BIOECONOMY POLICIES LED BY EUROPE AND GLOBAL INNOVATIONS

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"Bioeconomy" is the concept of using biological resources (biomass) and biotechnology to address global issues, such as climate change and food security, thereby achieving long-term sustainable growth. It is also referred to as a bio-based economy of the 21st century, in contrast to a fossil-based economy of the 20th century. In Japan, the government started to draw up its bioeconomy strategy from around 2017, but the concept is still unfamiliar to many people. Meanwhile, in Europe, various policy measures have been taken to realize the bioeconomy since the mid-2000s. The Sustainable Development Goals (SDGs) set by the United Nation in 2015 include many areas where the bioeconomy can help achieve the targets. The concept of the bioeconomy is sometimes called a circular bioeconomy, as several areas overlap with the EU's Circular Economy Strategy which was adopted in December 2015 and is centered on promoting recycling and reducing waste. In this report, an overview of bioeconomy policies/strategies in Europe will be presented together with technology development/innovations that affect the bioeconomy and their applications in industries, as well as the future outlook.

ACTIONS TAKEN IN EUROPE

The chart shows major actions taken by the European Union (EU), some member countries, and other international institutions in the area of bioeconomy.

Chart: Major Actions Taken by EU, etc. in Bioeconomy Area

Year	Led by	Event
2005	EU	Mid-term review of the Lisbon Strategy, a long-term strategy through 2010, focused on knowledge for growth and proposed "a bioeconomy based on knowledge".
2007	EU, Germany	Germany, which held the EU Council Presidency for the first half of 2007, announced report titled "Road to Knowledge-based Bioeconomy" (Cologne Paper) at a conference held in Cologne.
2009	OECD	OECD announced a policy agenda "The Bioeconomy to 2030".
2010	Germany	Germany announced a long-term National Research Strategy Bioeconomy 2030.
		The European Commission and Belgium, which held the EU Council Presidency for the second half of 2010, jointly held a conference and pointed out the necessity of a conprehensive and integrated policy framework.
2012	EU, Denmark	The European Commission adopted Europe's Bioeconomy Strategy, and Denmark, which held the EU Council Presidency for the first half of 2012, held a kickoff meeting.
2013	Germany	Germany adopted the National Policy Strategy on Bioeconomy.
2014	Finland	Finland announced its National Policy Strategy on Bioeconomy.
		The EU and the Bio-based Industries Consortium established a public-private partnership called "The Bio-Based Industries Joint Undertaking (BBI-JU)". BBI-JU decided to invest a total of EUR 3.7 billion for R&D program Horizon 2020.
		The IEA conducted a survey on member country's strategies on bioeconomy.
2015	Germany	The German government organized the first Global Bioeconomy Summit.
2016	Italy	Italy announced its bioeconomye strategy "Bioeconomy in Italy".
		Spain announced The Spanish Bioeconomye Strategy 2030 Horizon.
2017	France	France announced A Bioeconomy Strategy for France.
		The EU's Joint Research Center created the online platform "Bioeconomy Knowledge Centre" to integrate and share information on bioeconomy.
		The European Commission announced its review of the 2012 bioeconomy strategy.
2018	Germany	The German government organized the secound Global Bioeconomy Summit.
		The OECD published "Meeting Policy Challenges for a Sustainable Bioeconomy".
		The EU is to release the revised version of its Bioeconomy Strategy.

Source: Prepared based on information from European Forest Institute, etc. (*5)

In 2005, “a knowledge-based bioeconomy” was proposed at a mid-term review of the Lisbon Strategy (the EU’s growth strategy through 2010). This has been an important theme in the EU, as evidenced by the fact that the topic was repeatedly taken up by Member States such as Germany, Belgium, and Denmark, during the six-month presidency period of the Council of the EU. The EU adopted its bioeconomy strategy in 2012 (*1) and established a public-private partnership the Bio-Based Industries Joint Undertaking (BBI-JU) in collaboration with Bio-based Industries Consortium in 2014. The BBI-JU decided to invest a total of EUR 3.7 billion (EUR 2.7 billion for industries) over seven years from 2014 to 2020 in research-funding program Horizon 2020. As previous research programs centered on research and development and many projects did not achieve practical use, Horizon 2020 focuses on industrial-scale flagship projects as well as demonstration/pilot projects to facilitate commercialization. The BBI-JU categorized call-for-proposal projects into four groups: (1) flagship, (2) demonstration, (3) research & innovation, and (4) coordination and support. It adopted 64 projects from mid-2015 through 2017 with a total budget of EUR 410 million, of which EUR 120 million was earmarked for five flagship projects, and EUR 180 million for 20 demonstration projects. For example, one flagship project is aimed at commercial production of bio-based PEF (polyethylene furanoate), which is superior to PET (polyethylene terephthalate; plastics used for beverage containers, etc.) in barrier and heat resistance properties. The budget for the project is about EUR 25 million, and project members include Avantium, a Dutch developer of PEF technology, as well as German chemical giant BASF, Austrian packaging company ALPHA, food major Nestlé, and Danish toy manufacturer LEGO. Another flagship project is aimed at commercialization of MFC (microfibrillated cellulose), with the scope from production to marketing. The budget is EUR 27 million and project members include Borregaard, a pulp and paper manufacturer in Norway, and Holland-based major consumer goods manufacturer Unilever. In this manner, the public and private sectors have been working together to facilitate technical innovation and reduce costs in large-scale production, in a bid to encourage the use of biotechnology in various industries. Going forward, further commercialization efforts will likely be made by investing funds into other flagship and demonstration projects.

At the Member State level, some EU countries have also developed bioeconomy strategies to create new industries. Germany’s national policy strategy on bioeconomy (*2) encompasses a wide range of policies, including stable supply of food and energy, measures against climate change, conservation of the environment, and promotion of innovation. The country apparently focuses on developing domestic industries. In addition, it aims to take the initiative in international discussions and efforts to establish a framework, with a view to exporting its industrial products in the future. Finland, of which nearly 70% of the total land area is forest, has developed a bioeconomy strategy centered on growth of the forestry and pulp & paper industries (*3), which were hit hard by the wider use of IT in the 2000s. The country intends to make these industries evolve into sustainable materials industries. In 2017, Metsä Group opened its next-generation bioproduct mill that uses no fossil fuels. With a cost of EUR 1.2 billion, the mill is the largest investment in the history of the Finnish forest industry. As a result, pulp production increased from roughly 0.5 million tons to 1.3 million tons.

In 2017, the European Commission released its review of the 2012 bioeconomy strategy (*4). Based on the findings, it is to release the revised version of its strategy, which will likely focus more on innovations to drive economic growth, as well as sustainability, including recycling.

INNOVATIONS AND APPLICATIONS IN INDUSTRIES

While bioeconomy policies are led by Europe, technology development and innovations, which should affect the bioeconomy, have been taking place in different places around the world. For example, biology has evolved significantly since the second half of the 20th century. The discovery of the double-helix structure of DNA opened the door to molecular biology (study of biology at a molecular level), and led to genetic engineering (manipulation of an organism's genes). Human Genome Project (HGP) launched in 1990 took 13 years and cost roughly USD 3.0 billion to analyze human genome data. With huge advances in genome sequencing technology, it now takes only one day and costs about USD 1,000, if Illumina’s next-generation sequencer is used. UK's Oxford Nanopore Technologies has developed the next-next-generation sequencer with an even faster speed. Progress in the area of bioinformatics, which analyzes a vast amount of genome information collected, is also noteworthy. In December 2017, Roche's Foundation Medicine was granted the first U.S. Food and Drug Administration (FDA) approval for a test to help doctors understand the genetic profile of patients' tumors and guide them to effective and personalized therapies.

Along with the progress in genome information analysis, genetic engineering has advanced year by year. In the area of gene modification, the CRISPR/Cas9 genome editing technology, which was released in 2012, made it possible to modify target genes inexpensively, efficiently, and quickly. This innovative key technology was a major contender for the Nobel Prize in recent years, and it is expected to be applied to many industries. In drug development, a German life science company Bayer established a joint venture with CRISPR Therapeutics of Switzerland to develop new therapies for blood disorders and heart diseases by utilizing the latter's core gene editing technology. In the area of livestock farming, such as hog and poultry raising, the Roslin Institute in the UK is using the gene-editing technique to modify animals' genetic codes in a bid to tackle deadly viruses, and the Commonwealth Scientific and Industrial Research Organisation (CSIRO), Australia's national science agency, is working to create mutated allergen to prevent allergy. While the CRISPR/Cas9 genome editing technology is said to be a game-changer, it may raise ethical controversy in Europe, as genetic modification did.

Compared to drugs and agriculture products/foods, to which genome editing technology can add high value, ethical issues are less likely to arise in the energy, chemical, and materials industries, and the number of applications of the genome editing technology is increasing. Such examples include genetic modification of microbes that can produce bio-based chemicals more efficiently, as well as development of microbes that can decompose conventional, nondegradable plastics. Scientists from the University of Cambridge and the Spanish National Research Council (CSIC) reported in 2017 (*6) that their joint research team had found that moth caterpillars can break down polyethylene at uniquely high speeds. The discovery could potentially provide a solution to large-scale disposal of polyethylene waste, including plastic bags, if super-efficient polyethylene-degrading enzymes were developed by applying genome editing technology.

More recently, synthetic biology, an academic area that involves the application of engineering principles to biology to build artificial biological functions, is gaining increasing attention. With progress in efforts to synthesize molecules with a new function by creating new amino acids or nucleic acids that can replace DNA, an epoch-making study was published in the journal Nature in November 2017 that scientists had created the world's first semi-synthetic strain of E. coli that contains unnatural bases (*7). All organisms in nature use only four DNA bases (A, C, G, T). With the addition of the two unnatural bases, the number of amino acids encoded by an organism could increase significantly. As the semi-synthetic E. coli does not exist in the nature, there are many issues such as safety and stability to be resolved for practical use. However, the study result implies that unnatural bases can be embedded in microorganisms other than E. coli. This is an important step toward drug development using peptides and proteins with new functions, as well as synthesis of new materials and chemicals. Expectations are high for innovative new products to be developed by utilizing this discovery.

FUTURE OUTLOOK

In the previous sections, we have looked at (1) bioeconomy policies and (2) technology development and innovations (including genome editing and synthetic biology). These two have often been discussed separately. However, applications of technologies/innovations such as genome editing and ICT, combined with international policy coordination, will likely facilitate commercialization of bioeconomy products and technologies in many industries from now on.

While Europe takes a lead in bioeconomy policies/strategies, such moves have been spreading to other regions/countries. At present, more than 40 countries, including the US, China, India, Russia, Brazil, and Malaysia, have developed their bioeconomy strategies focused on industry policies or bioeconomy-related innovation strategies. In the first Global Bioeconomy Summit held in 2015, each country's bioeconomy policy was reported and information was shared. At the second Global Bioeconomy Summit scheduled in April 2018, discussions will be made on developing an international policy framework and promoting international cooperation, which is another step forward. While competition for establishing international standards for the bioeconomy, e.g., third-party certification for sustainability, may take place in the near future, international coordination is essential. Each country focuses on different aspects of the bioeconomy, i.e., Germany and Finland's focuses are different as stated above. As such, it will be important for companies to understand each country's bioeconomy policy based on its strengths in industries, while keeping an eye on international discussions toward developing a global framework.

On the technology development and innovation side, market entry into the bio-related industries is getting easier thanks to ICT development. As such, ICT companies, which have entered the retailing, financial, automotive, and electricity industries, are now making inroads into the bio-related areas. For example, US-based Alphabet, Google's parent, spun off its life science division and established Verify Life Sciences, which has focused on using data technology to meet healthcare needs. Google also established research and development biotech company Calio with the goal of combating aging and associated diseases. Another example is a joint research agreement between IBM Watson Health and Illumina announced in 2017. They are teaming up on cancer research and integrating the former's genome data analysis using Watson and the latter's kit to detect tumor genes using next-generation sequencing technology. If the relationships between DNA sequences and their properties are revealed by utilizing AI, the time and cost needed from the discovery of a new function to the launch of a new product will be significantly reduced, and development of personalized medicine will likely be facilitated. In bioeconomy, spillover effect, the effect of one innovation leading to applications in other area, is also noted (*8). For example, Japanese automotive supplier Denso developed a moisture-rich hand cream containing algal oil, which had been discovered in its biofuel research using microalgae. This example suggests that it is necessary to have a broader perspective and share information across industries for early commercialization.

Going forward, more and more countries will take policy measures reflecting social needs. This, together with new technologies and innovations, will likely lead to various applications and lower costs, which will further give rise to and accelerate commercialization of bioeconomy products and services in many industries.

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