a national Bioeconomy Panel was established to facilitate a continuous dialogue between public authorities, research institutions, business and civil society. The Panel's term of office lasted until April 2019 and should be set up again in 2020 with a new mandate to review the strategy. In addition to the panel, the Technical Research Centre of Finland (VTT) set up a Bioeconomy Forum. It acts as the operational arm of the Panel and prepares presentations on R&D and innovation, and implements the Panel's proposals. The forum comprises representatives from associations, clusters, research institutes, and ministries.

Other measures are aimed at evaluating and updated the sustainability of biomass use by generally accepted methods (e.g. the European RES Directive, Timber Regulation, Pan-European criteria and indicators for sustainable forest management, and domestic certification systems). Among the range of indicators proposed to monitor implementation of the bioeconomy strategy, the aim was to measure its environmental benefits as well as its sustainability. In addition, the strategy aimed to develop a range of sustainability indicators for ecosystem services, environmental and resource-efficiency, as well as environmental assets.²³⁰

Other measures included a regulatory survey on "Bioeconomy bottlenecks and boosters," the results of which were published in 2017²³¹ and open access to biomass data with the Biomass Atlas launched in 2017.²³²

8

How is the implementation of the strategy monitored and evaluated?

Implementation is led by national public bodies (coordination is led by the Ministry of Employment and the Economy), but other stakeholders (especially from the fields of business and research) implement specific projects. The Bioeconomy Panel is also consulted on the strategy's implementation. The new national Bioeconomy Panel will be charged with overseeing an update of the strategy in 2021.

According to a 2018 audit, the starting point of the bioeconomy-operating environment was extensively and systematically analyzed in the preparation of the strategy. The audit criticized the lack of foresight methods, and the fact that the indicators could not be used to monitor implementation of the measures or achievement of the strategic goals.²³³

9

Do dedicated regional bioeconomy policy strategies exist?

The region of **North Karelia** has been actively drafting a bioeconomy strategy.²³⁴ In 2017, it released a “Roadmap Towards Oil-Free and Low-Carbon North

Karelia by 2040” with one of the main sections focusing on natural resources and bioeconomy.²³⁵

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France



1

What have been the major developments in bioeconomy policy over the past decade?

As one of Europe's largest agricultural producers and host to one of Europe's biggest biorefineries (La Mède) and leading Bioeconomy Clusters (IAR), France has a long tradition in bioeconomy development and policy support. The term "bioeconomy", however, was not widely used in France prior to the publication of a national bioeconomy strategy in 2017, rather the biobased economy was discussed within the context of the green economy or industrial ecology.

Prior to the national strategy, important areas of bioeconomy policy were addressed in autonomous strategies such as the **National Plan for Climate Change Adaptation (2011)**,²³⁶ the **National Biodiversity Strategy (2011 – 2020)**,²³⁷ **The new face of industry in France (2013)**,²³⁸ the **2013 Strategic Agenda for Research, Technology Transfer and Innovation (France Europe 2020)**,²³⁹ and later the **2015 National Research Strategy (SNR)**²⁴⁰ During this period, two distinct approaches to bioeconomy prevailed: promoting cutting-edge technologies and motivating ecological transformation. In addition, this period was marked by a bottom-up approach in which industry acted as the driving force of the bioeconomy. However, the public sector was active in backing regional "Poles de compétitivité" or competitiveness clusters with an ecological focus, especially those concerned with "Chimie du végétal" or biobased chemistry.

In the interests of policy coherence, a proposal for a comprehensive national strategy on the country's

ecological transition was published in 2014, the "**The National Strategy of Ecological Transition Towards Sustainable Development (SNTEDD)**,"²⁴¹ with the aim of ensuring sustainable development. The driving idea was to achieve ecological transition by means of an industrial transition based on scientific and technological innovations, accompanied by a comprehensive societal transition and commonly practiced sustainable patterns of consumption. The majority of the proposed measures were legislative initiatives, including measures for making agriculture more ecological (Grenelle law), plant management (law on biodiversity or EcoPhyto Plan), a ban on plastic bags (law on the future of agriculture, food and forestry) and raising of green taxes to the average EU level.

First launched in 2012 by the Minister of Agriculture, Agri-Food and Forestry, Stéphane Le Foll, and enshrined into French law in 2014, the **Agroecology Project for France** aims to shift agriculture towards the objective of combining economic, environmental and social performance and expand biomass production using more diversified methods with less environmental impact. New actions were launched as part of a revised action plan and taking stock initiative in 2016.²⁴² Part of the project includes the thematic areas of plant-based proteins and agroforestry (e.g. Vegetable Protein Plan for France 2014 – 2020 and National Forest and Wood Program 2016 – 2026). In this same spirit, France launched the initiative "4 per 1000: Soils for Food Security and Climate" at COP21 to help increase

organic matter content and carbon sequestration in soils using appropriate agricultural practices.

With the second largest maritime area in the world, France has also invested in its maritime economy and in 2017 released a **National Strategy for the Sea and the Coast**. In 2019, the government launched a public consultation on its strategies for the four coastlines and maritime areas of mainland France (North and Normandy, Brittany and Loire, Aquitaine, and Mediterranean) and between 2019 – 2021 will develop action plans and a monitoring system.²⁴³

In March 2017, the Economic, Social and Environmental Council (CESE), a constitutional consultative assembly, presented its proposals for a sustainable bioeconomy in the document “**Vers une bioéconomie durable.**”²⁴⁴ It highlighted environmental and societal challenges of the bioeconomy which, among other measures, would require the adoption of new ways of sustainable production and consumption.

On publishing the dedicated national bioeconomy strategy “**A Bioeconomy Strategy for France**” in 2017 and a corresponding action plan in February of 2018, the

government laid the foundations for a policy for long-term bioeconomy development.²⁴⁵

In recent years the government has continued to publish bioeconomy-related strategies, including a **Roadmap for the circular economy** with 50 proposed measures and the objectives of 30 percent reduction of resource consumption in relation to GDP, halving the amount of non-hazardous waste sent to landfills, and reaching 100% recycled plastic.²⁴⁶ The circular economy is regarded as the third step of the ecological transition, with the first step being a low carbon economy and the second step a biobased economy. The Roadmap promotes “industrial and territorial ecology” in a decentralized manner through regional schemes.

As committed in the dedicated bioeconomy strategy, France adopted **The National Biomass Mobilization Strategy (SNMB)**²⁴⁷ in 2018, which provides a national framework for assessing the current and potential supply and demand for various biomass types (agricultural, forest-based and marine sources). A national biomass resources observatory has also been developed and has become a major source of data for regional authorities that make use of bioresources.

2

How is the dedicated bioeconomy strategy embedded into the wider policy context?

The French bioeconomy strategy is consistent with the other national strategies relating to the production of bioresources, their mobilization, their use, and environmental goals and issues: the plant protein plan, the agroecology project for France, the national low-carbon strategy, the national biomass mobilization strategy and regional biomass schemes, the roadmap for a circular economy, the

national biodiversity strategy, the multiyear energy program, the “4 per 1000” program, the national forest and wood program, the convention on biological diversity, and the national strategy for the sea and coastal areas. The action plan does not cover topics already addressed in those documents (e.g. actions relating to the circular economy such as biowaste recycling).

3

Who is the author of the strategy, and how were stakeholders consulted and engaged in the different phases of the strategy process?

The development of the bioeconomy strategy dates back to an inter-ministerial initiative in 2015. Four ministries were involved in the strategy process, in-

cluding the Ministry of Ecology, Sustainable Development and Energy; the Ministry of National Education and Research; the Ministry of the Economy, Industry

and the Digital Sector; and the Ministry of Agriculture, Agrifood and Forestry.

The strategy development process was further facilitated by various stakeholder workshops at national

and regional level. The strategy document was officially adopted in January 2017. Two months later, a strategic committee on bioeconomy was established to support its implementation.

4 How is “bioeconomy” defined in the main policy strategy?

In the French context, the bioeconomy encompasses “(...) the whole range of activities linked to the production, use, and processing of bioresources.” The strategy further highlights the circular economy component of the bioeconomy. In this respect, the focus is on closing the loop, i.e. by reusing and recycling biobased resources. Acceptance of the circular economy concept predates the bioeconomy strategy. Years before,

cooperation between industrial symbiosis and the bioeconomy was important (e.g. in the construction of the Bazancourt-Pomacle biorefinery complex).

The Action Plan deliberately focuses on the nonfood component of the bioeconomy. It does not address food-related exploitation of biomass, since this is covered by specific policies.

5 What is the main purpose of the dedicated policy strategy, and how does it relate to the SDGs and the Circular Economy? How does it introduce visions, targets, milestones, and action plans?

By developing a dedicated national bioeconomy strategy, the French government primarily seeks to promote sustainable economic growth in France. More specifically, it strives for increased employment, an improved balance of trade, and international competitiveness. The strategy also promotes a self-sufficiency argument by fostering regional and rural development, food sovereignty, and independence from fossil fuel imports. While the strategy defines issues and goals, it does not define targets. The strategy also highlights the French commitment to the Paris climate agreement by stressing the bioeconomy’s potential contribution to mitigating climate change.

The dedicated action plan was published in February 2018 and provides actions for the period from 2018 to 2020. The plan addresses five areas of action, including the improvement of knowledge, raising of public awareness on bioeconomy and biobased products, promotion of the demand and supply side, sustainable production and utilization of biobased resources, as well as new financing mechanisms. The strategy does not set out a concrete budget for implementing the measures proposed.

6 What are the priority areas of the strategy?

The French bioeconomy strategy focuses on innovations in **primary industries** which are intended to contribute to the sustainable and efficient production and utilization of bioresources. This includes, for

example, promoting **sustainable resource management** practices (including precision farming) and adopting innovative crop production systems (e.g. organic farming, agroecology and agroforestry). Re-

claiming uncultivated land and abandoned farmland, in addition to maritime and aquatic areas, also aims to increase the mobilization of biomass resources. In this respect, the strategy **prioritizes the utilization of waste resources** and residues from primary industries, as well as urban and industrial waste, e.g. for energy production. The action plan published in 2018 also highlights the development of **new value chains**, e.g. based on animal by-products.

A special characteristic of the strategy is its emphasis on the bioeconomy's **local dimension** and the conversion of locally produced biomass into high value biobased products, such as food and feed-stuffs, chemicals, biomaterials and bioenergy. At the same time, further **biorefinery development** and the integration of physical, chemical, and biological processes and technologies (including nanotechnology, biotechnology, and ICT) aims to ensure sustainable and efficient conversion of biomass resources. Here, for example, the emphasis is on state-of-the-art

bioenergy obtained from wood and organic waste resources. **Ligno-cellulosic resources** are also considered important for chemical applications in the pharmaceutical and food industries.

Another characteristic of the strategy is the prominent role and **involvement of society**, which is seen as a prerequisite for successful transformation to a bioeconomy. Here, for example, the strategy document identifies changing trends in consumer diets, which require investigation by conducting further research into consumer behavior and preferences.

The strategy also highlights **new and alternative food resources**, e.g. from the sea, which should be identified to ensure the future protein supply. Furthermore, special consideration will be given to sea regions and their huge deposits of biological resources. In this respect, the focus is on identifying overseas bioresources and evaluating their potential for industrial use.

7

What policy instruments are put forth in the strategy (and its action plan)?

The French bioeconomy strategy pursues a comprehensive approach to fostering bioeconomy development.

When promoting **innovation**, the focus is on increasing public and private R&D investment. The French government has been providing funding for bioeconomy-related research and innovation programs since 2010. For example, the “Future Investments” funding program, which focuses on promoting cutting-edge technology, will provide, over a period of ten years, EUR 1.5 billion for infrastructure, research, and training in the area of biotechnology, agricultural science, bioinformatics, and nanobiotechnology.²⁴⁸ In 2020, INRA and IRSTEA merged to form INRAE, France's new National Research Institute for Agriculture, Food and Environment, with a new bioeconomy thematic research area. This focuses on exploiting biomass as a source of renewable carbon to produce biomaterials, biofuels and bioenergy, and waste recycling (e.g., wastewater, solid waste from agriculture or the agrifood industry) through a circular bioeconomy

approach.²⁴⁹ In 2015, the European Center for Biotechnology and Bioeconomy (CEBB) was established to promote multi-disciplinary research for the sustainable production of biological resources, to foster biorefinery development and the agrifood industry. As the CEBB is situated near the Bazancourt-Pomacle biorefinery plant, it directly links academic research and its transfer into economic production.²⁵⁰

Beyond this, public R&D will concentrate on better understanding photosynthesis, metabolism, and environmental interactions. Advances in genetics are considered promising for increasing the overall efficiency of production systems and for facilitating their adaptation to climate change. Innovation partnerships between stakeholders in the primary sector and the chemical industry should also be encouraged.

Developing and supporting clusters is also highlighted, with the aim of creating synergies between the agrifood and industrial sectors. In France, research and industry collaborations have been organized on a regional basis

since 2005, within the framework “pôles de compétitivité”. Pôle IAR – le pôle de la bioéconomie is the leading French bioeconomy cluster, AXELERA is the cluster for chemistry-environment in the Auvergne-Rhône-Alpes region of France, and Mer Bretagne Atlantique and Méditerranée focus on the maritime sector.

Support for **infrastructure** development concentrates in particular on the funding of shared R&D facilities and on biorefinery development. After Finland, France has some of the strongest biorefineries in Europe. France has a strong industrial biobased sector with several large chemical and fuel companies active in the bioeconomy (e.g. France is the EU’s largest producer of bioethanol and has several large agro-industrial companies).

Measures related to promoting **commercialization** concentrate in particular on bringing biobased products to the market. The emphasis is therefore on increased marketing efforts, e.g. by showcasing biobased products from around the world on the www.agrobiobase.com website. This website provides information on product origin and the product’s environmental benefits. At the same time, it provides a B2B platform for developing the market for biobased products. Other tools for promoting commercialization are mentioned, e.g. demonstration platforms, living labs, and feasibility studies. The action plan of 2018 also highlights the need to facilitate access to capital for biobased companies and to raise awareness of potential investors, such as banks, business angels, pension funds, investment funds, etc. The Biobased-Industries Consortium (BBI) should be increasingly considered for financing public-private bioeconomy projects.

The government considers it extremely important to educate and train the workforce for the future bioeconomy. The focus here is on inter-disciplinary **education and capacity building**, including technical and vocational training, as well as life-long learning opportunities. Establishing the European Center for Biotechnology and Bioeconomy has leveraged the scientific and technical expertise of AgroParisTech, CentraleSupélec, the NEOMA Business School and the University of Reims Champagne-Ardenne. In this respect, it has also increased the support for bioeconomic-relevant chairs and academic programs (e.g. in the area of biotechnology, biomaterials, and green chemistry). The strategy document also stresses the need to strengthen the demand side of the bioeconomy, i.e. by raising awareness of biobased

products through standards, certifications, and labels (e.g. a dedicated label for biobased products). The strategy draws attention to the review of the French law on public procurement, which will also take biobased characteristics into account. In addition, favorable taxation, subsidies and price setting measures (e.g. by means of a regulated purchase price for the electricity produced using by biogas and biomethane) will incentivize the use of biofuels. The action plan of 2018 addresses the demand side by proposing several measures. For example, it foresees the establishment of a bioeconomy website which provides information, i.e. on R&D projects and success stories for the general public and bioeconomy professionals. It also mentions the development of an exhibition concept which will showcase the bioeconomy in everyday life, and the setting up of a bioeconomy award which honors successful projects and companies. As a flagship project, the action plan highlights the building of a biobased Olympic village for the Olympic Games in 2024, which could showcase biobased materials in construction, e.g. wood, hemp, flax fiber, etc.

Promoting policy coherence at regional, national and EU level is considered critical for bioeconomy development. With a view to **good governance**, the strategy plans to nominate a national bioeconomy council which would be composed of stakeholders from industry, NGOs, academics, and research institutes, as well as local, regional, and national decision-makers. The policy document also highlights the need to encourage multi-stakeholder dialogues (especially at local level) to promote outreach and participation. It also prioritizes monitoring biomass resources, e.g. by strengthening the national resource observatory (ONRB).

The strategy also emphasizes international collaboration in the bioeconomy. France intends to actively engage in bioeconomy-related discourse conducted on international policy and research fora, e.g. within the European Union, the Organization for Economic Cooperation and Development (OECD), the International Energy Agency, the United Nations Environment Program, and the UN Food and Agriculture Organization.

In order to create **bioeconomy-friendly framework conditions**, the strategy proposes regulations fostering the use of biofuels and biobased, compostable plastic bags but also regulations supporting the use of biobased innovation in the construction sector (e.g. using hemp materials in construction).

8

How is the implementation of the strategy monitored and evaluated?

No monitoring framework is mentioned.

9

Do dedicated regional bioeconomy policy strategies exist?

In August 2018, at the Châlons-en-Champagne fair, the regions of Ile-de-France, Hauts-de-France and Grand Est signed a Biopact, aimed at strengthening cooperation and pooling of their regions' resources in order to pursue a territorial strategy for the bioeconomy and agro-resources. This three-year action plan aims to give these territories visibility at national and international level, and also intends to boost cross-border cooperation to bring European projects to the fore.

In September 2018, the Hauts-de-France region in northern France adopted a regional Bioeconomy Masterplan.²⁵¹ The region has a strong higher-education and research infrastructure, many competitive clusters (e.g. IAR), and an innovative agriculture, food and chemistry industry. The roadmap perceives the bioeconomy in line with the "Third Industrial Revolution" by seeking to encourage renewable energies, energy efficiency, and a circular economy. This strategic plan

presents four major ambitions and 40 actions: 1) becoming a European leader in proteins (vegetable proteins, insects, micro algae, and dairy proteins), 2) establishing a sustainable biobased materials sector (e.g. transport and construction), 3) achieving 25% biogas in renewable energy produced by 2025, and 4) promoting bioproduction (e.g. through biotechnology and biobased chemistry).

In October 2019, the Region Grand Est adopted its Regional Plan for the Bioeconomy: a strategy serving the growth and competitiveness of businesses in the region.²⁵² The Bioeconomy Strategy is based on five priorities: 1) establishing energy strategies at the local level, 2) developing territorial biorefineries, 3) deploying sustainable agriculture to produce better and more, 4) biomaterials to build and renovate buildings, 5) food with biobased ingredients, sustainable packaging, and increased traceability.

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Germany



1

What have been the major developments in bioeconomy policy over the past decade?

With a dedicated **National Research Strategy Bio-Economy**²⁵³ published in 2010 and a dedicated **National Policy Strategy on Bioeconomy**²⁵⁴ published three years later, Germany established itself as one of the world leaders in bioeconomy policy. In 2009, an independent expert committee (the German Bioeconomy Council) was set up to advise the Federal German Government on bioeconomy policy questions and to promote stakeholder dialogue. While the National Research Strategy BioEconomy was the first dedicated policy strategy envisioning a natural cycle-oriented, biobased economy, the National Policy Strategy on Bioeconomy defined the goals and measures to support the structural transition and adapt framework conditions. It set priorities for a coherent and sustainable bioeconomy policy in Germany, linking industrial and energy policy, agricultural, forestry and fisheries policy, climate and environmental policy, as well as research and development policy.

In the **coalition agreement**²⁵⁵ adopted in 2014, the German Government demonstrated its commitment to promoting bioeconomy development with the aim of driving a transition from an economy based primarily on fossil fuels to a resource-efficient economy based on renewable resources, thus supporting the energy transition (Energiewende).

The **Sustainable Development Strategy for Germany** of 2016 highlighted the bioeconomy's contribution

to the SDGs on growth, industrial innovation, sustainable production, and consumption (SDGs 8, 9, 12, 15).²⁵⁶ In order to implement the National Sustainable Development Strategy and the High-Tech Strategy (2014), the Federal Ministry of Education and Research (BMBF) set up the third **framework research program on sustainable development (FONA)**. It recognized the bioeconomy as a pillar of the green economy, combining technology, economy, and ecology on a systemic, sustainable basis. For example, the program addressed new industrial value chains within its research priorities.²⁵⁷

In 2017, the bioeconomy was mentioned as one of six new future topics in the **High-Tech Forum's recommendations** on German innovation policy. In addition to digitalization, the biologization of economic processes was named as a key driver for social change.²⁵⁸

The **Coalition Agreement of 2018**²⁵⁹ reaffirmed that the bioeconomy could help drive the transition to a renewable resource-based economy. It further highlighted an interdepartmental agenda "From biology to innovation," led by the Federal Ministry of Education and Research and the Federal Ministry for Economic Affairs and Energy, which was developed together with industry, science and civil society with the aim of integrating biological knowledge, biotechnological and bioinspired processes even more robustly into the areas of life and business.²⁶⁰

The new **High-Tech Strategy 2025**,²⁶¹ published in 2018, additionally looked to expand the industrial, structural change towards a sustainable, biobased economy that had been initiated by making the entire range of biobased processes available for industrial use. Moreover, the strategy recognized the modern life sciences and the interplay of biotechnology, nanotechnology, and digital technologies. A newly established **Dialogue Platform on Industrial Bioeconomy** also helped initiate dialogue between industry and social actors at an early stage. The **Evaluation Report of the High-Tech Strategy**,²⁶² published in September 2019, emphasized that in future the bioeconomy should be driven forward within the framework of one overall strategy and not be divided into a research and a political strategy.

The **final report of the Coal Commission**²⁶³ in 2019, which was aimed at transitioning coal-mining areas and driving the energy transition forward, mentioned the necessity of promoting special bioeconomy/resource efficiency research priorities in the Lusatian mining district, as well as the work of the Lusatian Bioeconomy and Resource Efficiency Cluster (LCBR). It also sought to transform the Rhenish mining area into a model region for closed cycles and recycling management.

Efforts to implement a sustainable bioeconomy were intensified in 2019 by pooling previously taken measures and policies and merging them into a new strategy. In January 2020, the **new German Bioeconomy Strategy**²⁶⁴ was published. It harmonizes the various subgoals of the previous policy documents and links the corresponding measures more closely with one another. While considering new knowledge and current bioeconomy developments, the strategy focuses on expanding a biobased economy in Germany and setting new priorities.

On assuming the EU Council Presidency, the German Government published the **Programme of Germany's Presidency of the Council of the European Union in the Fields of Education, Research and Innovation**²⁶⁵ in July 2020. The bioeconomy was named as a key area of action and as an essential building block to creating a sustainable, climate-neutral Europe in line with the current European Green Deal. It further highlighted the **Science Year 2020|21 on the Bioeconomy** and the third **Global Bioeconomy Summit (GBS2020)** in November 2020 as important elements that would help to further the expansion of a sustainable bioeconomy in Germany, Europe and worldwide.

2

How is the dedicated bioeconomy strategy embedded into the wider policy context?

The new bioeconomy strategy was adopted by the Federal Cabinet in January 2020 and was presented jointly by Anja Karliczek, the Minister for Education and Research, and Julia Klöckner, the Minister for Food and Agriculture.

The strategy is in line with the **German Sustainable Development Strategy** and the High-Tech Strategy

2025. The German Government aims to contribute to its sustainability policy by strengthening the German biobased economy. The German bioeconomy strategy also includes the objectives and priorities of the revised EU Bioeconomy Strategy, published in 2018, which puts a stronger emphasis on sustainability and resilience.

3

Who is the author of the strategy, and how were stakeholders consulted and engaged in the different phases of the strategy process?

The new strategy is the result of a comprehensive agenda process that incorporated various conferences, stakeholder workshops and consultations with representatives from business, research, politics and civil society; recommendations of the German Bioeconomy Council (2016)²⁶⁶; an evaluation report of the National Research Strategy BioEconomy (2010)²⁶⁷, and an agenda seminar in 2018. In addition, the strategy is based on a comprehensive progress report of the National Policy Strategy on Bioeconomy (2013)²⁶⁸.

The draft strategy was shared with various stakeholders for comments. The strategy was then revised and finalized by the German Government. The Federal Ministry of Education and Research and the Federal Ministry of Food and Agriculture were and will be in charge of developing and implementing the new bioeconomy strategy. An Inter-ministerial Working Group (IMAG) will supervise the implementation process.

4

How is “bioeconomy” defined in the main policy strategy?

Compared to the 2010 and 2013 strategies, the bioeconomy strategy of 2020 refers to a more comprehensive and advanced understanding of the bioeconomy. The bioeconomy is recognized as a cross-sectoral concept and a core element of a sustainable economy. It is defined as “(...) the production, exploitation and use of biological resources, processes and systems to provide products, processes and services in all economic sectors within the frame of a sustainable economic system.”

According to the strategy document, a product, process or service is considered part of the bioeconomy depending on the type of biological resource (anything from raw agriculture, forestry and marine (esp.

fisheries and aquaculture) materials and microbial production to biogenic residues and waste materials). However, the definition refers not only to biological resources, but also to biological principles and processes which should be considered as part of the bioeconomy to an even greater extent in the future.

The strategy provides a holistic view of sustainable solutions for production and consumption by considering systemic relationships, e.g. the interactions between biological systems and their environment. The strategy highlights the importance of connecting different perspectives and considering interactions on all levels, ranging from organisms and ecosystems to the planetary climate balance.

5

What is the main purpose of the dedicated policy strategy, and how does it relate to the SDGs and the Circular Economy? How does it introduce visions, targets, milestones, and action plans?

By envisioning a sustainable biobased economy based on natural material cycles, the new bioeconomy strategy pursues six key goals: 1) develop bioeconomy solutions for the sustainability agenda; 2) identify and tap the potential of the bioeconomy within ecological limits; 3) expand and apply biological knowledge; 4) sustainably align the resource base of the economy

and replace fossil raw materials; 5) position Germany as the leading innovation location for the bioeconomy, and 6) integrate society and intensify national and international cooperation.

With its new bioeconomy strategy, the German Government is committed to promoting sustainable de-

velopment. The bioeconomy is seen as contributing to the Agenda 2030 for Sustainable Development of the United Nations as it addresses several aspects and subspects of its related UN sustainable development goals.

The strategy document emphasizes that the bioeconomy is particularly suited as a model for sustainably developing rural areas and structurally weak regions, provided that the processing of biogenic raw materials is carried out directly at the site of extraction or in its immediate vicinity, so that positive effects of value and job creation emerge in rural areas.

Two new, overarching guidelines are forward-looking and serve as a foundation for all measures to be implemented: 1) harnessing biological knowledge and responsible innovation for sustainable, climate-neutral development, and 2) using biogenic raw materials for a sustainable, circular economy. While the first guideline points to the importance of a sustainable resource base and to the innovation potential of biological knowledge and new technologies, the second links bioeconomy directly to the circular economy by focusing on expanding traditional value chains and on linking value chains to create new and efficient value creation networks, following the guiding principle of cascade and cycle use.

The strategy highlights that securing global food supplies should always take priority, and consideration must be given to ethical principles and socially recognized goals such as environmental protection, landscape conservation, and animal welfare. In this respect, the German Government acknowledges that not all sustainability goals can be achieved simultaneously, and that it is necessary to weigh opportunities, challenges, and trade-offs. Promoting systemic thinking and holistic approaches should help to create synergies, identify such conflicts, and reduce them based on scientific knowledge.

So far, the strategy paper has not been accompanied by an implementation concept or a dedicated action plan with concrete measures and milestones. The task of drawing up a roadmap of practical implementation will be assigned to a new, independent advisory body which will involve all relevant stakeholder groups.

The German Government announced at the strategy's release that it will provide a budget of EUR 3.6 billion for the strategy's implementation from 2020 to 2024. EUR 1.1 billion of this budget will go to the Federal Ministry of Education and Research for bioeconomy-related research, including institutional funding²⁶⁹. For comparison, the National Research Strategy Bio-Economy (2010) awarded EUR 2.4 billion for the period between 2010 and 2016.

6

What are the priority areas of the strategy?

The previous German policy document on bioeconomy highlighted the following priority areas: 1) global food security and defusing the competition among land use; 2) sustainable production and provision of bioresources (with special focus on agriculture production); 3) healthy and safe foods; 4) industrial application of renewable resources; 5) growth markets, innovative technologies and products; 6) processes and value-adding networks, and 7) development of biobased energy.

While the new bioeconomy strategy incorporates these target areas, the importance of **digitalization and converging technologies** is emphasized more strongly than before (e.g. by anchoring them in research funding and

naming this as a field of action). The strategy emphasizes that the combination of biology with technological advances through digitalization and new process technologies (e.g. based on nanotechnology, miniaturization, automation, and artificial intelligence) can result in new, sustainable innovations in production. In this respect, the strategy highlights the need to promote **systems biology** approaches and the merging of data obtained in the omics.

Metabolic engineering and synthetic biology also receive increased attention. The strategy recognizes that biotechnological research and new research approaches to artificial production systems will provide opportunities to develop new materials and products

with tailor-made properties (e.g. fully recyclable biopolymers, novel biopharmaceuticals or environmentally friendly chemicals). In addition, the strategy highlights that the development of **novel biotechnological processes** is essential and that new concepts for coupling and cascade use and optimized **biorefinery concepts** should be addressed holistically.

The strategy places additional focus on **waste streams** (e.g. organic waste, municipal or industrial wastewater, or industrial waste gases such as carbon dioxide or synthesis gas). Furthermore, the strategy highlights the need for innovative methods and processes for **efficient processing and recycling** of important resources such as rare metals or phosphorus.

In the agriculture and forestry sector, the strategy highlights the need to develop holistic **agroecological systems** with the help of key technologies and concepts that bring together existing agricultural techniques and ecological requirements in novel ways (i.e. from **smart and organic farming** approaches to (modular) **high-tech production systems, and largely closed circulation systems** such as vertical farming).

The strategy further states that it will be crucial to provide socially desirable **bioservices** such as resource and environmentally-friendly solutions that address increased sustainable consumption.

7

What policy instruments are put forth in the strategy (and its action plan)?

The strategy emphasizes the important role of research, suitable economic and legal framework conditions, dialogue with social groups and their participation, and international cooperation. The strategy, however, focuses mainly on merging the existing catalogues of measures from the policy documents of 2010 and 2013. These support measures and funding programs are publicly available.²⁷⁰ There is no dedicated action plan yet, but a new advisory body will be commissioned to develop recommendations for specific political measures to implement the National Bioeconomy Strategy.

With regard to **research and innovation**, the new policy strategy recognizes R&D as an important driver for bioeconomy development. Focus is placed on funding interdisciplinary, transdisciplinary and systemic research approaches beyond the subareas of the life sciences. Besides promoting natural and technical sciences, support should also be given to social sciences and ethical issues. The involvement of society and other research activities aimed at shaping social change are also considered in research funding and as an overarching instrument.

The strategy highlights the need to enable networking of the stakeholders (e.g. clusters) and cross-disciplinary cooperation, i.e. by developing virtual

interdisciplinary centers, and new multidisciplinary and cross-sectoral funding concepts for converging areas of knowledge and technologies.

The strategy highlights that breakthrough innovations require the provision of opportunities for science to pursue unfamiliar paths, i.e. by supporting open research without giving preference to certain methods and technologies.

It also emphasizes that research must be intensified, covering basic to application-oriented approaches, pilot plants and demonstrators and also experimental developments. With regard to startup support, the strategy mentions the Central Innovation Program for SMEs (ZIM) and that “measures to promote SMEs and startups are currently being further developed.”

The strategy promotes all kinds of technical, social, and systemic innovations. The focus, however, is on safe innovations, particularly the harmonization of digital data, efficient data management systems, further development of interface concepts, and the development and use of standards.

Monitoring approaches should also be promoted as an overarching instrument. The new strategy rec-

ognizes that to successfully design a sustainable bioeconomy, it is important to measure and assess the exact economic, ecological and social effects of biobased management. However, the focus appears to remain on understanding biomass flows and cycles by further assessing the availability of and demand for biomass.

With regard to international research cooperation, the German Government intends to continue to improve the conditions for international learning and research, to establish transnational research networks, and promote bilateral research cooperation with selected countries. Research cooperation in Europe should also be further strengthened by intensive exchange with EU countries in appropriate working groups – including the Standing Committee on Agricultural Research (SCAR) and the States Representative Group of the Biobased Industries Joint Undertaking (BBI JU).

The strategy focuses on **infrastructures** for bioeconomy research and technology transfer. However, it remains open which measures will be taken, and what kind of spaces should be created to enable the targeted development of scientific knowledge into marketable and competitive applications.

At the state level, however, interesting infrastructure investments have recently been made. In January 2020, for example, the Finnish Group UPM, one of the world's leading producers of paper, pulp and wood products, announced its investment in an industrial scale biorefinery at the Leuna Chemical Park to convert solid wood into next generation biochemicals. The company will invest EUR 550 million in construction of the plant which is expected to start up by the end of 2022. In addition, the federal state of Saxony-Anhalt announced that InfraLeuna GmbH will also invest around EUR 100 million in the chemical park's infrastructure.²⁷²⁽²⁷⁰⁾

In light of **commercialization** efforts, instruments for market introduction and the establishment of biobased products and processes refer only to dialogue formats and consumer awareness. It remains open to what extent these actions will steer consumer and investment behavior towards sustainable, biobased offers.

Reference is made to science communication and open dialogue formats with broad social participation as a form of **demand-side policies**. As an example, in 2018 the Federal Ministry for Economic Affairs and Energy initiated a dialogue platform called "Industrial Bioeconomy" with representatives from industry, associations, science, and society with the aim of identifying obstacles to converting the economy into a sustainable biobased economy and of developing joint solutions to the problems. Publicly funded citizen science projects will also be promoted in cooperation with educational institutions such as museums or botanical gardens.

The strategy further refers to the development of indicators for possible certification systems that clarify the additional benefits and sustainability of biobased products.

Initial and continuing vocational **education** and training and the promotion of young talent are described as overarching instruments in the strategy. The strategy recognizes the need for bioeconomy specialists with interdisciplinary expertise at the interfaces of sustainability, production processes, markets, and consumption. In this respect, it promotes knowledge and interdisciplinary networking in science, project funding, new training, and further education programs as well as courses at vocational and technical schools, technical colleges, and universities. It is also considered important to integrate converging technologies into bioeconomic education programs and to impart basic business knowledge. Special prizes and funding modules should create incentives for bioeconomic career planning in science or industry as part of research funding.

With regard to **framework conditions**, the strategy leaves open, for example, how German capital markets can be activated to help companies in the bioeconomy establish biobased innovations, and how regulatory policies will be shaped for a social and ecological market economy.

Good governance measures refer to policy coherence and the paper sets out important objectives. Their implementation, however, remains vague. The Inter-ministerial Working Group (IMAG) and a new advisory body should ensure that policy decisions are coherent across administrative levels. The strat-

egy further proposes a federal states working group and the establishment of an informal round table on national bioeconomy policy at EU level.

International cooperation is seen as an essential tool for achieving the overarching goals. To promote opportunities for exchange and best practices, the German Government will intensify cooperation within Germany, the European Union, and with international partners. It is recognized that the Global Bioeconomy Summit has established itself as a relevant platform for exchange with international experts, even beyond

research. Initiated by the German Bioeconomy Council in 2015 and funded by the German Government, the high-level summit has developed into an institution that provides important stimuli for the further development and coordination of various bioeconomy approaches. The strategy paper also suggests that the bioeconomy should receive greater attention in future international processes (e.g. G20, G7, and annual COP conferences) and that measures and strategies should be harmonized internationally, i.e. through intensified cooperation with the United Nations' Food and Agriculture Organization (FAO).

8

How is the implementation of the strategy monitored and evaluated?

Due to dynamic developments in the bioeconomy, the strategy document states that in the coming years the strategy itself and all resulting measures that the German Government undertakes will be reviewed for effectiveness and be updated as necessary.

As a further development of the German Bioeconomy Council (in office from 2009–2012 and 2012–2019), a new body will be established to advise the German Government. Members of the advisory board should represent a wide range of perspectives on

the bioeconomy. The board should include different disciplines of science and industry, as well as representatives of civil society organizations. The new advisory body will be tasked with developing recommendations and statements on bioeconomy developments, and on the promotion of public debates on the bioeconomy. It will also be commissioned to develop recommendations for specific political measures for implementation of the National Bioeconomy Strategy and will be expected to update them during the term of the strategy.

9

Do dedicated regional bioeconomy policy strategies exist?

Numerous Federal German states promote the development of the bioeconomy with their programs and initiatives.²⁷¹

Baden-Wuerttemberg, for example, was one of the first German states to have its own bioeconomy research strategy and a state research program entitled "Bioeconomy Baden-Wuerttemberg" in 2013. In June 2019, the Baden-Wuerttemberg government adopted an interdepartmental regional policy strategy, "**Sustainable Bioeconomy Baden-Wuerttemberg**". The regional strategy, which sets out a framework for a sustainable, cycle-oriented bioeconomy in Baden-Wuerttemberg, also describes suitable fields of action

and 37 measures. In addition, it intends to establish a regional bioeconomy council to supervise the strategy's implementation. The Baden-Wuerttemberg government will provide a total of EUR 50 million from 2020 to 2024 for implementation of the planned measures. The state strategy pursues four overarching goals: 1) using innovative biological concepts to tap renewable or recyclable sources of raw materials; 2) reducing greenhouse gas emissions, conserving natural resources and strengthening biodiversity; 3) making Baden-Wuerttemberg an exemplary federal state for the transformation towards a sustainable and cycle-oriented economy, and 4) strengthening rural areas in Baden-Wuerttemberg.

Bavaria was the first German federal state to convene a bioeconomy council in 2015 for the “Bioeconomy for Bavaria” initiative on behalf of the State Ministry of Food, Agriculture and Forestry. In March 2020, Hubert Aiwanger, the Bavarian Minister of Economic Affairs, gave the starting signal for a Bavaria-wide bioeconomy strategy under the motto “Future.Bioeconomy.Bavaria.”²⁷² The strategy is expected to be published in November 2020.

Under the leadership of the Ministry of Innovation, Science and Research, the government of **North**

Rhine-Westphalia published key points for a bioeconomy strategy for the state in 2013. North Rhine-Westphalia is the first region in Europe to extend the concept of the bioeconomy to include the health sector, in accordance with the definition of the Organization for Economic Cooperation and Development (OECD). Particular federal state-specific priorities are seen in North Rhine-Westphalia’s strong life science sector. A dedicated regional bioeconomy strategy for the state is currently under development and is expected to be published by the end of 2020.

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Ireland



1

What have been the major developments in bioeconomy policy over the past decade?

In 2008, the national advisory body for agriculture and food, Teagasc, published the foresight report “Towards 2030 – Teagasc’s role in Transforming Ireland’s Agri-Food Sector and the Wider Bioeconomy.” This report identified the research, innovation and support priorities for the next quarter century that would help evolve the economy into a new knowledge-based bioeconomy.

Until 2012, the bioeconomy was predominantly treated within the wider context of the green and blue economy. In the comprehensive policy statement, “**Delivering our Green Potential**” (2012)²⁷³, the government committed itself to developing a bioeconomy strategy as part of a broader green economy strategy. With the strategy paper “**Harnessing our Ocean Wealth**” (2012)²⁷⁴, the government formulated an integrated marine roadmap for developing the Irish blue economy.

In 2015 the government demonstrated further ambitions for promoting an Irish bioeconomy by funding the two-year Bio-Éire project, “A Bio Economy for Ireland - An Evaluation of Development Opportunities, Policies and Initiatives Shaping Ireland’s Transformation

to a Sustainable Low Carbon Bioeconomy”, as part of the national **Agri-Food Strategy Food Wise 2025** (2015)²⁷⁵.

Findings from the Bio-Éire project would then lay the foundation for the development of Ireland’s first national bioeconomy strategy, the **National Policy Statement on the Bioeconomy**²⁷⁶, published in 2018.

The strategy outlines the Government’s vision to be a global leader in the bioeconomy, especially in light of the potential economic consequences of Brexit, and to integrate sustainable economic development into the economic model in order to transition to a low carbon and circular economy. In 2019, the government published the **Bioeconomy Implementation Group’s First Progress Report**²⁷⁷ highlighting the progress made since the publication of Ireland’s National Policy Statement.

While only about ten percent of Ireland is covered by forest, the Council for Forest Research and Development (COFORD) in its 2017 report on **Growing the Irish Forest Bioeconomy**²⁷⁸ envisioned forestry as leading the drive towards land-use carbon neutrality in Ireland.

2 How is the dedicated bioeconomy strategy embedded into the wider policy context?

The National Policy Statement on the Bioeconomy, approved by the Irish Government in December 2017 and published in February 2018, delivers on commitments set out in the National Development Plan – Innovation 2020 (2015), the Action Plan for Jobs (2017), the Action Plan for Rural Development (2017), and the National Climate Mitigation Plan (2017).

Specifically, the overarching Project Ireland 2040 National Planning Framework (2019) recognizes the

transition to a circular economy and bioeconomy as essential, especially in rural areas. As a central initiative of this framework, the Regional Enterprise Development Fund (REDF) also provides significant funding for many bioeconomy-related activities.

The first Progress Report (2019) also aligns each of its recommendations and action plan for the next phase of the bioeconomy implementation with these wider government policies.

3 Who is the author of the strategy, and how were stakeholders consulted and engaged in the different phases of the strategy process?

The National Policy Statement was prepared by the Department of the Taoiseach, the Prime Minister's Office. Prior to its publication in 2018, an Interdepartmental Group on the Bioeconomy was established in November 2016, chaired by the Department of the Taoiseach, and representing seven other government departments asked specifically to produce this high-level national policy statement on the bioeconomy.

After the establishment of the Interdepartmental Group on the Bioeconomy in 2016, an initial scoping exercise was conducted with Departments and reporting agencies. In 2017, the Department of the Taoiseach, in conjunction with Teagasc, held a consultative workshop to bring together key stakeholders and external experts, which led to the publication of a discussion document for public consultation. Submissions from interested parties during the public consultation were then incorporated into the preparation of the national policy statement.

4 How is “bioeconomy” defined in the main policy strategy?

In the Policy Statement, the bioeconomy “extends across sectors - from farming and the agri-food businesses, marine and maritime industries, forestry, novel protein production, water and waste management, energy suppliers, and biopharmaceutical products.” The Policy Statement considers “using these renewable resources and their associated waste streams for conversion into value-added

products [as] at the heart of what is known as the bioeconomy.” The First Progress Report also refers to the 2018 updated EU Bioeconomy Strategy definition, which covers all sectors and systems that rely on biological resources (animals, plants, microorganisms and derived biomass, including organic waste), their functions and principles.

5

What is the main purpose of the dedicated policy strategy, and how does it relate to the SDGs and the Circular Economy? How does it introduce visions, targets, milestones, and action plans?

The National Policy Statement positions itself as a response to climate change that goes beyond target compliance and carbon mitigation and instead integrates sustainable development into the Irish economic model. In addition, it focuses on increasing the commercial potential of the bioeconomy as well as protecting the agri-food and maritime sectors cope with the uncertainties of Brexit.

The Statement emphasizes that the bioeconomy should promote circularity through the promotion of innovations that reuse and recycle materials and maximize resource efficiency. It especially places value on the use of waste streams for conversion into value-added products. While not directly mentioning the SDGs, the Statement recognizes the bioeconomy as crucial for sustainability.

The Statement sets out a policy framework to underpin the development of the bioeconomy, with four guiding principles, and four strategic objectives. The four guiding principles include, 1) sustainability principle (e.g. the necessity of both environmental and social feasibility assessments, a holistic viewpoint of biomass, and avoiding the degradation of resilience or biodiversity in the ecosystem), 2) cascading principle

(e.g. higher value applications are preferentially derived from biological resources prior to their use in energy and fuel generation), 3) precautionary principle (e.g. use of risk management approach), and 4) Food First principle (e.g. priority given to food and nutrition security). The four strategic policy objectives include, 1) sustainable economy and society, 2) decarbonization of the economy, 3) jobs and competitiveness, and 4) regional prosperity. While a central objective is to move toward a decarbonized economy by 2050, the government recognizes that the bioeconomy also provides an impetus for rural development and employment.

An Action Plan with seven key actions is provided together with a Progress Report, which reviews the actions taken since 2018 and develops further actions for 2019 and 2020 with identified leads, co-leads and key consultative stakeholders. The seven key actions include 1) sectoral coherence, 2) establishing a network of commercial entities and public bodies working on the bioeconomy, 3) promoting collaboration between academia and industry, 4) reassessing the definition of waste, 5) supporting the commercial viability of value chains identified by the Bio-Eire project, 7) examining how public awareness can be built up.

6

What are the priority areas of the strategy?

The strategy considers **food, forestry and marine** as core sectors of the Irish bioeconomy, with significant action devoted to helping primary producers in agri-food and marine become part of bioeconomy value chains. Current enterprise activity in the bioeconomy is being driven mainly by the potential of Ireland's natural resources (i.e. one of the largest seabed territories in Europe, the only country in Europe with over 50% of grasslands, and a large agri-food sector).

While **biorefining** is still in a nascent stage in Ireland, the biomaterials and biochemicals component of the bioeconomy is seen as the area with the greatest potential for high value products and export (e.g. the

industrial-scale biorefinery AgriChemWhey project led by Glanbia working with by-products from the dairy processing industry, the pilot-scale marine biorefinery from BioMarine Ingredients that takes non-food chain pelagic species and converts raw material into cost competitive, proteins, oil and calcium, the Biorefinery Glas project multi-product small-scale biorefinery, which optimizes the use of grass). Significant emphasis is placed on **waste management** and the valorization of marine discard and agricultural waste. The role of **cities/regional towns** in becoming circular bioeconomy hubs including the possible use of municipal solid biowaste and wastewater for recovery of bioresources is being explored.

Other relevant sectors include **bioenergy** and **biofuels** through the use of sustainable and reliable biomass, and a growing bio-pharmaceutical sector. Here we see movement in the **bio-based nutraceuticals** and functional food markets where the government is actively supporting the company, Nuritas, via Enterprise Ire-

land and other opportunities being offered by the EU. With 80 percent of the agri-food sector based in rural Ireland, there is a strong emphasis on **rural** job development. Engagement and mobilization of regional actors, including the Regional Assemblies is fostered in order to identify potential growth in regions.

7

What policy instruments are put forth in the strategy (and its action plan)?

The Policy Statement and corresponding first Progress Report pursue a holistic approach to supporting bioeconomy development. The following measures are funded through different national policies and European funding mechanisms.

Research and innovation are promoted through increased funding for R&D at the national and EU level as well as through engagement with private investors. These efforts are marked by significant industrial engagement and collaboration. The National Policy Statement seeks to maintain on-going contact and to further support, engage, and leverage the activities of bioeconomy related innovation clusters and research centers.

In recent years, Ireland has created and funded several research centers focused on the bioeconomy. Over EUR 17 million investment was made by one of Ireland's national research funders, Science Foundation Ireland (SFI) to develop the BioOrbic Bioeconomy SFI Research Centre, formally known as BEACON. BioOrbic performs fundamental and applied research through collaboration with five research institutions and industry partners. BioOrbic sits at the National Bioeconomy Campus in Lisheen, Tipperary County.

The very first bioeconomy innovation cluster, the Irish Bioeconomy Foundation (IBF), was established in 2017 at the National Bioeconomy Campus in Lisheen. IBF was awarded EUR 5 million from Enterprise Ireland (EI) in 2017 to develop a piloting biorefinery facility at Lisheen. Other innovation clusters include the Marine Innovation Park, Páirc na Mara in Connemara and the BioConnect Innovation Centre in Co. Monaghan (IBio-IC). IBioIC is led by six industries and seven academic partners and with the help of a EUR 5 million Enter-

prise investment works with agri-food producers in the region to grow and develop new bio-based products.

The largest-ever support for agri-business in Ireland was funded through a EUR 118 million EIB investment to enable technology company Devenish to develop a Global Innovation Centre in Dowth, County Meath. The center's hosts the 'One Health – from Soil to Society' research, development and innovation program and funds innovation-related capital projects and research into optimized circular biobased products including projects on animal nutrition, food innovation, health and sustainability.

With regard to small-scale biorefineries, the Department of Agriculture, Food and Marine (DAFM) co-funded the biorefinery Glas in Cork, which is one of the first bioeconomy initiatives in Europe that looks at moving farmers further up the bioeconomy value-chain. The project will demonstrate an integrated and mobile multi product small-scale biorefinery which will help farmers become bio-processors.

DAFM has also funded a number of collaborative, academic-led bioeconomy-related research projects, including the previously mentioned Bio-Éire research project, led by Teagasc, which focuses on identifying interlinking cross-sectoral value chains in the bioeconomy. Fifteen out of the eighteen BioÉire value chains have had scientific and technological development undertaken in Irish or EU funded research and innovation activities involving Irish participants. In addition, other value chains not identified by the BioÉire participants have also been advanced including projects at demonstration and pre-commercial large-scale level. Other notable research projects co-funded by DAFM include, Agri Bio Circular Economy (ABC Economy) and

BioCircle, which look to assess the available biomass, value chain development, valorization and market-based opportunities and socio-economic impact.

Other recommendations include: publishing a feasibility study and eventually securing funding for the establishment of National Marine Biomaterials Repository; providing research opportunity for a foresight analysis to examine Bioeconomy & Low Carbon Growth Opportunities; and using a citizen-science initiative and RTE-Brainstorm to enable public debate, and develop understanding of primary producer, consumer and citizen perspectives of the bioeconomy.

Much investment has gone to establishing the necessary innovation **infrastructure**. With regard to biorefineries, the AgriChemWhey project led by Glanbia, which has received around EUR 32 million in EU research and innovation funds, is building an industrial-scale biorefinery to take by-products from the dairy processing industry and convert them into lactic acid, which can in turn be used to make value-added bio-based products such as biodegradable plastics, bio-based fertilizer and other minerals.

The implementation Group is tasked above all with helping to establish the conditions required for the commercial viability of the bioeconomy. The market-focused Marine Innovation and Development Centre in Galway will provide enterprise and incubation space for marine enterprises including enterprises working on the bioeconomy. The center will also provide specialist training and business development support through collaboration with regional stakeholders and higher education institutes.

The development of a Bioeconomy Innovation Platform to examine the provision of specialized bioeconomy business support services with the aim to combine regulatory, technological and nontechnological service will also be investigated.

Furthermore, the implementation group is charged with examining the 2019 Department of Business, Enterprise and Innovation (DBEI) mapping and analysis report of Circular Economy & Bioeconomy enterprise opportunities to assess whether the current policy options are suitable or sufficient for the development of cross-cutting bioeconomy approaches, business models and new value chains.

With regard to **education**, training, and skill development in the bioeconomy, a number of initiatives have been developed including: a second-level bioeconomy teaching resource for distribution to all Irish secondary school science teachers; a third-level curriculum to account for bioeconomy developments; a Bioeconomy Training Network; and a MSc in circular Bioeconomy with Biobased Business in alignment with IT Tralee, UCD and Teagasc,

It is further recommended to develop and pilot second-level, vocational and higher-education curricula, including the involvement of social partners and the development of entrepreneurship programs.

Demand-side policies are also supported. Increased communication and awareness raising is called for and exemplified in the establishment in 2018 of the Bioeconomy Network, a public-private outreach network with an information portal. 2018 also witnessed the launch of a Bioeconomy Ireland Day to engage industry, the farming community, Government and wider society in the bioeconomy. The event was expanded in 2019 to become the Irish Bioeconomy Week from the 11th to 18th of October.

The implementation group further recommends identifying opportunities for use of certification, standards and labels as well as green public procurement to support market development for bio-based products.

Furthermore, a number of **framework conditions** are mentioned. A quality protocol is identified, which sets out end of waste criteria for the production and use of poultry; the conditions also explore the development of risk assessments and management protocols regarding the use of by-products. In addition, a technical working group on biological residual flows was established. While no roadmap has been developed for a streamlined process, a proposal for a systemic approach for management of residual waste flows for use in the bioeconomy was prepared in Q4 2019.

Further identification of measures to address the key regulator barriers to the development of the bioeconomy, including establishing “End of Waste” criteria for certain bio-wastes is also called for.

With regard to **good governance**, the Irish government expresses a strong desire to ensure greater

sectoral coherence within the bioeconomy. This is exemplified in the preparation of a sectoral coherence report in Q4 2019. Additional efforts include the secondment of a Teagasc representative in the Bioeconomy Strategy Unit of DG Research and Innovation to help with engagement at the EU level. While increased engagement with the EU innovation

system is seen as paramount, there is no reference to other international collaborations.

The bioeconomy implementation group will explore the development of standard requirements and key performance indicators for national bioeconomy implementation.

8

How is the implementation of the strategy monitored and evaluated?

The Statement mandates the establishment of a high-level implementation group jointly chaired by the Departments of Agriculture, Food and Marine and Communications and Climate Action and Environment and required to submit annual progress reports. The Group consisted of eleven Departments and eight agencies.

The Progress Report developed by the Implementation Group provides a set of twelve key recommendations, each aligning with a corresponding government policy for the next phase of bioeconomy implementation. The progress report further recommends clear measures

for 2019 and 2020 for each of the 7 key actions identified in the National Policy Statement.

In order to ensure strategy implementation, a Bioeconomy Forum was launched in October of 2019 to liaise with relevant industry bodies and other stakeholders in the bioeconomy, and to provide advice and guidance on the policy framework. This panel of high-level actors will review, and the implementation group will report regularly on the progress of the Action Plan and is committed to adapting or discontinuing activities that do not contribute to the objectives of the National Policy Statement.

9

Do dedicated regional bioeconomy policy strategies exist?

No, however the bioeconomy is promoted through regional policy objectives (RPOs) in the Regional Spatial and Economic Strategies (RSES) developed by the three Regional Assemblies of Northern and Western, Eastern and Midlands, and the Southern Regions.

These strategies are tasked with undertaking a bioeconomy feasibility study for their region in order to identify areas of potential growth to inform investment decisions under Project Ireland 2040.

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Italy



1

What have been the major developments in bioeconomy policy over the past decade?

Italy, behind Germany and France, is one of the leaders in the EU in terms of bioeconomy turnover, above all in food and agriculture. Initially, the concept of the “green economy” had greater political prominence than that of the bioeconomy. One area of key importance has been and continues to be the chemical industry’s transition to green or plant-based chemistry. For example, Italy took a pioneering role in market development and banned businesses from providing non-biodegradable plastic bags in 2011, which seems to have made a significant contribution towards stimulating green chemistry, especially in the North.

In 2010, Italy implemented a **National Marine Strategy**,²⁷⁹ a **National Biodiversity Strategy**,²⁸⁰ and a **National Action Plan for Renewable Energy**²⁸¹ in line with European Union Directives. Italy, in comparison with other member countries, has successfully coordinated many of its strategies with European programs.

In 2013, the Ministry for Economic Development set up the **Sustainable Growth Fund** (Fondo per la Crescita Sostenibile) with the particular aim of supporting SMEs. With a total funding of approximately EUR 300 million for R&D projects, it targets key innovation areas of the EU Horizon 2020 program. The bioeconomy has also received support from the **Environmental Annex to the Stability Law 2014**, in particular due to Green Public Procurement (GPP),

with minimum environmental criteria for new purchases by the public sector defined by labeling and certifications (e.g. Emas, Ecolabel, Environmental Footprints, Made Green in Italy).

Italy developed a **Strategy Action Plan on Innovation & Research in the Agriculture, Food and Forestry Sectors** in 2015 to incorporate the priorities of the EU’s Horizon 2020. In response to the 2030 Agenda, a **National Strategy for Sustainable Development (SnSvS)**²⁸² was published in 2017. All these documents would form the basis for the development of a dedicated national bioeconomy strategy in 2017, **Bioeconomy in Italy: A unique opportunity to reconnect Economy, Society and the Environment (BIT I)**.²⁸³

“**Towards a Model of Circular Economy for Italy - Overview and Strategic Framework**” (2018)²⁸⁴ helped define Italy’s strategic position in the circular economy and is part of the broader national strategy for sustainable development. It is the starting point for the realization of an official “National Action Plan on the Circular Economy.” The strategy seeks to pursue an economic transition, integrating bioeconomy and the circular economy models, and makes specific reference to biorefineries, which can economically, environmentally and socially revitalize territories.

In 2018, a new law on forestry and forest supply chains, the **National Law on Forests** came into ef-

fect in Italy and in 2019 drafting of the **National Forest Strategy 2019-2039** began. This aims to ensure the sustainable management of forest resources in Italy in a 20-year plan.

The first bioeconomy strategy, BIT I, was updated at the request of the Presidency of the Council of Ministers, and in May 2019 the revised strategy, **BIT**

II “Bioeconomy in Italy: A new bioeconomy strategy for a sustainable Italy,” was formally presented. Its aim was to more efficiently interconnect the main pillars of the Italian bioeconomy.²⁸⁵ A year later, the **BIT II Implementation Action Plan**²⁸⁶ was published along with a **National plan for post-Covid recovery via a circular bioeconomy.**²⁸⁷

2

How is the dedicated bioeconomy strategy embedded into the wider policy context?

In April 2017, the Italian government officially adopted its first bioeconomy strategy entitled “Bioeconomy in Italy: A unique opportunity to reconnect economy, society and environment” also known as BIT I. The document emphasizes that the bioeconomy strategy is considered part of the implementation process of both the National Smart Specialization Strategy and the Italian National Strategy for

Sustainable Development. Within the framework of the National Smart Specialization Strategy, Italy has designed strategic plans for the agrifood, biobased industry and the blue bioeconomy. More than other European countries, the Italian bioeconomy strategy considers integration of the bioeconomy sectors and EU-funded R&I with structural and smart specialization interventions.

3

Who is the author of the strategy, and how were stakeholders consulted and engaged in the different phases of the strategy process?

In September 2016, the Presidency of the Council of Ministers of Renzi’s government decided to prepare a national bioeconomy strategy for the country; a task force, consisting of delegates from the Presidency of the Council of Ministers, the Ministry for Economic Development, the Ministry of Agriculture, Food and Forestry, the Ministry for Education, University and Research, the Ministry of the Environment, Land and Sea, the Committee of Italian Regions, the Agency for Territorial Cohesion, and the Italian Technology Clusters for Green Chemistry, AgriFood and Blue Growth, prepared a first draft of the strategy (BIT I). The draft version was officially presented at the Ecomondo 2016 trade fair and posted on the web of the Italian Agency for Territorial Cohesion. The feedback and comments collected over three months were analyzed and included in the final document which was then officially presented on February 2017.

In March 2019, the Presidency of the Council of Ministers of the “Conte 1” government decided to set up a National Bioeconomy Coordination Group under its National Committee for Biosafety, Biotechnology and Life Sciences (CNBBSV) and asked it to update the former national bioeconomy strategy and promote its implementation. The Group, consisting of representatives from the same institutions which worked on BIT I, prepared BIT II, presented it officially at the Italian Presidency of the Council Ministers in May 2019, and then left it open to comments and suggestions from stakeholders and citizens.

In summer 2020, the National Bioeconomy Coordination Group prepared the BIT II-related Implementation Action Plan.

4 How is “bioeconomy” defined in the main policy strategy?

In the Italian context, bioeconomy development concentrates on increasing the added value from more efficient interconnection between the primary production sectors and those involved in the transformation of food and non-food biomass and biowaste. BIT I and BIT II define the bioeconomy as encompassing the integration of “the sustainable production of renewable biological resources and the conversion of these resources and waste streams into value-added products such as food, feed, biobased products and bioenergy”.

In 2017, the Italian bioeconomy turnover was EUR 330 billion per year and accounted for 2 million jobs (BIT II). According to a Banca Intesa study, in 2018 its turnover was approximately EUR 345 billion per year and accounted for 2 million jobs. It represented 10 percent in terms of production and 7.7 percent in terms of employment in Italy.²⁸⁸ Unlike the BIT I analysis, BIT II and the Banca Intesa analyses also consider the wood and furniture value chains and water and organic waste management.

5 What is the main purpose of the dedicated policy strategy, and how does it relate to the SDGs and the Circular Economy? How does it introduce visions, targets, milestones, and action plans?

On a global scale, the national strategy addresses Italy’s response and contribution to the great societal challenges, such as food security for an increasing world population, climate change and critical ecosystem resilience. Domestically, the strategy clearly envisions increasing Italy’s competitiveness through innovation and promoting green growth. Its primary aim is to reduce dependence on fossil fuels and non-renewables. Positive rural and coastal development, while preventing biodiversity loss and protecting ecosystems, are considered key objectives of the bioeconomy strategy.

Both BIT I and its update BIT II respond to the increasing importance of the circular economy concept in EU policy. The strategy refers to a transition towards a “circular bioeconomy” which reflects a vision “where the production and use of renewable bioresources and their conversion into value-added products is part of a circular system that will make businesses more economically viable and sustainable in the long term.”

The objectives of BIT II are to interconnect more efficiently the main pillars composing the Italian bioeconomy, namely the production of renewable biological resources and their conversion into valuable food, feed, bio-based products, wooden products, and bioenergy, along with the transfor-

mation and valorization of bio-waste streams. The general objective in BIT II was revised, based on a new economic analysis of the bioeconomy, to increase Italy’s bioeconomy turnover (around EUR 330 billion/y in 2017) and jobs (about 2 million) by 15 percent by 2030 and increase the level of circularity in the economy.²⁸⁹

BIT I announced the development of a dedicated action plan and BIT II created a national inter-ministerial bioeconomy taskforce coordinated by the Presidency of the Council of Ministers tasked with developing the national Implementation Action Plan (IAP), which was released in summer 2020.

The BIT II IAP uniquely views the circular bioeconomy model as a resilient tool to accelerate the post-Covid-19 departure. The IAP provides for actions in four main macro areas: 1) promoting the development and adoption of policies, standards, labels and emerging market-based actions and incentives; 2) launching pilot actions at local level and in cities in the domains of agrifood, biobased, forestry and marine and maritime sectors; 3) enhancing the knowledge, protection and restoration of national biodiversity and ecosystems, and ecosystem services and their resilience/adaptation to climate changes; 4) promoting awareness, skill upgrading, education, attitude, training, and entrepreneurships across the bioeconomy.

Three flagship projects are proposed with investments totaling EUR 570 million in the areas of 1) multi-purpose and multi-product biorefineries; 2) urban biowaste and wastewater valorization; 3) reconversion of industrial sites. Furthermore, it

addresses existing barriers, such as the lack of a clear and stable regulatory framework at both the European and national level, by proposing a number of actions to overcome legislative barriers.

6

What are the priority areas of the strategy?

For years, Italian bioeconomy development has been led by stakeholders in the chemical industry who are pursuing the transition to **green or biomass-based chemistry**. Pioneering companies in this field develop and produce biomaterials and bioproducts by bringing together chemical, agricultural and environmental expertise. Furthermore, several biobased innovation centers and clusters play an active role in the development of bioindustry.²⁹⁰ Consequently, the national bioeconomy strategy considers agriculture, forestry and the agrifood sector as well as the marine bioeconomy and biobased industries as the core sectors of “an integrated Italian bioeconomy ecosystem.” The strategy seeks to create networks among different bioeconomy sectors and their value chains, to increase the efficiency and sustainability of biobased value chains, and to generate value from **local biodiversity** and circular economy approaches. It also aims to promote sustainable bioeconomy in the **wider Mediterranean area**.

Government support for the agricultural and forestry sector concentrates on boosting more sustainable and **resilient primary production**, e.g. by exploring the sustainability potential of different agricultural and forestry models (including climate-smart agriculture and forestry, precision farming, ecological intensification, agroecology, etc.) and by examining the role of urban and peri-urban agriculture. The strategy uniquely focuses on **urban issues**, pointing to opportunities in the food industry (e.g. adopting new urban food systems) and in urban regeneration projects (e.g. **BioCities**).

In the forestry sector, the strategy generally emphasizes the need to improve **forest management**. It highlights the importance of modernizing the timber industry to develop new products and expand the use of high-tech

wood-based materials, e.g. in the construction sector. With regard to the development of biobased industry, the strategy focuses on producing next-generation bio-fuels and bioplastics, developing biopharmaceuticals and cosmetics, promoting biobased building materials, and increasing the production of biofertilizers, biolubricants and essential amino acids for feed production.

A new focus on **microbiomes** as enabling factors for biomass production, to protect crops, to restore and better manage soils, to improve human and planetary health, and to spawn new sustainable solutions is apparent and aligned with the **national initiative on microbiomes** launched by CNBBSV in 2018 and currently under implementation.²⁹¹

Looking at the marine bioeconomy, the strategy particularly recognizes that the Mediterranean region faces huge environmental challenges, but it also sees opportunities for **blue growth and jobs**. The Italian government has already initiated several projects (such as the PRIMA and the BLUEMED initiatives) for promoting sustainable **water management and food systems** in the Mediterranean region.

In addition, the national strategy highlights the need for better **coordination** between regional, national and EU policies and initiatives. It emphasizes the role of the Italian regions in social and economic development. Regional approaches are critical for implementing circular economy activities and for improving environmental resilience and adaptation to climate change. In this respect, the promotion of key **enabling technologies**, such as industrial and environmental biotechnologies, ‘omics’ and big data, digitization and precision farming, is considered vitally important.

7

What policy instruments are put forth in the strategy (and its action plan)?

The Italian strategy provides a bundle of support measures to foster bioeconomy development.

In the field of **research and innovation**, the strategy seeks to leverage existing support and publicly funded programs at EU, national and regional level. This will be realized by mainstreaming bioeconomy issues in the Cohesion Policy Funds and by providing direct funding grants and tax incentives. Public investments should concentrate on improving resource management, i.e. by implementing farming and forestry systems to improve soil fertility and water quality, and by increasing photosynthesis capacity and carbon dioxide sequestration. The focus of R&I investments should rely on creating value from local biodiversity, resources and circularity. This also relates to the conversion of abandoned land and industrial sites (e.g. former chemical complexes). Future R&I investments should also focus on the sustainable exploitation of marine resources (such as seaweed, phytoplankton, by-products and side products from fishery and aquaculture) for food, fine chemicals and energy, while protecting the marine environment and biodiversity. In order to encourage the development of a sustainable and competitive agrifood sector, the R&I agenda further focuses on improving food safety and security, and promoting healthy diets, e.g. by developing smart nutrition solutions, identifying consumer preferences and behavior, and identifying alternative food resources (including insects and algae) and novel food microbes. It also stresses the need to increase efficiency in food production, e.g. by considering the potential of food (processing) wastes for biochemicals and biofuels.

While bioeconomy development has been largely pioneered by companies in green chemistry through a “bottom up approach,” the state has concentrated on funding research and supporting clusters that take part in EU programs in the areas of biotechnology and biobased chemistry (e.g. tech clusters for Agrifood,²⁹² Green Chemistry (SPRING),²⁹³ Blue Growth.²⁹⁴)

Innovation is also encouraged by the BIT II IAP in the form of a support measure for startups through open-access infrastructures for pre-industrial scaling up.

Measures related to **infrastructure** development concentrate on investing in R&D facilities, technology clusters, demonstration plants and test beds to promote the scaling-up of process technologies and new biobased products. With an impressive number of flagship installations in the field of bioeconomy, Italy is playing in the top league of European countries such as France and Finland. Examples include the large-scale demonstration plant for biobased succinic acid in Cassano Spinola, as well as the conversion of bio(chemical) plants (closed or no longer profitable) into bioeconomy infrastructures for the production of biochemical and biomaterials. There is also a flagship biotech plant near Venice for the production of bio-BDO from renewable feedstock, and the implementation of a zero waste biorefinery for the production of biochemicals, biopolymers and biomaterials close to Rome.

With regard to **commercialization**, BIT II IAP encourages investors to finance the bioeconomy (e.g. banks, business angels, insurers, pension funds, investment funds, crowdfunding schemes) and to improve access-to-finance for projects, by helping improve their bankability and investment-readiness, structuring their financing and liaising with private investors.

With regard to **demand-side** measures, the strategy and BIT II IAP aim to stimulate demand for biobased products and services by implementing measures such as standards, labeling, green public procurement and communication campaigns. Life cycle thinking and ecodesign approaches are to be promoted. A methodological framework is to be developed for companies to communicate cost-benefit analyses of biobased products, which should help to better demonstrate the comparative advantages to buyers. Consumer information and communication are listed as important measures for increasing public awareness. BIT II IAP adds a support measure for promoting the use of sustainability standards, certification schemes and labels to help create a level playing field for biobased products, and highlights the European project STAR-ProBio.

Furthermore, BIT II IAP should promote citizens' awareness and engagement through campaigns

to showcase bioeconomy products, through “open days” in companies active in the bioeconomy, and by participating in the National Bioeconomy Day launched by the SPRING Cluster.

The BIT I and BIT II strategies as well as the IAP underline the social dimension of bioeconomy and the importance of **education**, training and societal participation. Cross-disciplinary education and professional training measures are considered necessary not only to increase awareness but also to develop a skilled workforce for the bioeconomy. The range of measures proposed encompasses new technical programs for schools, academic bioeconomy courses and post-graduate education in bioeconomy. In January 2017, the Universities of Milano-Bicocca, Naples “Federico II”, Turin and Bologna launched the first European master’s program in “Bioeconomy in

the Circular Economy”. This master’s program represents a public-private partnership between the four Italian universities named, three industrial partners and an Italian banking group.²⁹⁵

EU, national and regional policies and activities should be aligned to ensure **bioeconomy-friendly framework** conditions. This includes, for example, reviewing regulations designed to facilitate and support the development and commercialization of biobased products and the industrial use of wastes and residues.

With regard to **good governance** measures, a new support measure in BIT II strives to strengthen regional coordination, policy harmonization and best-practice sharing.

8

How is the implementation of the strategy monitored and evaluated?

With regard to good governance, BIT II established a National Bioeconomy Coordination Group (NBCG) to support the strategy implementation process and to ensure better stakeholder coordination. As mentioned above, it is an inter-ministerial group, coordinated by the Presidency of the Council of Ministers and consisting of the representatives from the same Presidency of the Council of Ministers, the Ministry for Economic Development, the Ministry of Agriculture, Food and Forestry, the Ministry for Education, University and Research, the Ministry of the Environment, Land and Sea, the Committee of Italian Regions, the Agency for Territorial Cohesion, and the Italian Technology Clusters for Green Chemistry, AgriFood and Blue Growth. This group developed the BIT II Implementation Action Plan (IAP) via a national consultation, which is to be updated regularly, and

is tasked with implementing and monitoring the Bioeconomy nationwide.

The strategy also defines a set of concrete indicators for monitoring the strategy’s implementation process. These indicators are based on the EU key performance indicators (KPI) and the sustainability indicators proposed by the EU initiative. The indicators relate to biomass availability, productive structure, employment structure, human capacity, innovation, investment, demographics, markets, ensuring food security, managing natural resources, reducing dependence on non-renewable resources, coping with climate change, and enhancing economic growth.²⁹⁶ BIT II plans to adjust its indicators based on the new monitoring system (BioMonitor Project) being developed at EU level.

9

Do dedicated regional bioeconomy policy strategies exist?

At regional level, the Conference of Regions and Autonomous Provinces of Italy developed a common position paper on bioeconomy development in 2016. More than 20 regions have collaborated on defining strategic positions in the area of marine bioeconomy, agrifood and biobased industries. Regional bioeconomy development will be co-funded primarily by European funds targeting the Research and Innovation Strategies for Smart Specialisation (RIS3).²⁹⁷

At the launch of BIT II in May 2019, a manifesto was signed to support the “industrial revolution” of the bioeconomy in Puglia, which formalized an alliance between the Puglia Region, the University of Bari and Confindustria Puglia.²⁹⁸

The Basilicata Region's Smart Specialisation Strategy (S3) identified the bioeconomy as one of its five specialization areas for regional development and has been particularly active in agrifood production and green chemistry.²⁹⁹

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Latvia



1

What have been the major developments in bioeconomy policy over the past decade?

Prior to the release of its dedicated strategy, Rural Development support (EAFRD) through the EU provided an important source of funding for the development of rural bioeconomy value chains and associated infrastructure in Latvia. In addition, the country's 2014 Smart Specialization Strategy (RIS3) specifically targeted the bioeconomy in two out of five priorities, namely, "Knowledge-intensive bioeconomy" and "Biomedicine, medical technologies, bio-pharmacy and biotechnologies."³⁰⁰

In 2010, the "**Strategy for Sustainable Development of Latvia until 2030**"³⁰¹ was adopted with the objective of becoming an EU leader in preservation, increase, and sustainable use of natural capital. Its focus was centered on the management of natural capital, creation of market instruments, capitalization of natural assets, and promotion of sustainable lifestyles.

A strategic objective of the "**National Development Plan for Latvia for 2014 – 2020**"³⁰² is to promote economic activity in the regions, with one measure intended to support the development of agricultural, fisheries and forestry production, further processing of products, and services (including niche prod-

ucts and services). It further seeks to promote the sustainable use and biological diversity of land and other natural resources and "green" production and "green" consumption.

In 2017, Latvia became the first Baltic state to publish a dedicated national bioeconomy strategy, called the "**Latvian Bio-economy Strategy 2030**".³⁰³ With this strategy, Latvia demonstrated a strong desire to not only ensure the strength of its traditional primary sectors, but also foster a "new" bioeconomy industry.

In 2018, Latvia joined the **BIOEAST** initiative, which brings countries in Central and Eastern Europe together to develop a knowledge-based bioeconomy. The central aim of the initiative is the circular use of biomass in order to avoid waste and generate new bio-based value chains. Latvia is also represented in the **Baltic Sea Region Bioeconomy Council**, which is an informal policy dialogue platform composed of 15 – 20 members.³⁰⁴ In addition, the **EU's Strategy for the Baltic Sea Region** (EUSBSR) includes the bioeconomy under one of its policy areas with a number of projects, for which Latvia is a partner.³⁰⁵

2 How is the dedicated bioeconomy strategy embedded into the wider policy context?

At the end of 2017, the Latvian government published the “Latvian Bio-economy strategy 2030” (LI-BRA). The strategy was developed in compliance with the Latvian Sustainable Development Strategy 2030 and the National Development Plan 2014-

2020 and is also strongly aligned with the European Union’s bioeconomy strategy of 2012, and also takes into account the EU Strategy for the Baltic Sea Region (EUSBSR) and the European Commission’s Circular Economy Package (2015).

3 Who is the author of the strategy, and how were stakeholders consulted and engaged in the different phases of the strategy process?

The strategy development process was led by the Latvian Ministry of Agriculture and is characterized by broad stakeholder involvement. Representatives from associations, research institutions and the inter-ministerial steering group (composed of

the Ministry of Agriculture, Ministry of Economics, Ministry of Environmental Protection and Regional Development, Ministry of Education and Science, Ministry of Welfare) were invited to provide input to the bioeconomy strategy.

4 How is “bioeconomy” defined in the main policy strategy?

According to the Latvian strategy, the bioeconomy encompasses the sustainable utilization of renewable natural resources (including plants, animals, micro-organisms, etc.) for producing food, feed, industrial products and energy. The strategy highlights the importance of the life sciences and converging technologies (such as biotechnology, nanotechnology and ICT) for producing more sustainable and environmentally friendly products, as well as com-

pletely new products. The strategy specifically emphasizes that the term bioeconomy also refers to the promotion of biobased services, for example, in the construction, catering, or accommodation sectors.

In 2017, bioeconomy turnover according to the EU was EUR 7 billion, value added EUR 2 billion, and 126,000 people were employed in the sector.³⁰⁶

5 What is the main purpose of the dedicated policy strategy, and how does it relate to the SDGs and the Circular Economy? How does it introduce visions, targets, milestones, and action plans?

The strategy is aligned with the UN Sustainable Development Agenda 2030 and highlights the potential of bioeconomy to contribute to a number of the SDGs. With reference to the EC Circular Economy Package (2015), the strategy aims to be aligned with fundamental principles of the circular economy.

The strategy sees itself as a response to decreasing employment in the bioeconomy sector due in large part to structural changes in the agriculture sector (e.g. reduction in the number of small farms and increasing production efficiency requiring fewer employees). It therefore defines three quantitative targets: 1) employment in the bioeconomy should increase by

up to 128,000 employees by 2030, 2) added value of bioeconomy products should increase to at least EUR 3.8 billion by 2030 and the value of bioeconomy-related exports should be boosted to at least EUR 9 billion by 2030.

The strategy specifically focuses on the promotion of rural development and the creation of local jobs and increased per capita incomes. Furthermore, the government seeks to reduce Latvia's dependence on fossil fuels by developing innovative, higher value-added bio-based products and services.

Five main action directions are presented: 1) attractive business environment for entrepreneurship in bioeconomy, 2) result-oriented efficient and sustainable resource management, 3) development of knowledge and innovations in bioeconomy sectors, 4) promotion of manufacturing the produce in bioeconomy, 5) socially responsible and sustainable development. The strategy does not identify specific measures, milestones, nor the sources of financing. There is no indication of an action plan being developed.

6 What are the priority areas of the strategy?

The Latvian bioeconomy strategy concentrates on the sustainable production and utilization of biobased resources. It specifically targets businesses in the **primary industries** (including agriculture, forestry and fisheries) and in manufacturing, such as the food and feed industry, the wood industry, the chemical and pharmaceutical industry and also the textile industry. It highlights, for example, the promotion of innovative plant and animal breeding technologies, sustainable resource management practices, and improved land use efficiency. The strategy further emphasizes the need for increased public R&D on **environmental protection** (particularly with respect to soil fertility, water and air quality), climate resistant crops and tree species, organic farming, and animal health and welfare.

The Latvian government mentions exploring untapped **marine bioresources** (such as seaweed, mussels and algae) for the production of chemicals and **pharmaceuticals**, and also innovative, higher-value food products (such as **functional foods**). The strategy highlights the promotion of sustainable fisheries and aquaculture as a prerequisite.

Biorefinery development should contribute to producing advanced **biofuels** (e.g. from cellulose), platform chemicals, biodegradable plastics, and biobased surfactants based on vegetable oils, fats, sugar, algae and waste. In addition, the strategy document points to circular bioeconomy approaches for **preventing waste** at all stages of the value chain.

7 What policy instruments are put forth in the strategy (and its action plan)?

The Latvian bioeconomy strategy pursues a comprehensive approach to fostering bioeconomy development.

In order to promote **research and innovation**, it particularly stresses the need for increased public R&D investment. For example, a National Research Program on Bioeconomy should be established to guide long-term R&D activities. The strategy also prioritizes cooperation between public and private actors, mainly in the

form of public-private partnerships. In addition, public R&D activities should be coordinated by a Strategic Bioeconomy Research Alliance, an initiative set up in 2014, which unites 14 research institutions from agriculture, food and forestry. The government also envisages public support and co-financing for pilot and demonstration projects.

Measures related to **infrastructure** development focus mainly on investment in the research infrastruc-

ture, but also on investment in the logistics infrastructure, such as roads, ports, warehouses, business parks, etc. While Latvia is considered a “data-driven nation” both in terms of technical infrastructure with nationwide internet coverage and in public administration, the strategy does not make specific reference to digitalization (e.g. digital agriculture and precision farming). Biorefineries do not exist so far, but the potential of a biorefinery based on macroalgae is being investigated.³⁰⁷

The strategy sees the development of the future bioeconomy as depending heavily on a highly qualified workforce. The Latvian strategy therefore highlights the promotion of measures related to **capacity building and education**, including interdisciplinary and multidisciplinary training and education programs, as well as higher education and life-long learning opportunities. At the same time, the strategy emphasizes further training courses to improve entrepreneurial and business skills.

The Latvian strategy has a business-oriented approach. With regard to supporting **commercialization**, the bioeconomy strategy focuses on promoting knowledge transfer and creating business-friendly framework conditions, e.g. by reducing administrative burdens in business, incentives for local entrepreneurship and also by means of stable tax policies. In addition, export promotion policies (e.g. in the form of export credit guarantees) and marketing efforts are considered important.

Public procurement policies targeting wood for the construction of public buildings, organically certified products, environmentally friendly packaging or locally produced products are proposed as **demand-side instruments**. Moreover, public awareness of bio-based products should be increased by means of dedicated information and education campaigns, and by adopting internationally recognized certification schemes and labels (e.g. FSC, PEFC, SBP). In addition, the strategy seeks to create and promote the brand of Latvia, emphasizing the significance of bioeconomy.

Among the measures mentioned for ensuring bioeconomy-friendly **framework conditions** are regulations for sustainable forestry and agriculture (e.g. land use policies based on functional land use principles). The government also seeks to provide a level-playing field for bio-based business and to ensure fair competition among actors. The strategy highlights the need for increased cooperation among law enforcement agencies aimed at controlling the business of small producers and traders so as to avoid price distortions, especially in the area of un-processed food.

The strategy proposes several measures to promote **good governance** in the bioeconomy (e.g. bioeconomy impact assessment for all strategic policy documents). International cooperation is encouraged between national and international research projects, particularly with countries in the Baltic Sea region and other EU member states. The aim is also to foster trade agreements with countries in Africa and Asia.

8

How is the implementation of the strategy monitored and evaluated?

No monitoring framework is put in place. Progress will be monitored for the three strategic targets of

the Strategy (employment, value-added, and export).

9

Do dedicated regional bioeconomy policy strategies exist?

No.

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Nordics

1

What have been the major developments in bioeconomy policy over the past decade?

In Northern Europe, the Nordic Council of Ministers, an official body for inter-governmental cooperation in the Nordic Region, has promoted bioeconomy development on a macro-regional level since 2012. The Nordic Council of Ministers consists of the Ministers for Nordic Cooperation (involving Denmark, Finland, Iceland, Norway, Sweden, the Faroe Islands, Greenland, and Åland) and 10 ministerial councils which cover different sectors and are supported by 16 committees of senior officials.³⁰⁸

The bioeconomy has been high on the political agenda of several annual programs for the Presidency of the Nordic Council of Ministers. In addition, specific actions have been taken in the North-West Atlantic, the Arctic region and the Baltic Sea Region. For example, in 2014, the Nordic Council of Ministers commissioned an **opportunity report for bioeconomy development in the West Nordic Countries**,³⁰⁹ including Greenland, Iceland, and the Faroe Islands. In 2016, the Nordic Council of Ministers, together with the Arctic Economic Council, decided to put more emphasis on bioeconomic development in the Arctic with the **Arctic Cooperation Programme**, aimed at qualifying knowledge of the business environment and taking the bioeconomy business environment to the next level.³¹⁰ In the Baltic Sea Region, the Nordic Council of Ministers leads the **Action Plan for the European Union Strategy for the Baltic Sea**

Region (EUSBSR) to promote cooperation within the bioeconomy and within the following countries: Denmark, Estonia, Finland, Germany, Latvia, Lithuania, Poland, and Sweden.³¹¹

In 2017, the Nordic Council of Ministers published a selection of **25 Nordic bioeconomy case studies**³¹² illustrating the diverse bioeconomy activities in the Nordic countries and helping to raise awareness of the bioeconomy, its importance and potential within the public.

In 2018, the Nordic Council of Ministers adopted the **“Nordic Bioeconomy Programme: 15 Action Points for Sustainable Change”**³¹³ under the Nordic cooperation which aims to create a strong Nordic community, while seeking to safeguard Nordic and regional interests and principles in the global community.

The Nordic Council of Ministers, in partnership with Nordic Sustainability and Nordregio, carried out an analysis, part of which identified current trends and policy insights for sustainable bioeconomy development in the Nordic countries. The report, published in 2020, addresses topics on biofuels, alternative protein sources, and circular economy, and pays special attention to the impact of the COVID-19 pandemic.³¹⁴

2 How is the dedicated bioeconomy strategy embedded into the wider policy context?

The Nordic Bioeconomy Programme builds on Agenda 2030 as well as the work of the Nordic Council of Ministers for Environment, Climate and Energy. It seeks to maintain and strengthen the Nordic region's leading position in the conversion of different types of biomass into valuable and sustainable technologies, products, and services. Furthermore,

as the Nordic countries have already developed their own national policy approaches to the bioeconomy, which differ in both form and content, the Nordic Council of Ministers' strategic program aims to add value to national bioeconomy policy efforts and create synergies by integrating these national Nordic strategies.

3 Who is the author of the strategy, and how were stakeholders consulted and engaged in the different phases of the strategy process?

Under the Icelandic Presidency in 2014, the Nordic Council of Ministers appointed the Nordic Bioeconomy Panel with the objective of developing a strategic program for the Nordic bioeconomy. The program was discussed at several meetings of the panel, as well as in relevant councils of ministers and committees of senior officials. The Nordic bioeconomy program thus presents the outcome of various con-

sultation activities and focuses primarily on the period 2018 – 2022. Further relevant actors involved in the policy development process included the Nordic institutions (particularly NordForsk, Nordregio, Nordic Innovation, NordGen, Nordic Forest Research, and the Nordic Joint Committee for Agriculture and Food Research).

4 How is “bioeconomy” defined in the main policy strategy?

According to the strategy document the bioeconomy “(...) encompasses the utilization of renewable biological resources and the conversion of these resources (including side streams and waste streams) into value-added products, technology and services.” The focus is on products like food, feed, biobased products, chemicals, materials, and bioenergy, but also services, such as water and air quality, shelter

and recreation (e.g. walking, skiing and foraging for berries and mushrooms), and non-anthropogenic outcomes like biodiversity. Furthermore, the Nordic bioeconomy perspective includes better management of the carbon cycle in relation to human activities and the interplay between food, energy, and other biobased goods.

5 What is the main purpose of the dedicated policy strategy, and how does it relate to the SDGs and the Circular Economy? How does it introduce visions, targets, milestones, and action plans?

In the Nordic bioeconomy program, the Nordic Council of Ministers bundles its environmental, social and

economic ambitions for a more sustainable Nordic Region. The aim is to develop a new era of bioecon-

omy, which builds up new industries, creates new jobs and achieves new standards for resource efficiency. In this respect, it seeks to increase the competitiveness of Nordic biobased industries and food industries by developing new value chains, guiding the transition of traditional biobased industries into technologically advanced industries and optimizing the production and value creation of biomass. The strategic program should help in answering the key question of how biological sectors can contribute to serving the needs of a growing population and mitigate climate change through the replacement of fossil-based products and improved use of global resources.

The document states that the bioeconomy can significantly contribute to the United Nations COP process and to reaching the 17 Sustainable Development Goals for 2030. It further includes five sustainability principles outlined in the appendix which set out the overarching criteria for a sustainable bioeconomy

in the Nordic region: 1) responsible use of shared resources; 2) safe, sufficient and nutritious food for all; 3) a livable planet; 4) sustainable fair societies; 5) changing mindsets and consumer behavior.

The document further defines a shared vision for the Nordic Bioeconomy, summarized as follows: competitive biobased industries, sustainable resource management, resilient and diverse ecosystems, and inclusive economic development.

While introducing prioritized, short-term targets that can be achieved with the help of soft measures and funding already available, the policy strategy identifies 15 action points allocated to three broad categories: 1) innovate (supporting research, innovation and human capital); 2) accelerate (policies and market development), and 3) network (forging new and stronger connections). However, a budget for implementation is not documented.

6 What are the priority areas of the strategy?

The focus of the strategic bioeconomy program is on the **primary production**. As the Nordic region is a major producer of primary biomass (approx. 30 percent of Europe's forest production and more than 50 percent of the total marine harvest in Europe), the strategy emphasizes the potential benefit from adding value to biomass products through the promotion of resource efficiency and digitalization. It highlights that **digital technologies and big data** are increasingly playing a key role in the bioeconomy, as finding new ways to manage and process data would enable better understanding and more sustainable utilization of the different biological resources.³¹⁵

In particular, primary industries in **rural areas** are seen as offering opportunities for young people and women to stay in rural regions and to maintain a degree of self-sufficiency in terms of energy, food and feed, fibers and contributing to increased resilience and security.

The strategic program further recognizes the huge potential of the Nordic region in **food production and reduction of food waste in urban areas**. The program thus focuses on promoting innovations in food production systems and on developing new, sustainable and healthy food, and pharmaceutical products.

The strategy states that the diversity of biomass available in the Nordic region enables the parallel development of relevant value-chains. By bringing together different stakeholders within research and innovation, primary production and industry (e.g. through the creation of networks), it is envisaged that **biorefining** in one sector should create synergies for other sectors and regions.

Further priority areas highlighted in the document include timber construction, packaging, bioenergy, marine resources, and the borders between aquatic and terrestrial ecosystems.

7

What policy instruments are put forth in the strategy (and its action plan)?

With regard to **research and innovation**, the focus of the strategy is on increasing R&D funding throughout the value chain within Nordic co-operation. NordForsk and Nordic Innovation are identified as key players in terms of providing future R&D funds. In addition, more bioeconomy R&D funding should be made available at the EU level.

There is also focus on mapping the interaction between biological by-products and the development of second and third-generation biofuels, and investigating how the bioeconomy can most efficiently contribute to the reduction of greenhouse gases.

In addition, the strategy promises investment support to scale up demo and pilot projects within the Nordic bioeconomy. In this regard, an investment fund should be set up to boost interest in establishing biobased startups and to help them bridge the gap between pilot and demonstration, as well as helping bridge the gap between demonstration and industrialization. This should be achieved, for instance, by establishing strategic partnerships with existing financial institutions or via new “green” venture capital in line with the Nordic Green Bonds.

Industrial clusters and public-private partnerships (e.g. SME clusters around biorefineries) should be fostered as a tool for sharing best practices and facilitating development and innovation. Open access to test and demonstration centers should be ensured through public-private partnerships or solely through public or private funding. This should help with the lack of access to innovation centers in rural areas by providing employment opportunities at hubs for local expertise. Furthermore, setting up a digital Nordic/Baltic Bioeconomy Portal should facilitate public-private partnerships and cluster-to-cluster collaboration.

With regard to **commercialization**, the strategy focuses on providing market analysis and the mapping of Nordic/Baltic positions of strength within the bioeconomy (particularly in the areas of digitalization, climate work, social inclusion, and gender equality).

Moreover, subsidies and/or tax incentives should promote investment in the bioeconomy and business development, with a view to making the biobased products economically competitive and establishing a Nordic brand. A virtual or more formally structured network (e.g. of Nordic stakeholders) should further provide expert assistance on commercialization, marketing, product registration, and funding opportunities.

In order to **promote the demand side** of the bioeconomy, targeted public procurement at national and EU level should be introduced and biobased chemicals, materials and energy prioritized. In addition, coherent certification frameworks and harmonized labels and standards should contribute to building on the Nordic ecolabeling scheme and to developing a Nordic biobased brand that emphasizes sustainability. The program also looks to influence consumer behavior, attract young people to the bioeconomy and promote exports.

The strategy document recognizes that bioeconomy development requires a well-educated and competent workforce with many skills. This is why innovative **educational approaches** should be fostered, especially in the lower levels of the school system. In addition, the strategy strives to establish Nordic bachelor’s and master’s programs and apprenticeships, promote the exchange of PhD students, create new vocational training systems (allowing for trends such as interdisciplinary value chains and new technologies), and start the dialogue with relevant stakeholders for developing new education and training programs.

With regard to promoting **good governance**, the strategy focuses on promoting coherent policies and aligning existing strategies and R&D programs, both nationally and internationally. In this respect, the pan-Nordic institutions should make a significant contribution by aligning their strategies and focusing on activities to facilitate sustainable change in the bioeconomy. Furthermore, the active dialogue on sustainable bioeconomy development should be promoted with the EU and other international players.

The strategy further highlights the important role of the EU regional innovation strategies and smart specialization strategies for developing new industries and technologies in the bioeconomy.

In addition, macro-regional collaboration with the Baltic Sea and the Arctic region seeking to create multi-level platforms should be promoted, e.g. by continuing the work of the Nordic Bioeconomy Panel. According to the strategy document, the Nordic institutions play a key role in maintaining these connections in relation to the bioeconomy.

Interestingly, the strategy emphasizes **regulatory frameworks** to support green alternatives to fossil-based products and services and thus lays the foundation for setting policy targets for the use of biomass, for the mandatory use or prohibition of products, or even for direct financial incentives in the form of taxes on products that are to be discouraged, and subsidies for new solutions.

In addition, the strategy highlights the need for cross-border freedom of movement to increase the long-term commercial viability of innovative bioeconomy products.

8

How is the implementation of the strategy monitored and evaluated?

The strategy document does not make clear how the program will be monitored or evaluated.

9

Do dedicated regional bioeconomy policy strategies exist?

To date, the macro-regional cooperation among the Nordic countries is an established, institutionalized regional bioeconomy cooperation that is unique in

the world and that, with secure financial means, also promotes national and regional bioeconomy development.

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Norway

1

What have been the major developments in bioeconomy policy over the past decade?

Norway is rich in both terrestrial and aquatic biological resources and political support over the years has fostered a strong research environment. Over the years, bioeconomy development has become closely related to the topic of climate change and sustainable development. Recently, key questions center on how to develop more sustainable consumption patterns, i.e. what the diets of the future are, how can food production (incl. salmon) be increased in a sustainable way, what are alternative food sources of the future.

Norway is one of the pioneers of fostering the sustainable use of marine resources and developing innovative marine bioindustries. In 2009, the government released the “**Marine Bioprospecting Strategy**”³¹⁶ as well as the “**Strategy for an environmentally sustainable Norwegian aquaculture industry**”³¹⁷. The **bioprospecting strategy** is oriented towards innovation and commercialization and seeks to strengthen the pharmaceutical and processing industries. While the aquaculture strategy largely refers to industry development, it also includes environmental aspects of sustainable farming. The aquaculture strategy also seeks to strengthen international cooperation (e.g. 2014 bilateral agreement with Germany) in order to ensure sustainable fisheries.³¹⁸

In 2011, the “**National Strategy for Biotechnology**” (2011 – 2020)³¹⁹ defined a more comprehensive development path for biotechnological innovation and

commercialization across biotechnology sectors. More specifically, biotechnology should contribute to food safety as well as to “greening” of the industry and energy sectors.

A broader vision of an innovation-driven “biobased society” was presented in 2012 with the release of the “**Research Programme on Sustainable Innovation in Food and Biobased Industries**” (**BIONÆR**),³²⁰ which aims to strengthen the level of profitability and sustainability in the bio-based industries within agriculture and land-based biological resources.

In order to bundle scientific competencies related to bioeconomy and biobased industries, the **Norwegian Institute of Bioeconomy Research (NIBIO)** was created in 2015 by merging the country’s most important agricultural and forestry research institutes.

In November 2016, the Government published its first dedicated bioeconomy strategy under the title “**Familiar resources – undreamt possibilities**”³²¹ and, three years later in 2019, a corresponding **Joint Action Plan for Research and Innovation**³²² from the Research Council, Innovation Norway and Siva.

The Norwegian Government considers bioeconomy as an essential part of its future circular economy and, as announced in the bioeconomy strategy, published a **White Paper on waste policy and the circular economy** in 2017.³²³

In 2017, “**Better growth, lower emissions – the Norwegian Government’s strategy for green competitiveness.**”⁴³²⁴ was launched with the goals of reducing greenhouse gas emissions, increasing value creation, and ensuring high employment. The circular economy is highlighted prominently, and reference is made to the bioeconomy strategy as a means to ensure the sustainable use of biological resources and as an area that offers promising “green solutions.”

Since publishing a national bioeconomy strategy, Norway has developed into one of the most locally structured bioeconomies in the world with a number of **dedicated regional strategies.**

Over the years Norway has had a very active role in the bioeconomy activities of the Nordic Council

and the Nordic Council of Ministers. In 2018, Norway joined a regional collaboration, the Nordic co-operation, involving Denmark, Finland, Iceland, Sweden, the Faroe Islands, Greenland, and Åland, and under the leadership of the Nordic Council of Ministers pursues a strategic program for the Nordic bioeconomy. The **Nordic Bioeconomy Programme** presents a range of activities aimed at promoting the bioeconomy in the region, primarily covering the period 2018 – 2022.³²⁵

Norway recently took over the chair (from 2019 – 2021) of the **Barents Euro-Arctic Council (BEAC)**, an inter-governmental cooperation between Norway, Finland, Russia, and Sweden which works on advancing the transition to a low carbon society. Norway also holds the chair of the Barents Forest Sector Network and has prioritized the forest-based bioeconomy.

2

How is the dedicated bioeconomy strategy embedded into the wider policy context?

The Norwegian government published its bioeconomy strategy “Familiar resources – undreamt possibilities” in November 2016. In 2019, its action plan was published by the Norwegian Research Council together with the public I&R agency, Innovation Nor-

way, and the Industrial Development Corporation of Norway (SIVA), a government cooperation with the aim of improving national infrastructure for innovation.

3

Who is the author of the strategy, and how were stakeholders consulted and engaged in the different phases of the strategy process?

The strategy is a result of a broad collaboration between the Ministries of Trade, Industry and Fisheries, Agriculture and Food, Climate and Environment, Education and Research, Local Government and Modernization, Petroleum and Energy, Transport and Communications, and Foreign Affairs. National institutions such as Innovation Norway, the Research Council of Norway and the Norwegian Environmental Agency were especially important advisers in the process.

The Norwegian government initiated the development of a dedicated bioeconomy strategy in March

2015. It was developed over an eighteen-month consultative, multi-stakeholder process which involved a national conference as well as a series of international expert workshops and regional meetings. Industry representatives, research institutions, and NGOs were also given the opportunity to provide written input to a draft version.

The Norwegian Research Council, Innovation Norway, and SIVA are the authors of the action plan published in February 2019.

4 How is “bioeconomy” defined in the main policy strategy?

Bioeconomy is defined as the “sustainable, effective and profitable production, extraction and use of renewable, biological resources for food and feed, health products, energy, industrial materials, chemicals, paper, textiles, and numerous other products.” The bioeconomy therefore encompasses almost all sectors, which produce, process or use biological resources in whatever form. It is especially the marine industry that raises productivity and value creation within the bioeconomy in Norway.

As highlighted in the action plan, the report “Socio-economic indicators for the Norwegian bioeconomy in transition”³²⁶ published in 2020 provides an overview of value creation and employment in biobased sectors

in Norway using the same methods as used by Ronzon and M'Barek (2018)³²⁷ to measure the European Union. Their analysis reveals a high level of productivity and a relatively low share of workers in the bioeconomic sectors (144,000 employed in 2008 versus 130,000 in 2017). Productivity strongly increased from NOK 76 billion added value in 2008 to NOK 130 billion in 2017, with the fishing and aquaculture sectors largely responsible for this impressive growth spurt. Overall, food-related sectors accounted for more than 80 percent of the total added value in the Norwegian bioeconomy. In addition, pharmaceuticals experienced a dramatic shift towards biobased production. The report further points out that the bioeconomy is important for securing jobs in rural areas.

5 What is the main purpose of the dedicated policy strategy, and how does it relate to the SDGs and the Circular Economy? How does it introduce visions, targets, milestones, and action plans?

The Norwegian bioeconomy strategy seeks to lay the foundations for a common understanding of bioeconomy and its national opportunities and challenges. The strategy points out three overarching objectives - increased value creation, reduction in climate gas emissions, increased resource efficiency and sustainability - and four focus areas. It clearly pursues economic goals, such as the creation of wealth and employment, and improvement of the country's competitiveness.

The bioeconomy should contribute to sustainable development, specifically to a more circular and environmentally friendly, low-emission economy. Further development of the bioeconomy is closely linked to a circular economy. The SDGs are not explicitly stated in the strategy, but there are clear aspirations to reduce

greenhouse gas emissions and contribute to more sustainable utilization of renewable biological resources.

The Action Plan can be seen as a guiding document for how the main policy actors (the Research Council of Norway, Innovation Norway, and Siva) will work together to ensure a smooth transition between relevant institutions and instruments within and across government agencies. Four “subobjectives” are defined as: 1) offering the right and customized instruments, 2) simplifying the transition between different instruments, 3) mobilizing research and innovation within the bioeconomy, 4) promoting research and innovation collaboration. The strategy is not intended to replace other white papers and programs, but to enable cross-over cooperation and innovation.

6 What are the priority areas of the strategy?

As Norway is rich in natural resources, the national bioeconomy strategy emphasizes the primary industries, especially the forest and marine sectors. The strategy

focuses on four priority areas: 1) co-operation across sectors, industries, and thematic areas, 2) developing **markets** for biobased products, 3) **sustainable pro-**

duction of biological resources, 4) efficient use and **profitable processing** of biological resources.

In addition to the four priority areas, the strategy emphasizes the promotion of **key enabling technologies** (including biotechnology, nanotechnology, and ICT) to facilitate the development of new biobased processes, products and services, such as the microbial production of biopharmaceuticals and food ingredients, and the anaerobic fermentation of biogas. **Digitalization** plays an important role in promoting the sustainable production and utilization of these bioresources and cutting labor costs. The strategy specifically addresses **goal conflicts** and opportunities to minimize them, for example by minimiz-

ing waste and optimizing efficiency of use. **Biorefinery development** in the food and wood industry is also considered a promising route in Norway.

The action plan sets priorities in the following areas: 1) **circular economy** (e.g. increased use of residual waste and side streams), 2) bioeconomy as a platform for **technology development** (e.g. biotechnology, automation and other digital solutions), 3) strengthen **exports** (e.g. recruit foreign companies for trade and research collaboration), 4) active participation in EU and **international work**, 5) dissemination of **knowledge** (e.g. arrange regional thematic meetings and active dialogue with stakeholders).

7

What policy instruments are put forth in the strategy (and its action plan)?

The Norwegian dedicated bioeconomy strategy promotes a comprehensive array of instruments.

With a view to promoting **research and innovation**, the strategy supports public R&D and encourages innovation projects along the entire bioeconomy value chain. In 2020, funds for the public sector were announced under the heading “A circular biobased economy.” The action plan calls for life cycle analyses and potentially requires that such analyses are included in the announcement of selected projects. Biodiversity mapping is supported to make production and extraction activities in the primary industries more sustainable.

In order to strengthen (societal) dialogue and innovation activities across disciplines and across national borders, the strategy proposes support for networking activities, cooperation platforms, the establishment of public-private partnerships, and bilateral collaboration with selected countries. Cluster development is encouraged to increase cooperation across sectors, industries and thematic areas, and to establish new business fields. Three main cooperation platforms for development of the bioeconomy are the SFI Centre for Research-based Innovation, Norwegian Innovation Clusters (NIC), and the Innovation Program of Siva. To further develop these collaboration platforms, greater focus is placed on enabling technologies rather than raw sources.

With regard to research and innovation, the Action Plan specifically points to the various instruments offered by the Research Council of Norway, Innovation Norway, and Siva along the entire project development chain from basic research to market access. For example, Norwegian companies can apply to Innovation Norway, through the environmental technology scheme, for grants to develop, construct, and test new environmental technology.

The Action Plan also highlights co-financing of test and demonstration facilities that can be shared by several companies and R&D institutions.

Infrastructure support is focused mainly on the research and innovation sector. SIVA, a state-owned real estate company investing in industry parks and Science and Technology parks, has no special schemes dedicated to supporting the bioeconomy. It has, however, invested about NOK 250 million in total in physical infrastructure aimed at bioeconomy-related activity.

Norway is home to one of the most advanced biorefineries in operation today, based on lignocellulosic feedstock and run by Borregaard in Sarpsborg. The Research Council of Norway and Innovation Norway were involved in financing the R&D project that laid the foundations for the factory. In 2016, Borregaard opened the world’s first commercial-scale facility for microfibrillated cellulose.

Norway has a long tradition of private- public co-operation, and many public instruments are in place to support innovation and business development. **Commercialization** and the efficient use and value-oriented processing of biobased resources should be supported by public certification schemes and subsidies for sustainable forestry. Examples highlighted in the Action Plan include Innovation Norway's "Bioeconomy scheme (Bioøkonomiordningen)", which managed about NOK 90 in 2019 for activities within the biobased business sector.

Demand-side measures are considered necessary to stimulate markets for biobased products, e.g. by developing product and labeling standards and certification systems. Publicly-funded information campaigns, education materials, and product labeling should further raise awareness of biobased products. The public sector should serve as a role model and use its purchasing power to leverage market demand, e.g. by implementing suitable public procurement practices and by constructing biobased buildings.

With regard to **bioeconomy friendly framework conditions**, Norway already has many years of experience in environmental taxation in line with the country's climate policy. In this context, the government proposes several regulatory improvements to create a level playing field for biobased products, for example taxes or quota for fossil-based products to account for negative environmental and climate effects. In addition,

regulatory changes are considered necessary to promote circular economy approaches and the use of residues, e.g. in the field of wastewater treatment. With a view to the sustainable production and extraction of biological resources, the strategy intends to develop new regulations for the harvesting and exploitation of microalgae, to revise bioprospecting regulations, and to adapt legislation to promote investments in sustainable fisheries.

With regard to **good governance** measures, international collaboration in the bioeconomy is stimulated by Norwegian participation in the EU Framework Program for R&I and the country's OECD membership.

The action plan provides a framework and direction for the work of the three main actors and above all seeks to ensure the most efficient allocation of tasks between these institutions and the different instruments they offer. For example, a collaboration committee has been established for the three main actors and there is a working group of professional advisers in the bioeconomy composed of various actors. The working group meets regularly to create greater ownership of common tasks and objectives in the bioeconomy and aims to organize an annual seminar in 2020 and beyond for relevant employees across various bodies. In addition, there are plans to simplify the sharing of information between the three main actors especially in the early phase of projects.

8

How is the implementation of the strategy monitored and evaluated?

The strategy paper covers a period of 10 years and will be assessed by a mid-term evaluation (audit) after five years.

9

Do dedicated regional bioeconomy policy strategies exist?

Norway is one of the few countries in the world that has several dedicated regional bioeconomy strategies. The focus is on bioeconomy clusters and on how to use a multi-stakeholder approach. In this respect, some regions concentrate on agricultural

resources, some on forestry resources, and some on fishery resources.

The **Bioeconomy Strategy for Innlandet 2017 – 2024**,³²⁸ a business strategy with an action plan, looks to

contribute to increased competitiveness and value chain creation and to the “green shift” in Norway. Innlandet has a significant proportion of the country’s biological resources and the strategy sets five goals to become a leading player in the bioeconomy: 1) knowledge and competence, 2) market and competitiveness, 3) biological resources and waste streams, 4) cooperation, 4) visibility and communication. The strategy was prepared with collaboration between the county municipalities and the County Governor of Hedmark and Oppland, and responsibility for implementation lies with the steering group. In addition, a Council for Bioeconomic Growth (BioRåd) has been established to report to the steering group.

The **Bioeconomy Strategy for the Gjøvik Region 2018 – 2022**³²⁹ is a follow-up to the above-mentioned Innlandet bioeconomy strategy and strives to build on its comparative advantage in R&D and business development to become a leader in sustainable biobased industries.

The **Strategy for Bioeconomy in Rogaland 2018 – 2030**³³⁰ sees itself as part of a “green shift” and seeks to move from a linear to a circular economy in order to become a bioeconomy powerhouse in Norway. Its overarching goals include increasing job cre-

ation, reducing greenhouse gas emissions, increasing biomass production from land and sea by at least 20 percent by 2030 (biomass should be primarily in high protein), increase production of raw materials for feed to cover at least 30 percent of the needs of the agriculture and aquaculture industries in Rogaland, and becoming an internationally recognized center of competence for research on the bioeconomy. It includes an **Action Plan** with the county municipality responsible for its implementation and a Bio-Council with industry representatives and working groups for the focus areas. It requires yearly reporting to regional authorities and more in-depth reporting on goals and deliverables every four years.

Namdalen in the county of Trøndelag developed its own **Bioeconomy in Namdalen - proposed regional strategy**³³¹ in 2018. As a large raw material supplier, Namdalen looks to increase biomass production and value creation with this strategy.

In the county of **Viken**, Østfold developed its own strategy in 2016, **Strategy for Bioeconomy in Østfold**.³³² It seeks to increase value creation and employment in the bioeconomy, enhance the regional innovation system, and ensure maximum resource utilization of available biomass through a number of comprehensive measures.

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Spain



1

What have been the major bioeconomy policy developments over the past decade?

In 2016, the Spanish government adopted the first national bioeconomy strategy. The document titled “**The Spanish Bioeconomy Strategy: 2030 Horizon**” reflects the government’s goal to develop a sustainable Spanish bioeconomy in the coming 15 years.³³³ In 2018 a second dedicated **Bioeconomy Action Plan** was released.³³⁴ The bioeconomy has also been included, in a comprehensive fashion, among the Spanish research and innovation objectives, within the framework of the revision of the **State R & D Plan for the period 2017 – 2020**.

Unlike any other country in Europe, the development of the bioeconomy in Spain has been characterized by a strong regional focus (partially supported by the EU and the National Rural Development Programme). Several autonomous communities have

started to develop their own initiatives in the area of the bioeconomy. All 17 Spanish regions featured the bioeconomy in their “smart” specialization strategies and almost half are working on their own strategies. As of 2020, **Extremadura, Andalusia, Basque and Castilla León** have finalized strategies.

At the beginning of June 2020, the Spanish Government published **España Circular 2030**, a Strategy for Circular Economy in Spain until 2030. It seeks to contribute to Spain’s efforts to transition to a sustainable, decarbonized, resource-efficient and competitive economy and contains the objectives of a 30% reduction in the national consumption of resources and a 15% reduction in waste generation (as compared to 2010).³³⁵

2

How is the dedicated bioeconomy strategy embedded into the wider policy context?

With the adoption of a dedicated bioeconomy strategy in 2016, the Spanish government sought early on to embed the bioeconomy comprehensively into the

political context. More recently, the concept of the circular economy has gained political relevance.

3

Who is the author of the strategy, and how were stakeholders consulted and engaged in the different phases of the strategy process?

The first initiative for a national bioeconomy strategy was taken by the Ministry of the Economy and Competitiveness and the Ministry of Agriculture, Food and the Environment in early 2014. A working group, composed of private and public experts and chaired by the Secretary of State for Research, Development and Innovation (SEIDI), was set up to elaborate a first strategy draft. From this point, the

document underwent public consultation, addressing more than 200 key experts identified through a survey, as well as public feedback. The strategy was finalized and adopted in March 2016. From the beginning, the regions of Spain have also played a strong part by vocalizing their interest and their role in implementing biobased activities.

4

How is “bioeconomy” defined in the main policy strategy?

The national bioeconomy strategy defines the bioeconomy as “the set of economic activities based on products and services, generating economic value, making efficient and sustainable use of resources of biological origin as fundamental elements.” The definition covers the production and commercialization of food, forestry products, bioenergy, and other

biobased products by means of physical, chemical, biochemical, and biological processes.

Based on statistical analyses of the Bioeconomy Knowledge Center in 2017, the bioeconomy in Spain generated a turnover of EUR 219 million, added value of EUR 65 million and employed 1.42 million.³³⁶

5

What is the main purpose of the dedicated policy strategy, and how does it relate to the SDGs and the Circular Economy? How does it introduce visions, targets, milestones, and action plans?

The national bioeconomy strategy has two elements. From a global perspective, they address the great societal challenges Spain is already facing, including climate change and global food security. In the regional and national context, the strategies intend to increase competitiveness and boost economic growth by promoting innovative technologies and the internationalization of biobased companies. Moreover, Spain seeks to develop a diversified and more environmentally sustainable economy in which bioeconomy is seen to contribute specifically to rural development and stronger territorial cohesion.

No direct reference is made to the SDGs, however the strategy can be viewed as in line with advancing the transition to a circular economy, as launched by the European Commission in 2015.

On adoption of the strategy in 2016, the government also published the First Annual Action Plan for 2016 with five main actions and a budget estimate. The strategy document proposed the publication of annual action plans at the beginning of each financial year. However, the second action plan was published in 2018. The five main actions and most of the submeasures from the first action plan remain the same: 1) to promote public and private research and company investments in innovation, 2) to reinforce the social, political and administrative context, 3) to promote the competitiveness and development of the market, 4) to develop demand for new products, 5) plan to expand and promote the bioeconomy.

It was announced that the Spanish Strategy on Bioeconomy would be updated in 2019, but this has not yet taken place.³³⁷

6 What are the priority areas of the strategy?

From the beginning, the national bioeconomy strategy document explicitly emphasizes that the transition to a sustainable bioeconomy will be driven by innovations in the **biosciences** and **digitization**. The strategy builds strongly on the competency and economic importance of the **agrifood** and **forestry** sectors to promote more sustainable production and lead bioeconomy development. In this respect, new technologies and innovation should contribute to improving the efficiency of productive, organizational and logistics processes. For example, **cropping systems** should be improved by sustainable intensification practices and “**omics**” **technologies** as well as precision farming tools. New processing, packing, conservation, and cold chain technologies should help to **reduce waste** throughout the supply chain while also improving the nutritional quality of traditional and new functional products. In the forestry sector, the strategy stresses the implementation of sustainable resource management systems. Knowledge gained in the field of **genetics and genomics** should contribute to increasing the sector’s productivity. In doing so, the useful life of traditional **wood products** (e.g. construction, packaging, furniture, etc.) should be extended. The strategy promotes the development of high-tech materials, such as wood composites, to increase added value as well as material efficiency.

The strategy document seeks to foster positive spillover effects from the primary sector to bioinnovation

in other **industrial** sectors. For example, by supporting **biorefining** projects, which use residues and by-products from agriculture and the food industry, to develop a range of new biomaterials and bioproducts (including biolubricants, bioplastics, food additives, cosmetics, solvents, chemicals, etc.). Advances are also anticipated in the **bioenergy** field, in particular by developing new ways of synthesizing biofuels through the use of thermochemical or biochemical technologies and of using alternative feedstocks, especially organic waste and residues. Furthermore, the Spanish strategy targets the promotion of **marine biotechnology** and development of the blue bioeconomy, which uses a variety of marine compounds (such as enzymes, polymers, carbohydrates, etc.) to obtain pharmaceuticals, chemicals, and other bioproducts. Great potential is also attributed to the production of biomass from non-conventional sources (such as algae and microorganisms). Spain has been impacted by hot weather conditions and seasonal droughts. Consequently, the policy paper stresses that bioeconomy development can only be based on the efficient and sustainable use of **water resources**, i.e. by promoting adequate water management and water reuse across sectors.

The strategy also highlights the importance of the bioeconomy’s **social dimension** and underlines the need for public engagement. In particular, the acceptance of new and innovative technologies would create the basis for further bioeconomy development.³³⁸

7 What policy instruments are put forth in the strategy (and its action plan)?

Spain takes a comprehensive approach to developing the national bioeconomy. The first action plan provides a budget estimate for research and innovation funding composed of European Union funds (H2020), general state administration funds, and regional administration funds. In 2016, the available funds were estimated to add up to EUR 230 million. The strategy document plans for a total bioeconomy budget of EUR 1.1 billion up to 2020. No further funds are defined in the second action plan.

The Spanish strategy defines a mix of public **research and innovation** programs funded under Horizon2020 and RIS 3, which provide EUR 570 million. It further specifies the support for new multidisciplinary alliances which will be funded, e.g. under Horizon2020, the State Scientific and Technical Research and Innovation Plan and further innovation programs in the context of Rural Development Programs (PDR), providing around EUR 696 million. The promotion of public-private sector collaboration in order to enhance existing value chains and to cre-

ate new ones is an important pillar in the strategy. Successful public-private partnership models will be analyzed to develop a database of best practices for bioeconomy-related public research projects.

The government promotes clusters and IT platforms, including campuses of excellence, to build up a state-of-the-art bioeconomy **infrastructure** and to enhance networking activities among stakeholders. Co-funding by the private sector is considered important in these activities, e.g. when it comes to pilot and demonstration plants. However, a large commercial biorefinery on the scale of France or Finland is not yet foreseen.

With respect to measures promoting **capacity building and education**, the strategy places emphasis on new training and education programs that answer the needs of the private sector, such as bioeconomy curricula in universities. The policy document also highlights the need for train-the-trainer programs to ensure the professional management of research projects at universities. In terms of fostering public awareness and further education, the strategy supports the development of tools and materials for self-learning, including open access platforms. As of 2018, 21 dissemination and training courses were organized (8 by the central administration and the autonomous regional communities, 7 by universities, and 6 by private entities).³³⁹

The Second Action Plan specifies developing at least 2 courses for those engaged in training in the management and financing of bioeconomy-related projects (e.g. in Castilla León and Andalusia).

The government seeks to mainstream **commercialization** support for bio-based products in existing policies and measures of the ministries, and in the activities of the trade promotion agencies. The strategy also supports communicating and demonstrating the various success stories of biobased innovations and their positive effects (including increased productivity and job creation) to foster awareness in the business community.

Another package of measures relates to promoting bioeconomy development on the **demand side**, including the organization of an annual bioeconomy conference (not yet delivered) for which the action

plan in 2016 foresaw a budget of EUR 10,700. To raise awareness of the bioeconomy, the strategy stresses the need to create stakeholder dialogue platforms and design a communication strategy. The strategy also highlights the development of a public procurement policy and labeling systems to increase demand for biobased products. In addition, the strategy lists the need to give visibility to bioeconomy actions through a specific website and newsletter.

The Second Action Plan highlights results from the report by the Spanish Foundation for Science and Technology (FECYT) on social perception of the bioeconomy. This project was based on discussions with 20 focus groups throughout the country and resulted in varied conclusions: among them the limited knowledge of what underpins the bioeconomy and the need to improve information and communication.

The strategy highlights the need to improve the regulatory **framework conditions** to provide incentives for bioeconomy development and remove barriers. This should be achieved, for example, by identifying and overcoming legal and administrative hurdles in order to bring biobased products to the market.

The Spanish bioeconomy strategy seeks to foster **good governance** in the bioeconomy, notably by forming a Spanish Bioeconomy Observatory, which includes a Bioeconomy Strategy Monitoring Group composed of representatives from ministries and autonomous communities. A Strategy Management Committee, composed of representatives from the Strategy Monitoring Group, a Technical Scientific Support Group, and the Technological Networks Group will monitor and reinforce the implementation of support measures.

With a view to international collaboration, the government seeks mainly to increase cooperation and exchange with other EU member states and with the Latin American countries active in bioeconomy development. Furthermore, the strategy stresses the importance of international monitoring activities and seeks to contribute to such efforts.

The Second Action Plan calls for the preparation of a map of the bioeconomy in Spain identifying indicators and capacities (e.g. research groups, facilities,

projects under development, and technology companies working in the field) as well as smart monitoring

and gathering of financing opportunities, collaboration, and market prospecting.

8

How is the implementation of the strategy monitored and evaluated?

Implementation is monitored through the Bioeconomy Strategy Monitoring Group, the Strategy Man-

agement Committee, a Technical Scientific Support Group, and the Technological Networks Group.

9

Do dedicated regional bioeconomy policy strategies exist?

At the regional level, 8 out of 17 autonomous regions are promoting bioeconomy developments.³⁴⁰

In 2017, the Extremadura regional government announced the “**Extremadura 2030**” policy strategy which targets various bioeconomy-related topics.³⁴¹ Bioeconomy policy is treated under the umbrella of the green and circular economy. The strategy seeks to strengthen regional specialization in the agrifood, forestry and wood processing, clean energy, green tourism, and health sectors. It calls for improved resource management, i.e. by means of reuse and recycling technologies as well as sustainable water management practices. Agroecological practices are also considered important for promoting green agriculture. In addition, the strategy aims to encourage new business models for the “4th industrial revolution” which are based particularly on circular approaches but also on integrating physics, digital, and biological technologies.

The **Andalusian Circular Bioeconomy Strategy**³⁴², approved by the Andalusian Government in September 2018, focuses on the areas of bioeconomy activities that are less developed in the community and therefore need greater institutional support. It sets the time horizon for 2030 and dedicates EUR 1.4 million aimed at specific actions that have been developed with the collaboration of more than 50 external experts from the sectors of interest. It sees the bioeconomy as key to sustainable development as well as an opportunity for increased knowledge and business for the industries and the citizens of Andalusia. Relevant sectors for the bioeconomy in-

clude agriculture, forestry, fishing, food, and paper production, as well as part of the chemical, biotechnology, and energy industries.

The Government of **Castilla y León** released the first **Agrifood Bioeconomy Strategy** in Spain in 2019.³⁴³ The main objectives of the plan are to 1) increase the profitability of agricultural and livestock farms and related industries through sustainable and competitive production in a climate change environment, 2) to use by-products/residues from agricultural or livestock production and reincorporate them into the agrifood value chain under the principles of the circular economy, 3) develop new treatment and extraction processes to obtain sustainable bioproducts and cleaner energy, 4) efficient and sustainable use of water. The plan establishes five lines of action through 42 programs to achieve the objectives. The Ministry of Agriculture and Livestock will allocate EUR 5 million a year to boost the agrifood bioeconomy. The plan is the result of the work carried out through the Agri-Food Research and Innovation Map, launched in 2016, with a budget of EUR 10 million per year, and with 168 projects underway in the sector.

A new regional bioeconomy strategy was released with an emphasis on showing the possibilities of the circular forest-based bioeconomy in the **Basque Country** and how it can help to create new productive models that promote sustainable economic development.³⁴⁴

In 2018, plans were announced for the creation of an **Aragonese Bioeconomy Strategy**. In the same

year, the President of Aragon, Javier Lambán, inaugurated the Center for Innovation in Rural Bioeconomy.³⁴⁵

The preparation of a bioeconomy strategy is underway in Valencia. A first “Workshop on European Bioeconomy Strategy. Opportunities for Comunitat Valenciana” was held in September 2016, which concluded with setting-up a Standing Group to be led by the Regional Government to articulate the strategy of the region in bioeconomy and a corresponding Action Plan.³⁴⁶

The Government in Catalonia has approved the basis for a Catalan Bioeconomy Strategy for the period 2021 – 2030, which should be drafted in line with the SDGs and the EC Strategy. It is seen as both a necessity and an opportunity for the agricultural, forestry, and fishing sector to improve competitiveness and sustainability. The Strategy is expected to be deployed in triennial action plans, the first of which will be applied in the period 2021 – 2023.³⁴⁷

In addition, the governments of **Asturias**, and **Region Murcia** are in the process of preparing bioeconomy strategies.

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United Kingdom

1

What have been the major developments in bioeconomy policy over the past decade?

As a biologically resource-poor country, the UK has sought to capitalize on its strengths in adding value to byproducts and waste and building off a strong knowledge base that is well connected to industry.

In 2011, the **Natural Environment White Paper (NEWP)**³⁴⁸ laid out a sustainable vision for agriculture for the next 50 years. This would give rise to the “green food” project, for example, dedicated to sustainable intensification in agriculture and the food supply chain. This year also brought about the publication of the **Anaerobic Digestion Strategy and Action Plan**³⁴⁹ the aim of which was to help divert waste from landfills, reduce greenhouse gas emissions, and produce renewable energy.

Following a **Biomass Strategy**³⁵⁰ in 2007, a specific UK **Bioenergy Strategy**³⁵¹ was adopted in 2012, envisaging the use of biomass as mandatory in order to meet the targets of the UK’s decarbonization by 2050 and emphasizing the use of various waste materials and perennial energy crops.

The **High-value Manufacturing Strategy**³⁵² of 2012 was a re-industrialization strategy aimed particularly at the commercialization of innovative technologies. Among other actions, it fostered industrial projects associated with the development of biofuels, bio-based plastics and materials, and industrial biotechnology. Accordingly, the **2014 – 2015 strategic plan of the UK innovation agency** (InnovateUK) explicitly named the agricultural

sciences, biosciences, and advanced material sciences as key areas for a high-value industry, the food supply chain, and resource efficiency. The Biotechnology and Biological Science Research Council (BBSRC) also concentrated on the promotion of biosciences in its 2010 strategic plan titled “**The Age of Bioscience.**”

The first strategy for agricultural technologies, **Agri-tech Industrial Strategy**,³⁵³ was published in 2013, specifically aimed at technology transfer and the commercialization of agricultural and forestry research.

The UK published its own innovation strategy for forestry in 2013 with the **Science and Innovation Strategy for Forestry**.³⁵⁴ The aim of the strategy was to strengthen the ecosystems and resilience of the forests, and contribute to a sustainable, low-carbon timber industry. Similar key aims for marine research were defined in the **Marine Science Strategy 2010 – 2015**.³⁵⁵

In a 2015 parliament-driven policy report on “**Building a high value bioeconomy: opportunities from waste**”,³⁵⁶ an attempt was made to prepare a national bioeconomy strategy and to leverage biogenic residues and waste as a resource for high-value products and in turn promote a circular economy. Similarly, the **UK Synthetic Biology Strategy Plan “Biodesign for the Bioeconomy” (2016)**,³⁵⁷ based on the **Synthetic Biology Roadmap (2012)**,³⁵⁸ placed synthetic biology at the innovative heart of the bioeconomy and set out to achieve a GBP 10 billion market for synthetic biology by 2030.

The **Clean Growth Strategy (2017)**³⁵⁹ sets out to decarbonize all sectors of the UK economy through the 2020s and strives to support the bioeconomy by developing less carbon-intensive products such as biobased chemicals, plastics, and other materials.

After much anticipation from academia and industry and over two years of development, the UK launched its own dedicated bioeconomy strategy in 2018, **“Growing the Bioeconomy: Improving lives and strengthening our economy: A national bioeconomy strategy to 2030,”**³⁶⁰ with the aim of doubling the size of the bioeconomy’s impact. Previous roadmaps and strategies were updated and bundled together under the leadership of the Department for Business, Energy and Industrial Strategy (BEIS) to form an industrial strategy that focuses on capitalizing on world-class R&D and leveraging greater investment.

The **“25 Year Plan to Improve the Environment” (2018),**³⁶¹ which provides a comprehensive plan for the UK’s natural environment, contains many elements relevant for the bioeconomy, such as waste management and plastics pollution. The plan additionally called for the publication of a new **Resources and Waste Strategy (2018)**³⁶² which sets the targets of a zero avoidable-waste economy by 2050, phasing out avoidable plastic waste by 2042, and eliminating food waste from landfill by 2030.

The establishment of the national funding agency, **UK Research and Innovation (UKRI)**, in 2017 by the Higher Education and Research Act brought together seven Research Councils, Innovate UK and Research England as one organization, to invest in science and research with a combined budget of more than GBP 7 billion.

2

How is the dedicated bioeconomy strategy embedded into the wider policy context?

The Bioeconomy Strategy seeks to be consistent with the broader priorities of delivering clean air, clean growth, and increased productivity. The strategy sits alongside the government’s UK Industrial Strategy White Paper (2017), the 25-Year Plan to Improve the Environment (2018), and the Clean Growth Strategy (2017) which all call for the publication of

the bioeconomy strategy as a measure to achieve their goals.

The Strategy is also critically linked to the wider goals, actions and funding of the Industrial Strategy and its four Grand Challenges (Clean Growth, AI and Data Economy, Aging Society, Mobility).

3

Who is the author of the strategy, and how were stakeholders consulted and engaged in the different phases of the strategy process?

The dedicated strategy is a joint strategy between industry, represented by the Bioeconomy Strategy Consortium, and the Department for Business, Energy and Industrial Strategy (BEIS), making the strategy more industry forward than many other national bioeconomy strategies in Europe and elsewhere.

In December 2016, BEIS published a joint call for evidence, together with five industry sector leadership councils, to collect input from the country’s bioeconomy stakeholders. The resulting document,

the Government Response to the Bioeconomy Call for Evidence (2018), brought together over 100 responses from businesses, the research community, trade bodies, NGOs, public authorities, and interested individuals. The development of the strategy brought together various other groups representing agri-food technology, chemistry, industrial biotechnology, medicines manufacturing, and synthetic biology. These groups worked alongside government departments, research councils, and innovation bodies across the UK.

The strategy's action plan also called for continued dialogue with stakeholders on bioeconomy issues through a stakeholder engagement platform.

4

How is “bioeconomy” defined in the main policy strategy?

The strategy defines the bioeconomy as “... the economic potential of harnessing the power of bioscience. A thriving bioeconomy produces innovative products, processes and services that rely on renewable biological resources instead of fossil fuel

alternatives.” Notably, this definition includes all sectors of the economy, even medicine. Under this definition, the UK bioeconomy contributed GBP 220 billion in gross value added in 2014 and supported 5.2 million jobs.

5

What is the main purpose of the dedicated policy strategy, and how does it relate to the SDGs and the Circular Economy? How does it introduce visions, targets, milestones, and action plans?

The strategy seeks to build a world-class bioeconomy in the UK, removing the country's reliance on finite fossil resources while increasing productivity across the country. It envisions the UK as a global leader in developing, manufacturing, using, and exporting biobased solutions by 2030. In particular, the potential of the bioeconomy is seen in its contribution to industry and innovation. The strategy positions itself, in part as a response to Brexit, by focusing on improving a highly skilled workforce, promoting interdisciplinary research, and improving coordination. Furthermore, an innovative biobased economy is viewed as offering opportunities for the development of a more circular economy. The SDGs are not specifically mentioned.

The long-term vision is underpinned by four high-level goals, namely, 1) capitalizing on the UK's world class

R&D; 2) maximizing productivity and potential from existing bioeconomy assets; 3) delivering measurable benefits for the UK economy; 4) creating the right societal and market conditions to allow biobased products and services to thrive. The Strategy sets a quantitative target of doubling the size of the bioeconomy from GBP 220 billion in 2014 to GBP 440 billion by 2030.

The Bioeconomy Strategy Consortium is tasked with developing a 'delivery plan' to realize the actions set out in the strategy. A key aspect of the delivery plan is to develop a bioeconomy sector deal, a partnership between the government and industry on sector-specific issues. Currently, sector deals relating to the bioeconomy include the Life Science Sector Deal (2018) as well as the Chemistry Council Sector Deal (2018).

6

What are the priority areas of the strategy?

The Strategy holistically spans all industrial sectors from agriculture and medicine to manufacturing and energy. Thematic priorities are based on the Industrial Strategy's four Grand Challenges: supporting clean growth through low carbon alternatives, fusing expertise in bioscience with AI, meeting the needs of an aging society through the manufacture of medicines, and developing **advanced fuels** and **lightweight materials** to advance **mobility**.

Emphasis is strongly placed on the fields of **synthetic biology** and **industrial biotechnology** which are seen as key to transformations, such as better medicines, cheaper or more effective materials, healthier sustainable foods, and a cleaner environment. The bioeconomy is viewed as being rooted in **industrial clusters** and **knowledge centers**. This is exemplified in the government's support of multidisciplinary networks like the Networks in Industrial Biotechnology and Bioenergy (BBSRC NIBB) and the Industrial Biotechnology Innovation Centre (IBioIC) in Glasgow. Other examples include the alliance of four open access **biorefinery centers**, known as BioPilotsUK, and the **regional innovation cluster**, BioVale, in Yorkshire and Humber which focuses on value from biowastes and advanced biorefining. By matching research and

innovation with entrepreneurship, the strategy seeks to bring forward more innovative products and processes. **Startups** in the synthetic biology sector have received significant support over the years, coupled with a well-funded nationwide Synbio network which has received almost GBP 300 million in investments through the Synbio for Growth Programme.

With regard to materials, weight is given to investing in the area of **biobased plastics and chemicals** (e.g. UK Plastics Pact, biobased alternatives to adipic acid, biobased alternatives to pesticides, standards for biodegradable compostable and biobased plastics).

The strategy regards **transport fuels from waste** and industrial by-products as another key area, e.g. transforming carbon-rich industrial waste gases from steel mills into jet fuel and the use of gasification technology to convert household waste into transport fuel.

In the field of **medicine**, areas of interest include the processing of alternative waste materials to produce penicillin antibiotics and the use of gene-sequencing to combat the spread of malaria.

7

What policy instruments are put forth in the strategy (and its action plan)?

With regard to **research and innovation**, funding for the strategy is based on the Industrial Strategy Challenge Fund, GBP 4.7 billion worth of research funding to be made available over the next four years including GBP 1 billion for a range of innovation areas linked to the bioeconomy, such as healthcare and medicine, robotics and artificial intelligence, and manufacturing and materials of the future. Although funding for the UK's networks and innovation centers which foster academic-industry partnerships, such as the BBSRC NIBBs, totals GBP 8.2 million as of 2017, there are no specific amounts committed to them in the strategy. The Bioeconomy Strategy further points to initiatives such as the UK Plastics Pact, which provides up to GBP 60 million

for Smart Sustainable Plastics Packaging, GBP 20 million of which goes to the Plastics Research Innovation Fund, as a measure for fostering a thriving circular bioeconomy.

The Strategy specifically looks to explore the benefits of a "market intelligence tool" to support evidence-based decision-making in resources allocation. It looks at various potential high-value uses of existing natural resources, showing the relative value that can be derived from different feedstocks such as food waste, industrial by-products, and other forms of biomass while ensuring the natural environment is protected and enhanced.

Investments from the Industrial Biotechnology (IB) Catalyst, which awarded GBP 76 million between 2014 and 2016, are celebrated for helping to accelerate the **commercialization** of industrial biotechnology-derived products and processes.

With regard to **education and capacity building**, the Strategy emphasizes STEM education, vocational training and continuous professional development. It contains a commitment to education and training, with GBP 406 million being put into STEM subjects as well as GBP 64 million for the creation of a National Retraining Scheme.

These build on previous capacity building programs such as the SynbiCITE LEAP – Leadership Excellence Accelerator Programme in the synthetic biology industry, the Knowledge Transfer Network set up by Innovate UK, and the National Productivity and Investment Fund (NPIF), which supports industrial partnerships and new fellowships for early and mid-career researchers.

Demand-side actions are favored, such as the launch of Green Great Britain Week in October 2018, which seeks to inform business and the public on how they can better contribute to tackling climate change. In addition, communication improvements are seen in both the minimization of waste and the maximization of value from unavoidable waste, including collection services, recycling and labelling, and separation technology.

One of the first implementation actions involved developing standards for biobased and biodegradable plastics and other biomaterials.

In order to establish the right **regulatory landscape**, the Strategy calls for the identification of potentially unfavorable aspects of the existing regulatory framework, barriers to introducing new products, as well as investigating intellectual property practices, and policy, regulation and industry guidance on waste. In addition, the strategy looks to identify actions and processes that enable rapid development and deployment of new technologies. On a global scale, the government calls for trade promotion, export finance, and future trade policy activities.

With regard to **good governance**, the strategy makes no mention of goal conflict resolution in the bioeconomy. International collaboration is especially seen as understanding resource flows and creating international supply chains to allow biobased products and services to grow. It is also noted that linking bioeconomies can help establish effective operating standards in an international marketplace.

The strategy looks to capitalize on regional expertise by identifying where the key UK bioeconomy assets can be found, including actual and potential interrelationships. As previously set out in the Industrial Strategy, Government will agree on Local Industrial Strategies that build on local strengths.

8

How is the implementation of the strategy monitored and evaluated?

The bioeconomy strategy consortium is responsible for the delivery plan. The delivery plan is supported by a governance group made up of representatives from government, industry, and the research community. A lead coordinator is assigned to three action groups (government, UK Research and Innovation, and Industry) to help with coordination. The Strategy also seeks to involve different government bodies in the creation of this action plan, such as local/regional authorities, Local Enterprise Partnerships and the Devolved Administrations.

In order to evaluate and monitor the actions set out in the delivery plan, the governance group is charged with establishing a set of key bioeconomy metrics, including economic, environmental and societal impact, which can be monitored and reported on a regional level across the UK. The main metrics for measuring success, however, are economic (GVA, jobs, and productivity).

Do dedicated regional bioeconomy policy strategies exist?

In 2013, **Scotland** published a National Plan for Industrial Biotechnology³⁶³ which set out targets of a GBP 900 million turnover and over 200 companies active in industrial biotechnology by 2025. In 2015, the **Biorefinery Roadmap**³⁶⁴ set out a plan to build a globally competitive biobased industry over a ten-

year period. Scotland was one of the first in Europe to present its own strategy for a **circular economy** in 2016.³⁶⁵ The strategy allocated EUR 70 million between national and European funds to reducing food and building waste.

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Summary

The Evolving Definition of the Bioeconomy

While the term “bioeconomy” has become more mainstream in policy strategies globally, no single common definition prevails. With dedicated bioeconomy strategies spanning almost a decade of development, country **definitions and understanding of the bioeconomy have become more comprehensive and complex**. Concrete definitions of the bioeconomy are provided by all national and regional dedicated strategies analyzed; however, their scope and emphasis still vary.

Bioeconomy strategies and definitions tend to vary with the countries’ technological capacity, natural resource base, and economic comparative advantage. However, in general, most definitions focus on the production and utilization of biological resources to generate high-value biobased products. More than half recognize that the bioeconomy encompasses **all economic sectors**, place bio- and high-tech innovation in the foreground (e.g. life sciences, biotechnology, and other converging technologies), and include bioeconomy **services** in addition to products. A smaller portion consider products, services, and **processes** as part of the bioeconomy (EU, Costa Rica, Germany, South Africa, UK, USA) and an even smaller portion (EU, Germany, Ireland) highlight the inclusion of **all systems** that rely on biological resources, their functions, and principles.

While many countries define the bioeconomy as encompassing all economic sectors, differences persist. Whereas the **health sector** is included in country definitions such as Finland, Japan, Malaysia, Thailand, South Africa, UK, and USA, the EU excludes health biotechnology and biological medicines. Under the proposed National Academies of Sciences, Engineering, and Medicine (NASEM) bioeconomy definition for the U.S., **forestry** is not included since the use of biotechnology and fermentation processes is not thought to be significant enough.

Governments, such as the UK, view harnessing the power of **bioscience** as forming the basis of the bioeconomy. Others, such as Japan, place a strong emphasis on the application of biotechnology and other high-tech aspects of the bioeconomy (e.g. the

fusion of biotechnology with digital technologies such as big data and AI). The USA increasingly emphasizes the **“security”** benefits of the bioeconomy (e.g. protecting against biological threats, developing biotechnology for military use, and safeguarding biological infrastructure and data).

Countries such as Costa Rica and South Africa seek to benefit from their breadth of biological resources and biodiversity by promoting **bioprospecting** in a sustainable manner. In light of deteriorating natural resources, Thailand, Italy, and the Nordic Countries focus on preventing **biodiversity loss** and protecting ecosystems.

The provision of **services** based on biological resources, processes, and principles is increasingly viewed as an essential component of the bioeconomy, with strategies from Costa Rica, the EU, Finland, Germany, Latvia, Nordics, Spain, Thailand and the UK incorporating them into their definitions. The bioeconomy services identified range from construction, catering or accommodation (Latvia) to ecosystem services (Costa Rica and Thailand) or shelter and recreation (Norway).

The evolution of more **comprehensive definitions** is most apparent in the newer (post-2018) or updated strategies (e.g. Costa Rica, EU, Germany, Italy, and Japan). Costa Rica’s bioeconomy definition refers to the Communiqué of the Global Bioeconomy Summit 2018 and the inclusion of a whole range of biological resources and knowledge to provide products and services in all sectors. In Germany, the bioeconomy is clearly recognized as a **cross-sectoral** concept and refers not only to biological resources, but also to biological processes and principles. It further considers **systemic relationships** by addressing the interactions between biological systems and their environment. Furthermore, all new strategies (Austria, Costa Rica, EU, Germany, Ireland, Italy, Japan, Nordics, UK) increasingly draw attention to **side- and waste streams** for conversion into value-added products. Lastly, an important element in the evolution of the concept of the bioeconomy is its **increasing proximity to converging technologies**, such as biotechnology, nanotechnology, information technologies, and digitalization (e.g. the concept of “advanced bioeconomy” in Costa Rica’s strategy).

Bioeconomy Strategy Goals Then and Now

In 2015, the source of political motivation for promoting bioeconomy development varied according to a country's resource endowment, specialization, and economic development track. Oil importing countries with large biomass resources often strived for higher energy independence and sought to increase the added value of their biological resources. Industrializing countries with a significant share of rural population and primary industry jobs also considered bioeconomy development as a means of fostering rural development and social inclusion. Industrialized countries with fewer biological resources and a smaller share of primary industry jobs focused more on the opportunities to be gained from the industrialization of biology and on creating added value from biosciences. More recent strategies consider a wider range of goals. Due to a recognition of the increasing complexity of the bioeconomy and the integration of topics, such as sustainability, climate, and circular economy, there is no longer a clear hierarchy of goals, but rather a **more diverse set of equal goals**.

A range of bioeconomy strategies (Austria, Italy, Japan, Spain, Thailand) seek to address **global societal challenges**. The bioeconomy is recognized as a strategy for coping with **climate change**, particularly for shifting to a low-carbon economy and reducing GHGs, promoting the decarbonization of production and consumption processes, contributing to the Paris Agreement or to better managing the carbon-cycle. In the EU, the **Green New Deal** focuses on climate adaptation and briefly touches on the role of the bioeconomy in reducing GHG emissions, e.g. nature-based solutions.

The relationship between the **Sustainable Development Goals (SDGs)** and the bioeconomy has solidified since their adoption of the 2030 Agenda for Sustainable Development in 2015. Almost all strategies highlight the bioeconomy's contribution to the SDGs, either its link to promoting a sustainable economy or as part of their overall sustainability policy. Interestingly, only Germany's strategy acknowledges that not all SDGs can be achieved simultaneously, and that it is necessary to weigh opportunities, challenges, and trade-offs.

Emphasis is increasingly placed on a **transformation of both economy and society**. The EU calls for a "green transformation", an economically sensible and ecologically sustainable reorientation of the economy and society and a **systemic change** in the production and consumption of resources. Austria strives for a sustainable **social transformation** in which the general public is able to form qualified judgements about bioeconomy-related topics. Japan and Spain highlight the importance of the bioeconomy's social dimension and underline the need for public engagement, particularly with regard to the acceptance of new technologies. Austria, Germany, and the Nordics emphasize the need for changes in behavior and values, both for producers and consumers, and the Austrian government is committed to **reducing per capita consumption**.

Of almost equal importance to all countries analyzed in this report is the pursuance of an economic agenda aimed at **growth and job creation**, especially in **rural areas**. The bioeconomy is increasingly viewed as a strategy for **reindustrialization**. For example, in the EU, Germany, Italy, and UK, the bioeconomy is highlighted for its ability to transform former coal or structurally weak areas, contribute to the renewal of industry, or modernize the primary production sectors. Italy focuses strongly on the conversion of **abandoned land** and industrial sites such as former chemical complexes. Latvia's strategy can be seen as a response to decreasing employment due to **structural changes** in the agricultural sector. In addition, bioeconomy strategies continue to include comprehensive research and innovation agendas focused on new knowledge, technologies and skills, often to secure international competitiveness or simply boost economic growth.

Strategies that have been updated, such as the EU, Germany, Italy, and Japan, reveal a desire to maximize impact by better aligning with other policy priorities and to further expand the biobased economy. One of the central aims of the updated EU strategy is to **adapt to a policy context that has significantly changed**, especially with regard to the EU Circular Economy and the Paris Climate Agreement and the 2030 Agenda for Sustainable Development. More recent strategies such as those of Ireland and the UK respond to the uncertainties brought about by **Brexit**. In Japan, the bioeconomy strategy positions

itself in response to global changes in **international power structures**, with the world's center of economic power shifting from the existing industrialized countries of Europe, Japan and the US to developing countries in Asia and Africa. It views the global trends of rapid population and economic growth in Asia and Africa as not only contributing to social challenges such as environmental degradation, but also increasing demand for goods, such as better tasting and healthier food varieties, and medicines.

Costa Rica, Italy, and Japan's strategies/action plans were released in the aftermath of the global **Covid-19** pandemic and accordingly recognize the potential of the bioeconomy to produce more efficiently, reinvent economies, maintain value chains, and sustain jobs and livelihoods, while ensuring the sustainable use and rehabilitation of nature. The Italian action plan points to the resiliency of the bioeconomy and consequently sees it as an area for accelerating the post-Covid-19 departure. However, the topic of the bioeconomy contributing to increased **resilience** plays a less significant role in strategies, with the exception of the Nordic countries. Japan's updated strategy published in 2020,³⁶⁶ highlights the bioeconomy's role in the post-Covid-19 era in developing measures against future public health crisis (e.g. diagnostic and therapeutic methods, vaccines, devices, and systems for emerging infectious diseases) and in building an efficient supply chain that combines globalization and self-sustainability, as well as centralization and decentralization (e.g. strengthening of domestic production in the short term and building a strategy and efficient global supply chain in the long term). Further consequences of Covid-19 have not been dealt with in this report; however, dynamic developments in this area are expected in the future.

While Japan, Malaysia, South Africa, and the USA consider innovations in the bioeconomy as important for improving **human health** (e.g. early disease detection and cheaper, accessible medicines), no strategy takes up the concept of "One Health" or an integrated approach to mitigating health threats at the animal-human-plant-environment interfaces.³⁶⁷ Discussion in the academic world regarding systemic solutions that deliver co-benefits across health, environment, and the bioeconomy, do not appear to have entered the bioeconomy policy realm as quickly.

While there appears to be a shift from a sectoral to a systemic focus in bioeconomy strategies, it does not appear that these changes are accompanied by an increasing recognition of interlinkages between environment, economy and society, an emphasis on transforming both the economy and society, a more concrete role for transitions thinking, including adequate room for policy innovation and experimentation, as well as long-term targets and multidimensional goals.³⁶⁸

Role of the Circular Economy

A decisive trend in newer dedicated bioeconomy strategies is the heightened role of the circular economy. The relationship between these two concepts, however, remains rather vague.

On the one hand, the EU and Italy view the **bioeconomy as a subsector of the circular economy**. The strategy in Italy refers to a transition towards a "circular bioeconomy" where the production and use of renewable bioresources and their conversion into value-added products is part of a circular system that will make businesses more economically viable and sustainable in the long term. Similarly, France, Latvia and Norway view the bioeconomy as an essential part of the circular economy and the UK as an opportunity for developing a more circular economy. The potential contribution of the bioeconomy to the circular economy, however, is not thoroughly explored.

On the other hand, the view that the **bioeconomy is circular by nature** has gained traction. Strategies in Austria, Costa Rica, Germany, Japan, Malaysia, and the Nordics view circular concepts as essential elements of the bioeconomy, for example, by expanding traditional value chains and linking value chains to create new and efficient value creation networks, following the guiding principle of cascading use. Similarly, the bioeconomy in Ireland promotes circularity through innovations that reuse and recycle materials and maximize resource efficiency.

These distinctions, however, are not always clear. In Costa Rica, the concept of a circular bioeconomy goes beyond seeking efficiency in the use of fossil resources, but rather aims to replace them. Thai-

land's BCG Model attempts to integrate the bioeconomy, circular, and green economy. In general, few attempts are made in bioeconomy strategies to create synergies between the two concepts or develop links between them (e.g. in the area of waste management or chemical use).

Core Elements of Bioeconomy Policy Strategies

Dedicated bioeconomy strategies typically provide a vision statement with a number of goals, objectives, and qualitative targets. Less frequently, quantitative targets are provided which focus on increasing economic output, employment or exports (Finland, Italy, Latvia, Malaysia, UK). Principles and guidelines that align with the SDGs are laid out in the strategies of Austria, Germany, Ireland, Japan, and the Nordics. The extent to which policy goals are translated into concrete measures continues to be limited, with vaguely defined measures and budget appropriations (with the exception of Germany, Spain, and Thailand where separate press conferences were held and financial support indicated). However, without clear targets, milestones, timelines, an inventory of resources and constraints, and indication of responsible bodies, the implementation of strategies is impeded.

The trend towards developing a corresponding **action plan** is on the rise. Less than half of the countries have published action plans (EU, France, Ireland, Italy, Norway, Spain) thus far and Costa Rica, Germany, Japan, and the UK are in the process of creating them. Action plans vary significantly from more concrete policy measures with appropriate indicators and some milestones (EU), to regular progress reports with identified leads, co-leads and key consultative stakeholders (Ireland), to a more general guiding document for how main policy actors should best collaborate (Norway). The action plans are formulated in different ways, some have outsourced their development to public research and innovation corporations (Norway), consortia representing the government, industry and research community (UK), other multi-stakeholder bodies (Costa Rica) or more high-level interministerial working groups such as in Italy and Ireland.

In most countries, significant efforts have been made to involve stakeholders in the strategy development process. Typical engagement elements include a consultation process, calls for evidence to collect input from stakeholders, stakeholder working groups to set up draft documents, public consultation, inter-agency efforts, and conferences. While countries are increasingly applying a **participatory, multi-stakeholder process** to consider input from a broad knowledge base and to foster a society “buy-in,” the extent to which these strategies mobilize actors to engage and align with the shared vision requires further investigation.

It is worth noting that some countries and regions e.g. (including the EU, Germany, Italy, and Japan) have already updated their dedicated bioeconomy policy strategy based on a comprehensive strategy review process, while others have not. South Africa and the USA, as examples, demonstrate the potential implications of this. In the USA, the vision of the bioeconomy has changed significantly over the years; however, no single agency has a clear lead in advancing U.S. bioeconomy goals. Instead, individual agencies advance different interpretations of the bioeconomy. In the USA and South Africa, the focus today is more on regulating modern biotechnologies than on the further development of policy strategies.

Prioritization and Specialization in Policy Strategies

Almost all countries look to make advancements in **sustainable and innovative primary industries** (agriculture, forestry, fisheries) through improved cultivation, harvesting and processing technologies, precision farming, utilization of digitalization, organic farming, urban and vertical farming and so on. The **forestry sector** of the bioeconomy is prioritized in the strategies of Austria, Finland, Ireland, and Japan. Austria and Finland's strategy not only focus on paper and pulp production and bioenergy, but also see opportunities for great growth potential in **new and advanced materials** based on cellulose, lignin, wood fiber, wood wool, and fiber plants. Austria, Costa Rica, Japan, and the Nordics focus on **wooden construction**.

Recent key discoveries on **microbiomes** are seen as offering solutions in the EU and Italy for primary

production and food systems to restore and better manage soils. In Austria, Finland, South Africa, and Spain, the bioeconomy is tied to the **protection of water resources**, whether by improving technologies for water efficiency and water recycling in Finland or by sensibly utilizing unused nutrients in sludge from biogas or sewage plants in Austria.

Many dedicated bioeconomy strategies (Austria, Costa Rica, EU, Finland, France, Germany, Ireland, Latvia, Nordics, Norway, Spain, Thailand, and the UK) have at their heart **biorefinery** development using by-products and residues from primary industries and the food industry to develop novel, high-value biomaterials and bioproducts, and add value to waste. The EU plans to develop a roadmap for the deployment of 300 biorefineries on a small and decentralized scale with a focus on sustainable chemicals. Italy sees biorefinery development as an opportunity for the reindustrialization and decontamination of former oil refineries and chemical plants in rural and marginal areas. Other countries, such as Costa Rica, Latvia, Ireland, France, Nordics, similarly see biorefinery development as essential for rural areas to maintain a degree of self-sufficiency.

The EU, Germany, Ireland, and Latvia and point to the potential of “**new products**” with completely new functions and the potential to create new markets. **High-performance biobased materials** (e.g. lightweight, durable, and safe) are a central focus area for exploration in Japan’s strategy. Austria, Japan, Malaysia, and the UK prioritize **biobased plastics** and the EU, Japan, and Malaysia call for plastic-free seas and oceans by emphasizing marine biodegradable plastics. France highlights **protein production** as a source of new and alternative food resources, while Austria and Costa Rica emphasize insects as a sustainable source of protein for animal feed. Bioeconomy development is strongly related to the **medical sector** in Japan, Malaysia, and Thailand, e.g. through precision medicine, vaccine and biopharmaceuticals, biosimilars, medical devices, regenerative therapy, and herbal extraction for medicine. Japan places special emphasis on digital health through Big Data collection and AI for evidence-based individualized and stratified medical care, remote diagnosis, and nursing care. Ireland and Norway have growing **biopharmaceutical** sectors, and in Ireland **biobased nutraceuticals** are actively encouraged.

Bioprospecting plays a major role in the strategies of Costa Rica and South Africa, including exploring opportunities in **indigenous knowledge systems** (IKS), to develop the largely informal markets for natural and plant medicines. **Functional food** markets are explored in Ireland, Japan, and Thailand. Malaysia and the Nordics promote innovations in food production systems, and developing new and healthy food and pharmaceutical products.

Across dedicated bioeconomy strategies, countries place a decidedly different emphasis on the **role of technology**. Whereas the EU, Finland, and the USA have a strong focus on the application of biotechnology in general, Japan, South Africa and the UK also focus on industrial biotech; Costa Rica, Germany, Thailand, UK, and the USA on synthetic biology; and the EU, Italy, Ireland, Latvia, Nordics, Spain on marine biotech.

All strategy papers mention the importance of **converging technologies and digitalization**. The EU, Spain, and the UK specifically look to **fusing bioscience with robotics and AI**, and Austria to **biodigitalization** to encourage the development of new, innovative and sustainable products and applications. Japan looks to capitalize on innovative solutions brought about through **biofoundries**.

The strategies of EU, Finland, Ireland, and Italy see great potential in developing new **urban bioeconomy hubs/cities** specifically with regard to urban biowaste and the redevelopment of urban brownfields (derelict and contaminated sites), but also with regard to experimental smart green urban infrastructures (e.g. urban farms, community gardens). Costa Rica’s strategy also intends to further develop the concept of the bioprincipled city by experimenting with sustainable management and valuation of solid waste residues, interurban biological corridors, as well as urban design approaches inspired by biological principles, processes, and systems. In general, the concept of the bioprincipled city has received little attention in dedicated bioeconomy strategies since 2015; however, similar concepts are emerging around the world under the term nature-based solutions. In addition, to date, no urban bioeconomy strategy has been adopted.

Proposed Policy Measures

The following section delves into the role of governments in steering the transition to a bioeconomy by analyzing the political commitment and measures proposed in dedicated bioeconomy strategies and action plans over the past decade. These policy measures were often loosely defined and not supplemented with budgetary allocations. Countries with an action plan (e.g. Spain, France, Norway, Italy, Ireland, and the EU) provided more concrete indications of what measures would be taken to support the strategy's implementation. Generally, the proposed measures focus on both the demand and supply side. Public investment in bioeconomy development typically includes research and innovation funding; infrastructure development; capacity building and education; commercialization support; demand-side instruments; bioeconomy-friendly framework conditions; and measures for good governance. In the following section, the report summarizes trends, differences, and specific features of policy measures defined in dedicated bioeconomy policy strategies and their action plans.

A. Research and Innovation Promotion

Public research and development funding continues to be widely considered a key measure for enhancing the innovation ecosystem for the bioeconomy. Policy strategies specifically highlight the importance of promoting links between fundamental and applied research, and supporting **multidisciplinary research alliances** (e.g. through R&D grants, competitions, and public funds). Countries also underline the need for increased private R&D, e.g. in the form of industry-led consortia. The establishment of research networks and centers of excellence, which aim to ensure continuous stakeholder cooperation and dialogue, is also frequently mentioned. In general, many strategies look to strengthen the **international networking** and cooperation of research institutions.

The development of **bioeconomy hubs, networks, and clusters** is also considered important for bringing together stakeholders, ensuring learning from best practices, and encouraging regional innovation ecosystems. Cluster development appears to be the

most commonly used term for increasing cooperation across sectors, industries, and thematic areas. A popular concept in Asia (Thailand, Malaysia, Japan) has developed following the Singaporean example of the so-called "**Biopolis**" in which major research institutes come together to create a center of excellence in bioeconomy experimentation.

In general, it appears that **technological innovation** is promoted over other types of innovation such as organizational or social. Exceptions can be found in Austria, Costa Rica, Germany, Japan, and the EU where the focus is also on promoting open innovations.

Only Germany touches on the need to provide **space for experimentation**, e.g. providing funding for "open research" where science can pursue unfamiliar paths. Furthermore, the involvement of society and other research activities aimed at shaping social change are also considered important. A central focus of the Japanese strategy is to strengthen the relationship between science and society by promoting ELSI-related research in collaboration with the fields of humanities/social sciences and natural sciences, as well as public dialogue. In Germany, publicly-funded citizen science projects are promoted in cooperation with educational institutions such as museums or botanical gardens.

Costa Rica's strategy pursues a broad concept of innovation which spans technological, social, and economic innovations. South Africa fosters innovation based on traditional knowledge (e.g. bioprospecting using Indigenous Knowledge Systems). "**Safe innovation**" is a new topic in the strategies of Germany and Japan particularly referring to the harmonization of digital data, efficient data management systems, the further development of interface concepts, and the development and use of standards.

Bioeconomy monitoring approaches have been developed in Austria, EU, Germany, Italy and the USA, however differ scope and depth. The EU strategy seeks to better track economic, environmental and social progress and highlight trade-offs and synergies through an EU-wide monitoring system. The BioMonitor project, a consortium of universities, statistical and standardization institutes, consultancies and data modelling experts has already begun setting up the assessment framework to track progress

towards a sustainable bioeconomy and document its impact on biodiversity, ecosystems, and climate change. Italy plans to adjust its indicators based on this new EU monitoring system.

The promotion of **public-private partnerships** remains highly relevant in almost all the countries analyzed to ensure jointly funded innovation projects and to spread risks. The EU has taken the lead with the EUR 3.7 billion Bio-Based Industries Joint Undertaking (BBI JU) public-private partnership to kick-start demonstration and deployment of biorefineries and new value chains. The Nordic countries intend to set up a digital Nordic/Baltic Bioeconomy Portal to facilitate public-private partnerships and cluster-to-cluster collaboration. Furthermore, public-private partnerships should ensure open access to test and demonstration centers.

The goal of enhancing technology transfer remains of central importance to all bioeconomy strategies. In addition to fostering multi-user **pilot and demonstration** facilities, establishing **biorefinery demo plants** is considered most relevant in almost all strategies.

B. Infrastructure Investments

With regard to bridging the gap between demonstration and industrialization, we see large-scale biorefinery development in Finland, France, Ireland, Italy, and Norway. Italy's action plan centers on investments in flagship projects aimed at the development of infrastructures in urban biowaste and national multi-input and multi-product biorefineries. In Germany at state level, EUR 550 million in foreign investments from UPM is supporting the development of an industrial-scale biorefinery, with the state of Saxony-Anhalt investing EUR 100 million in the chemical park's infrastructure. Thailand has invested THB 3.4 billion to develop a pilot biorefinery in the EECi Biopolis complex.

C. Industry and Commercialization

Dedicated bioeconomy strategies provide a wide array of measures to support industry. From **direct financial assistance** via grants, loans, cooperative

agreements, and tech transfer activities (USA), subsidies and **tax incentives** for making biobased products economically competitive (Malaysia, Nordics) to market access platforms and help reducing administrative burdens (Latvia, Nordics, Malaysia). In general, measures that level the playing field for biobased businesses (e.g. through subsidies, lump sums, tax exemptions) are rather weak and the role of SMEs in the bioeconomy is not widely discussed.

Startup support is more widely seen as a tool to promote bioeconomy innovation (Costa Rica, Germany, Italy, Japan, Nordics), e.g. through open-access infrastructures (Italy), improving bankability and investment-readiness (Italy), special competitions and fairs to support favorable business environments (Costa Rica), and startup ecosystems and global investment (Japan).

Over the past decade there has been an increasing recognition that funding of high-risk investments is still not well supported. Consequently, newer bioeconomy strategies focus on leveraging **greater investment and risk finance** in the bioeconomy. We see this both for demonstration and large-scale deployment activities as well as R&D and **startup promotion**. Venture capital and investment funds for biobased startups are promoted in France, Nordics, South Africa, USA (California), and the UK. The Nordics strategy suggests "green" venture capital in line with Nordic Green Bonds.

The push to **mobilize private capital** for bioeconomy development is seen not only in the increasing role of public-private partnerships but also in thematic investment platforms. The EU launched a EUR 100 million European Circular Bioeconomy Fund (ECBF) with a target fund volume of EUR 250 million to help de-risk private investments for bioeconomy projects (pilot, demonstration, and industrial scale). Under the Eleventh Malaysia Plan (11MP) 2016–2020, Malaysia launched a RM 100 million Biotechnology Commercialisation Fund (BCF 2.0) to facilitate the commercialization of biobased products and services and also to assist the expansion of existing biobased businesses. The Japanese strategy supports the establishment of a green finance system for ESG (Environment, Social and Governance) investment in the biotechnology field.

On a more global scale, strategies (Austria, Finland, Latvia, Norway, and UK) call for **export promotion** policies (e.g. export credit guarantees, trade promotion and marketing efforts).

D. Bioeconomy-Friendly Framework Conditions

While bioeconomy-friendly framework conditions are often held up as effective means to promote the bioeconomy, they are generally weakly specified measures that are kept rather general. On the one hand, strategies focus on establishing the right regulatory landscape (Ireland, Spain, UK, USA) by identifying potentially unfavorable aspects of the existing regulatory framework, barriers to introducing new products, and identifying actions and processes that enable rapid development and deployment of new technologies.

On the other hand, strategies seek to provide better incentives for bioeconomy development. Strategies in Costa Rica, Italy, Norway, and the UK focus on policy, regulation and industry **guidance on waste** (e.g. European Waste Codes, measures relating to single-use plastics, conditions for the collection of organic waste), including identifying incomplete application of laws and sanctions already in force, and the lack of homogeneity in the authorization approach. Costa Rica, Japan, South Africa, and the UK look to investigating **intellectual property** (IP) practices and the protection of genetic resources and knowledge. Other countries (Norway, Nordics, Thailand) focus more on **environmental taxation** (e.g. taxes or quota for fossil-based products, carbon pricing, green tax measures).

The Austrian and Nordic strategies identify a number of framework conditions designed to foster a **level playing field for biobased products**, including compensating companies for additional costs for biobased products, bans on unsustainable products, regulations and standards for using secondary raw materials, and, in the construction sector, to promote the trend of living with natural materials, policy targets for the use of biomass, etc.

E. Demand-side Measures

A more specific route that allows innovative and sustainable products to compete with existing ones has been followed by means of **public procurement policies** (Austria, EU, France, Ireland, Italy, Latvia, Nordics, Norway, South Africa, Spain, UK and the USA and California). In Italy, for example, Green Public Procurement legislation requires that all contracting stations apply Minimum Environmental Criteria (CAM); however, the action plan seeks to increase compliance (e.g. by the municipalities) through clearer requirements and additional training.

Many strategies further promote **labeling, certification, and standards for biobased products** (Austria, EU, Finland, France, Germany, Italy, Ireland, Japan, Latvia, Nordics, Norway, Thailand). Here, we see considerable overlap with other framework conditions that support negative incentives (e.g. Norway, Nordics, Thailand).

A key demand-side measure of increasing importance in almost all bioeconomy strategies is the need to **raise public awareness** (e.g. through fairs, conferences, communication and marketing strategies, dialogue platforms). In Germany, science communication and open dialogue formats have become increasingly popular and a number of citizen science projects are publicly funded (e.g. Science Year 2020|21 on the Bioeconomy). Other measures to increase public awareness include “Bioeconomy Days/Week” to engage industry and wider society in Ireland and Italy. The Spanish strategy underlines the importance of the bioeconomy’s social dimension and focus groups are used to better understand social perception of the bioeconomy. Other techniques include prompting new consumption concepts, e.g. sharing economy, cradle-to-cradle (Austria), consumer behavior and preferences (France).

F. Education and Capacity Building

Support for education and capacity building measures are deeply rooted in almost all bioeconomy strategies. Proposed measures regarding bioeconomy-related education range from programs for lower level school systems (Malaysia, Nordics, US) and general STEM education (Italy, UK) to bachelor,

master and apprenticeship programs (Nordics, USA), continuing professional development and training (EU, France, Italy, Ireland, Latvia, Spain, Thailand, UK) and self-learning tools and open access platforms (EU, Spain). Some strategies focus on preparing for future manufacturing jobs (USA, California), environmental education (Costa Rica), industry partnerships for early career researchers (UK), advanced digital skills and integrating converging technologies (EU, Germany, Japan), and bioeconomy specialists with interdisciplinary expertise (Germany).

In Europe, several academic bioeconomy programs have emerged over the last decade leading to the establishment of the European Bioeconomy University, a new alliance of the six leading European universities in bioeconomy research.³⁶⁸

While still in their infancy, a number of countries (Costa Rica, EU, Finland, France, Italy, Ireland, Latvia, Malaysia, Nordics, Spain) look to new training and education programs that answer the needs of the private sector. The EU Bioeconomy Innovation Bootcamp supports entrepreneurship skills training for researchers, including new business approaches, evidence of enhancing biodiversity and ecosystems, examples of positive synergies with local communities, and interdisciplinary and transdisciplinary expertise advice. Programs and coaching for regulators and investors to support bioeconomy development are notably missing.

G. Good Governance

Dedicated bioeconomy policy strategies vary significantly in scope and depth, in the different objectives they pursue, and the various actors involved in their formulation and implementation. **Coordination of the broad range of bioeconomy actors** and their different interests poses a considerable challenge to bioeconomy development. As a result, the issue of good governance has received an increasing level of attention at conferences and workshops, in political memoranda, and in the publication of scientific papers.³⁷⁰ However, principles of good governance continue to develop faster implicitly in national and international forums rather than explicitly in policy strategies.

Increasingly dedicated policy strategies recognize the complexity of the bioeconomy with its many interacting elements and stakeholders. This is most apparent with regard to the objective of increased **policy coherence and effectiveness** in dedicated bioeconomy policy strategies. Translated into concrete measures, strategies have either relied on **inter-governmental coordination** (Germany, Costa Rica, USA) not just for the purpose of strategy formulation and implementation, or have prioritized policy coordination (e.g. expanding federal-state cooperation through the use of networking activities of regional clusters in Austria and Germany). In the UK and Italy, the strategies look to capitalize on regional expertise (e.g. with local industrial strategies and involving local/regional authorities in implementation).

As indicated above, when it comes to the process of **strategy formulation**, most of the countries have adopted a bottom-up, participatory approach involving science, industry and civil society representatives as well as the public in general. Multi-stakeholder dialogue (e.g. in the form of regional, national or international policy forums) is generally rated as very important for ensuring mutual learning and inclusive participation in the bioeconomy.

In order to foster **interregional coordination** and best practices, the EU strategy will set up an EU Bioeconomy policy support facility (with a focus on central and eastern Europe) to allow Member States to share knowledge and expertise, and receive independent guidance. It also forms a European Bioeconomy Forum to help increase cooperation and facilitate networking/interaction and knowledge exchange among Member States.

International collaboration in the bioeconomy has thus far not been adequately incorporated into dedicated bioeconomy strategies. While most strategies promote international collaboration with a view to strengthening international networking and cooperation between research institutions (e.g. Ireland, Italy, and Norway) or to improve international competitiveness (e.g. removing unjustified trade barriers and expanding markets in the area of agricultural biotechnology in the USA or fostering international supply chains in the UK), there is substantially less attention paid to good governance principles of fairness,

including harmonizing international trade and policy frameworks, ensuring knowledge sharing between industrialized and developing countries, as well as fostering international monitoring activities. There is even far less discussion about issues relating to the global interconnectedness of the bioeconomy, biomass resources, value-added chains, and technologies with international division of labor.

Exceptions can be found in France, Germany, Japan, and the EU. One objective of the Japanese strategy is to increase internationalization by internationally harmonizing systems and data, coordinating with trade policy, and protecting intellectual property and genetic resources. France calls for standardization, international regulatory harmonization and stabilization of the biomass supply as part of its international research and demonstration promotion. The EU and German strategies recognize the need for regular and strategic international cooperation at the multi-partner level and the importance of the Global Bioeconomy Summit as a platform for exchange with international experts beyond research. This was also the impetus for the European Commission to establish the International Bioeconomy Forum, a mechanism for long-term R&D collaboration, in 2017. The German strategy paper also advocates that the bioeconomy should receive greater attention in future international processes (e.g. G20, G7, and annual COP conferences) and that measures and strategies should be harmonized internationally, i.e. through intensified cooperation with the UN FAO.

A new dynamic with regard to **bilateral collaboration** has emerged in the USA, where MoU have been signed between the U.S. states of Maine and Michigan and Finland to foster an exchange of information and cooperation in developing the bioeconomy. While the focus of the MoU in Michigan is predominantly on R&D, the goal is to build long-term partnerships in support of market access and bilateral investment opportunities.³⁷¹

Some countries have established **dedicated bioeconomy advisory councils or stakeholder panels**, for example in the EU, Finland, France, Germany, Italy, Nordics, and Costa Rica has committed to forming one.

Most countries that have an action plan or are in the process of creating one strive for some level

of accountability by establishing **implementation groups** which help promote the evaluation of policy programs and provide for adaptation and feedback-cycles in bioeconomy policy making. For example, Ireland (Bioeconomy Implementation Group), Italy (National Bioeconomy Coordination Group), Spain (Spanish Bioeconomy Observatory), Japan (Bio-Strategy Task Force and the Bio-Strategy Advisory Council), Germany (German Bioeconomy Council), and both Costa Rica and France plan to nominate a National Bioeconomy Council. Others like Norway and South Africa make use of collaboration committees or interdepartmental stakeholder groups. While Finland does not have an action plan, it established a Bioeconomy Panel which is tasked with strategy formulation, review, and update, and is consulted on implementation. In Malaysia, the public agency, Bioeconomy Corporation, is responsible for implementation and monitoring.

The extent to which policy strategies and their implementation groups support on-going learning and include mechanisms allowing for adaptation of their elements is rather unclear.

The few country strategies that propose **metrics and indicators** for measuring success are mostly based on economic performance, e.g. jobs, productivity, exports, investment (Latvia, Japan, Malaysia, South Africa, UK), as opposed to appropriate social and environmental indicators. For example, the Bioeconomy Contribution Index (BCI) in Malaysia specifies five indicators: value-added, productivity, investment, exports, and employment as identifiers of bioeconomy performance. The Japanese strategy not only calls for roadmaps for each market segment with Key Performance Indicators (KPIs), it tasks the Bio-Strategy Task Force with identifying both qualitative and quantitative indices by 2021. Proposed quantitative indicators include market size, investments, and jobs in biotechnology, international collaboration and corporate awareness. South Africa's strategy proposed 18 key quantitative indicators (related to industry, market, knowledge transmission and application, as well as knowledge base and human resources) to track and monitor the strategy. These have yet to be implemented. In 2018, the National Advisory Council on Innovation (NACI) developed a set of indicators to better measure and monitor the bioeconomy's contribution to South Africa's

GDP which include output, employment, exports, investment, and innovation.

Interestingly, **regional bioeconomy policy strategies** are predominantly promoted in Europe (France, Germany, Norway, Spain, and the UK) and Latin America (Argentina and the Amazonas region). Particularly in Europe, this development can be traced back to the policy approaches and funding mechanisms of the European Commission, such as the European

Structural and Investment Funds (ESIF) and Smart Specialization Strategies (RIS3) which help strengthen the bioeconomy in regional and local European areas. While beyond the scope of this report, many of regions have developed modern bioeconomy strategies that delve into important elements of the bioeconomy such as manufacturing (e.g. Baden-Wuerttemberg in Germany). The increasing number of regional strategies points to a growing trend towards regionalization.

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Outlook

This analysis has demonstrated that the trend for developing **dedicated bioeconomy policy strategies** has prevailed in recent years. In 2010, Germany had adopted the only dedicated national bioeconomy strategy in the world, five years later there were seven strategies (EU, Finland, Germany, Japan, Malaysia, South Africa, and the USA), and now, in 2020, there are **19 dedicated national and macro-regional bioeconomy policy strategies** worldwide, including Austria, Costa Rica, EU, Finland, France, Germany, Ireland, Italy, Japan, Latvia, Malaysia, Nordic Countries, Norway, South Africa, Spain, Thailand, UK, USA, and East Africa.³⁷² This trend appears to be on the rise. To the authors' knowledge, Colombia, Denmark, Ecuador, Estonia, Eswatini, Hungary, Iceland, Lithuania, Mexico, Namibia, Puerto Rico, Sweden, and Uruguay are in the process of preparing dedicated bioeconomy policy strategies.

Over the past decade, expectations associated with the bioeconomy have changed significantly and, in many respects, have increased. Today, the bioeconomy is seen as an important driver of economic growth and job creation. Beyond this, the relationship between the **Sustainable Development Goals** and the bioeconomy has solidified since the adoption of the 2030 Agenda for Sustainable Development in 2015, as bioeconomic solutions are increasingly valued for their contributions towards achieving the SDGs. In addition to this, recent policy documents view the bioeconomy as a new strategy for **reindustrialization** and for coping with changing **global political contexts and challenges**, such as the Covid-19 pandemic, fostering resilience, combating zoonotic and epizootic diseases, and biodiversity issues. The effects of the coronavirus pandemic on the development of bioeconomy strategies will be considerable; however, due to time constraints this report was not able to fully explore these issues.

While the term “bioeconomy” has become more **mainstream** in policy strategies globally over the past decade, definitions and understanding have become more **comprehensive and complex** due to the integration of topics such as sustainability, climate, and circular economy. Definitions increasingly recognize the bioeconomy as a cross sectoral concept and include a whole range of biological resources

and knowledge to provide products and services. There also appears to be a growing interest in the potential of the bioeconomy and its interactions with converging technologies, such as digitalization, AI, synthetic biology, and cognitive sciences.

The same applies to **political motivation** for promoting the bioeconomy. More recent strategies consider a **wider range of objectives** and there is no longer a clear hierarchy, but rather a diverse set of equal goals. As a consequence of this growing complexity and diversity of goals, newer or more recently updated strategies seek to **maximize impact** by better aligning with other policy priorities. Strategies highlight the potential role of the bioeconomy for a necessary **transition and transformation** into a more sustainable economy and society.

These endeavors go hand in hand with the recognition that, while the bioeconomy can make a significant contribution to a wide variety of goals, it must also be **governed properly**.³⁷³ This analysis, however, has shown that many policy goals have not been translated into **specifically implemented policy measures**. While more and more countries are committing to developing corresponding action plans, less than half the countries analyzed have published dedicated action plans at this point. Furthermore, action plans vary significantly: From more concrete policy measures with indicators and milestones to progress reports or more general documents on how main policy actors should best collaborate. The shift from a sectoral to a systemic focus in bioeconomy strategies and the emphasis on transforming economy and society does not appear to have manifested itself as concrete policy experimentation, multidimensional goals, and long-term targets.

Today, bioeconomy strategies provide substantial **support for public research and innovation, infrastructure investments, industry and commercialization, and demand-side policies**. Notably, support for education and training measures is deeply rooted in almost all dedicated bioeconomy strategies. However, without a long-term vision, clear targets and milestones, timelines, an inventory of resources and constraints, and indication of responsible bodies,

the implementation of policy strategies will be impeded in the future.

The understanding of the bioeconomy continues to be diverse and demonstrates that there is not one bioeconomy but many. Bioeconomy strategies and definitions vary with the countries' technological capacity, natural resource base and economic comparative advantage. There is also a trend towards increasing **thematic prioritization and specialization** in the political strategy papers. Existing documents, however, often fail to reflect and capitalize on the most **recent discussions in academia and industry**. Current topics of interest, including ecosystem services, "One Health" approaches, critical raw material safety, the use of carbon dioxide and the conversion of carbon-containing feedstocks, as well as the role of hydrogen are not touched on in existing policy documents or only to a limited extent. Furthermore, the latest trends in biomanufacturing, including biofoundries, new and advanced manufacturing processes to produce the (bio) fabrics, medicines, plastics and fuels that underpin society, are rarely addressed. Policy strategies tend to focus instead on biorefinery development. With the exception of a few countries and regions, the concept of a bioprincipled city has also not been further developed and included in policy documents.

Furthermore, coordinating the broad range of bioeconomy actors and their different interests poses

a considerable challenge to bioeconomy development. As a result, **good governance** and multilateral structures for bioeconomy development have never been more relevant than they are today. The report has shown that more and more **multi-stakeholder initiatives** are promoting bioeconomy development and strongly fostering the country's or region's vision of the bioeconomy. Against this background, bioeconomy development is being driven by the increasing engagement of macro-regional and international actors as well as regional activities. The trend towards regionalization demands further inter-regional coordination mechanisms.

While the bioeconomy is represented more in multilateral policy processes and meetings today than in 2010, there is still a lack of international institutionalization. To avoid the replication of efforts and reinforce insights and outcomes, existing macro-regional and global bioeconomy initiatives need to be integrated into **one global platform** that in turn advances regional collaboration. Besides international and interregional coordination, a global platform could also shed light on the global interconnectedness of the bioeconomy, with respect to biomass resources, management of value-added chains, and technologies with international division of labor. Successful sustainable bioeconomies also require the measurement of bioeconomic advances and such metrics must be better aligned at the international level.

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About the International Advisory Council on Global Bioeconomy (IACGB)

The IACGB was initially formed to support the Global Bioeconomy Summit 2015 and has been maintained and extended since. The IACGB is composed of about forty high-level policy experts and drivers of the bioeconomy in all hemispheres. IACGB members act in their personal capacity as experts and do not represent an official government or organizational position. The members combine a broad range of expertise and backgrounds and they are actively involved in different international bioeconomy-related policy and research fora. While currently being an informal mechanism, the IACGB has gained credibility and legitimacy as an expert think tank and are actively working to develop further in the coming years. The IACGB is significantly involved in the development of the GBS2020 plenary agenda and workshop program to ensure its global spirit and its non-commercial nature. The IAC develops and approves policy recommendations on how to promote the development of a sustainable bioeconomy globally. These recommendations have been summarized in the Communiqués of GBS2015 and GBS2018 and new recommendations will be published during GBS2020. Furthermore, IACGB members act as important multipliers and take the GBS messages and the policy recommendations to other global and international bioeconomy networks and policy fora. Documents download and further information is available at <https://gbs2020.net>

About this report

Authors of this study are Lily Teitelbaum, Christin Boldt and Christian Patermann.

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