BCG (Bio-Circular-Green) economy in Thailand

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Summary

1. Thailand is becoming increasingly environmentally oriented, with the establishment of a "BCG (Bio-Circular-Green) economy" proclaimed as part of its "national agenda" (key themes) for future economic and social development. Therefore, understanding the BCG economy concept, related policies, and challenges with implementation is important for assessing the future outlook for the Thai economy and policies.

2. *B: Bioeconomy* refers to a broad range of economic activities, including the production and trade of goods that utilize biomass (biological resources) and biotechnology (bioengineering). In Thailand, it accounts for the largest share of the BCG economy, and positioned as priority industries are the production of high value-added agricultural, forestry, and fishery products, food production using these products, production of biofuels and bioplastics, development of pharmaceutical products, green tourism, etc. By expanding the bioeconomy, the government aims to promote the *C: Circular economy* and the *G: Green economy*, as well as to correct income disparities among regions and productivity gaps among industries. In addition to this, it is attempting to establish a circular-green economy by introducing renewable energy, promoting proper disposal and recycling of plastics and metals, and popularizing environmentally friendly vehicles and energy-saving home appliances. Expansion of the BCG economy will lower economic security risks through increased self-sufficiency in metal minerals and energy, along with reduced GHG (greenhouse gas) emissions.

3. Data such as the amount of new investment in BCG-related industries, the share of electricity generated from renewable energy, and the number of environmentally friendly vehicles registered attests to the expansion of the BCG economy in recent years. The government is trying to accelerate this trend by attracting foreign investment, but there are some fields where it is difficult to lure foreign capital, such as R&D projects and smart agriculture in the northern and northeastern regions. In addition, a shift to a production and consumption system with less environmental impact could lead to a decline in export competitiveness through higher costs. As such, it is expected to take a cautious stance toward the introduction of strict environmental regulations that could temporarily harm the economy.

4. Although the BCG economy faces challenges with implementation, the growing environmental orientation is an irreversible trend, and the broad outlines of related policies are not likely to change even with a change of administration. Therefore, Japanese companies in Thailand need to adapt to the BCG economy and reconsider how to utilize Thailand as an export base, taking into account trends in environmental regulations in each country. The Japanese government should support Japanese companies in Thailand in expanding their BCG-related businesses in Thailand to other emerging Asian countries, thereby contributing to both economic growth and environmental conservation in Asia as a whole.

Introduction

Against the backdrop of growing global environmental awareness, countries are building production and consumption systems that balance environmental conservation and economic growth. With this in the background, in January 2021 the Thai government announced a policy of positioning the BCG (Bio-Circular-Green) economy as a component of its "national agenda" (key themes) for future economic and social development. In November of the same year, Prime Minister Prayut also announced at COP26 (the 26th Conference of the Parties to the United Nations Framework Convention on Climate Change) in the U.K. that his country would aim to achieve carbon neutrality as early as possible within the second half of this century, thus articulating a stance of emphasizing the environment (UNFCC [2021]). In response to these developments, Japanese companies in Thailand are reviewing the way they do business.

It is highly probable that this emphasis on the environment will spread to other emerging Asian economies, which have lower income levels than Thailand and have prioritized economic growth to reduce poverty. Thailand's presidency of APEC (Asia-Pacific Economic Cooperation) in 2022 is expected to make the BCG economy a key agenda item at the October-November meeting. The importance of promoting the bioeconomy, circular economy, and green economy as an integrated whole may come to be recognized in other emerging Asian countries as a result of the conference and ASEAN-related meetings, and may influence the policies of those countries. Therefore, understanding Thailand's efforts to expand the BCG economy and considering how Japan should respond to these efforts is also important from the perspective of the economies and policies of emerging Asian countries other than Thailand and the prospects for Asian business for Japanese companies.

With the above issues in mind, this paper will provide an overview of Thailand's BCG economy and examine the challenges the Thai government faces in promoting the BCG economy and the implications of these challenges for Japan.

1. What is the BCG economy?

To begin, let us confirm the concept of the BCG economy. The components *B: Bioeconomy*, *C: Circular economy*, and *G: Green economy* suggest that the goal is to build a production and consumption system with less environmental impact through the promotion of agriculture and biotechnology-related industries, the encouragement of recycling, and the introduction of renewable energy. It should be noted, however, that the definition of the BCG economy is ambiguous and the scope of coverage is broader than the name might imply.

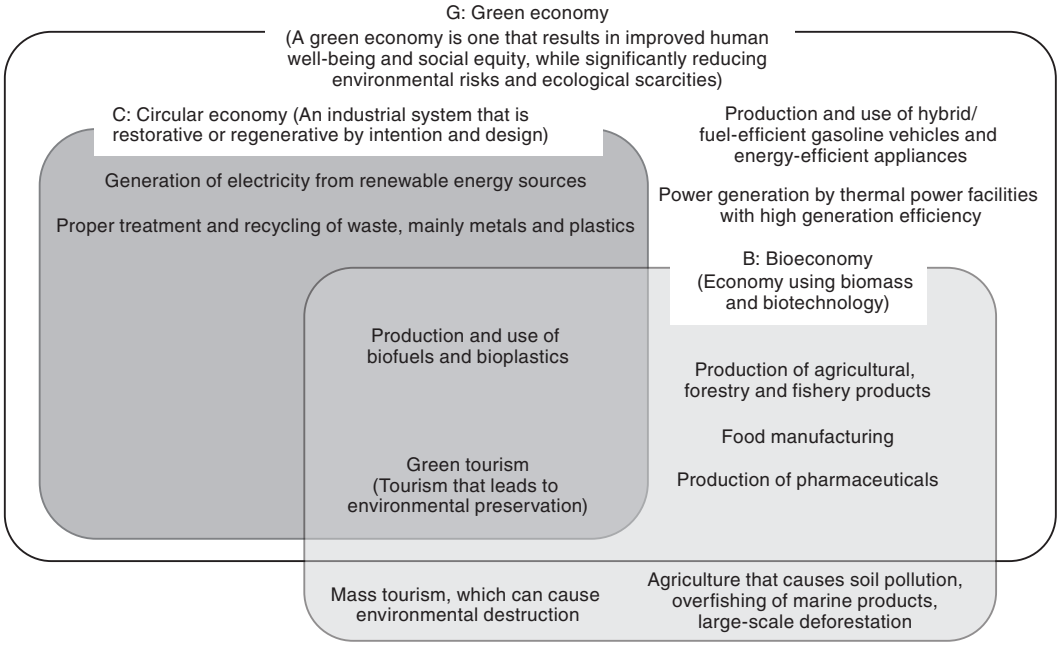
Below is a summary of what is/is not included in B, C, and G, how each is linked, and how they relate to existing policies[(1)]:

(1) Bioeconomy at the core

First, to summarize the general positioning of B,C, and G, *G: Green economy* is a high-level concept that broadly covers various economic models for promoting environmental protection (Fig. 1). One of these components is *C: Circular economy*, and *B: Bioeconomy* can be seen as playing a particularly important role in realizing this element.

Next, I will provide an overview of each concept. The bioeconomy is economic activity related to biomass (biological resources), consisting of animals, plants, and microorganisms, and biotechnology (bioengineering), which is technology based on biology[(2)]. Because biology is closely related to medicine, agriculture, and many other fields of study, the areas included in the bioeconomy are broad. Biotechnology includes not only cutting-edge technologies such as genetic modification technology for the improvement of crop varieties and cloning technology used in regenerative medicine, but also traditional technologies such as the production of fermented foods and

Fig. 1 Illustration of BCG economy



Notes: This shows the relationships between areas covered by broad definitions of each economic concept, and different definitions may be used in different papers.
Source: Prepared by JRI

brewed alcohol and the treatment of water using microbes. Another factor contributing to the broad scope of the bioeconomy is that it includes not only the production of agricultural, forestry, and fishery products and biotechnology-based products, but also indirect economic activities such as wholesale, retail, and transportation of goods produced from these products.

The four focus areas of the BCG economy announced by the government in January 2021 ((1) agriculture and food, (2) bioenergy, biomaterial, and biochemical, (3) medical and wellness, (4) tourism and creative economy (e.g., arts and media-related industries)) are all closely related to the bioeconomy, as shown below. There is also overlap with the circular economy and green economy areas[(3)].

First, with regard to (1) agriculture and food, almost all businesses are part of the bioeconomy, from crop cultivation and fishing based on traditional methods to agricultural production in plant factories using the latest technology, aquaculture of marine products, and production of processed foods using these products[(4)]. The Thai government is trying to increase agricultural productivity by expanding so-called "smart agriculture" that utilizes digital technology, and is also trying to add value to the food manufacturing industry through the production of functional foods that improve health and foods derived from alternative proteins.

Next, looking at (2) bioenergy, biomaterial, and biochemical, the bioeconomy includes economic activities related to the production and trade of food trays, plastic bags, PET bottles, and automobile/power generation fuel made from bioethanol derived from agricultural waste. Currently, petroleum is the main raw material for plastic products and automobile fuel, but the depletion of natural resources, CO_2 emissions, and soil and water pollution associated with these production and consumption processes are serious problems. On the other hand, when plant-derived ethanol is used as a raw material, CO_2 is absorbed from the atmosphere during the process of producing the raw material, so even it is consumed or incinerated

and burned, the net CO_2 emissions are zero. In addition, even if plastics made from biomass are disposed of as is, they decompose into CO_2 and water by the action of microorganisms, thereby avoiding soil and marine pollution problems associated with improper disposal of plastics. Amid increasingly strict regulations on the use of fossil fuel-derived products in many countries, Thailand, a major producer of agricultural crops such as cassava and sugarcane, the main raw materials for bioethanol, is aiming to become a production center for bio-related products (Table 1).

Next, looking at (3) medical and wellness, the bioeconomy includes the production of traditional medical herbs[5] derived from agricultural crops, the diagnosis of diseases and the development of new treatments based on genetic research on plants and animals, and the production of biopharmaceuticals using cell culture technology. Thailand is aging at a relatively fast pace among emerging Asian countries, and the challenge is how to increase people's healthy life expectancy while enhancing economic sustainability through the control of social security-related expenditures. As such, the government aims to make the nation a center for research and development of new medicines and treatments using AI (artificial intelligence)-related technologies. The country also hopes to apply the knowledge gained in medical-related industries to improving crop varieties, enhancing the functionality of food products, and increasing the efficiency of production of bioplastics and biofuels.

Finally, looking at (4) tourism and creative economy, so-called "green tourism," which involves enjoying the rich nature, agricultural and forestry products, and hands-on farming practice in rural areas, is also included in the bioeconomy[6]. The government is trying to increase interest in green tourism in the northeast and north through the promotion of creative industries, with arts and media-related industries at the core. By doing so, it aims to revitalize agriculture, forestry, and fisheries, and to protect the environment of beach resorts in the south, where marine pollution is a concern due to excessive numbers of tourists prior to the COVID-19 pandemic.

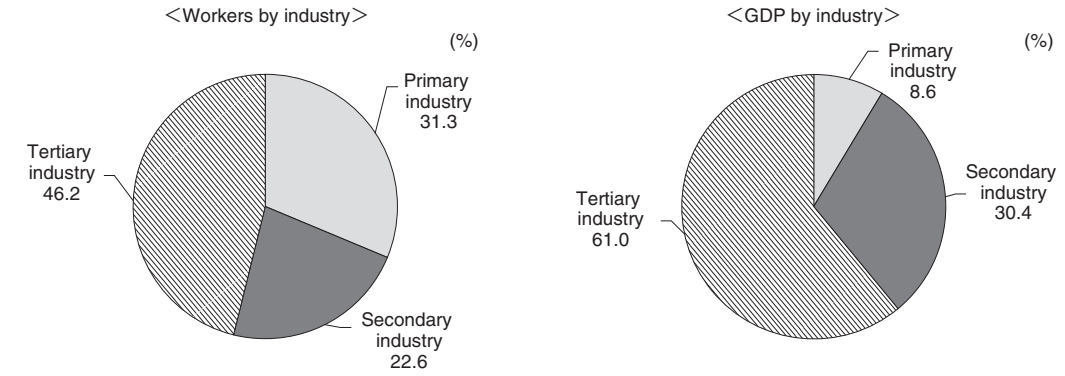
Promoting the bioeconomy is important not only for environmental protection and economic growth, but also for political and social stability. The reason for this is that one of the reasons for the political conflict in Thailand that has persisted since the 2000s is the economic disparity between regions caused by low productivity in the agriculture, forestry, and fisheries industries. While agriculture, forestry, and fisheries employ about 30% of all workers, their share of GDP is less than 10% (Fig. 2), and income levels are low in the northern

Table 1 Production of main agricultural products used as raw materials for bioethanol in each country (2020)

	Cassava		Sugarcane		Rice		Maize	
Order	Country name	Output (Million tons)	Country name	Output (Million tons)	Country name	Output (Million tons)	Country name	Output (Million tons)
1	Nigeria	60	Brazil	757	China	214	U.S.	360
2	Congo	41	India	371	India	178	China	261
3	Thailand	29	China	109	Bangladesh	55	Brazil	104
4	Ghana	22	Pakistan	81	Indonesia	55	Argentina	58
5	Indonesia	18	Thailand	75	Vietnam	43	Ukraine	30
6	Brazil	18	Mexico	54	Thailand	30	India	30
7	Vietnam	10	U.S.	33	Myanmar	25	Mexico	27
8	Angola	9	Australia	30	Philippines	19	Indonesia	23
9	Cambodia	8	Indonesia	29	Brazil	11	South Africa	15
10	Tanzania	8	Guatemala	28	Cambodia	11	Russia	14

Notes: Thailand's maize production is 4.81 million tons, ranking 26th in the world.
Source: FAOSTAT

Fig. 2 Ratios of workers and nominal GDP by industry (2020)



Source: National Economic and Social Development Council

and northeastern regions, where agriculture, forestry, and fisheries account for a large portion of the economy.

The Prayut administration has so far responded to these economic disparities by increasing taxation of high-income earners through the introduction of gift and inheritance taxes, and by providing cash benefits to low-income earners, who are issued a "welfare card." However, in addition to implementing redistribution policies, it will also be necessary to promote the bioeconomy, for which agriculture, forestry, and fisheries makes up a large part, thereby narrowing pre-redistribution disparities[7].

(2) Importance of promoting B, C, and G as a single unit

Next, let us look at the circular economy. While no uniform definition exists, a World Economic Forum report that mentioned the concept at a relatively early stage defined the circular economy as "an industrial system that is restorative or regenerative by intention and design"[8]. Examples of this include, first of all, the production and use of biofuels and bioplastics discussed above. On the other hand, not included in the bioeconomy domain is power generation from renewable energy sources such as solar, wind, hydro, and geothermal. As the need to review the composition of power sources increases due to the depletion of domestic natural gas resources and the lowering of the water level of the Mekong River caused by the construction of dams, the government is aiming to increase the ratio of power generation from solar and wind power.

Proper disposal and recycling of waste materials is another important element. Of particular interest is the proper disposal of plastic products, which are a major source of marine pollution. In recent years, there have been a series of incidents in Southeast Asian countries where large amounts of plastic waste have been found inside the bodies of whales that have washed up on the coasts[9]. This has triggered a growing awareness among the Thai public about the negative impact of plastic product waste on the ecosystem.

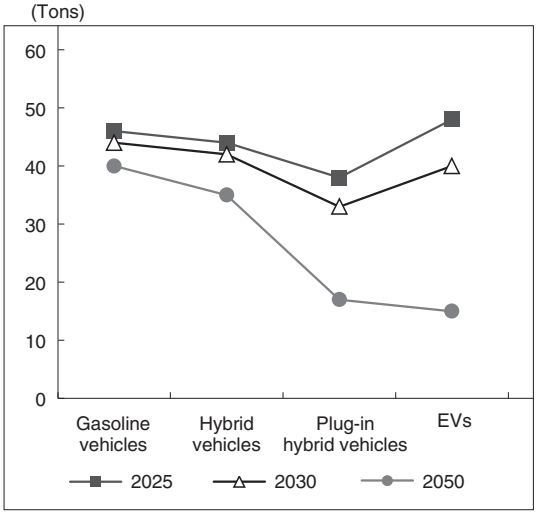
In addition, recycling of metal products is also attracting attention. Of particular importance are steel products, which play a fundamental role in the production activities of various industries, including construction and manufacturing, but also see the emission of large amounts of CO_2 during their production. To reduce their environmental impact, the world's major steelmakers are reconsidering the way they make steel. At present, they use blast furnaces, with iron ore and coal as raw materials, but are now looking to expand output of steel products from electric furnaces, where steel scrap from end-of-life buildings, industrial machinery, and automobiles are the raw materials. Thailand does not have any blast furnaces and

is not as interested in reviewing its production system as the world's major steel producing countries, which include China, Japan, and India, but the country has been working to reduce CO_2 emissions by improving the quality of steel products that can be produced in electric furnaces and increasing the ratio of renewable energy in the electricity consumed in the steelmaking process. In addition, the automotive and electronic equipment industries are seeking to use alternative materials such as aluminum and titanium in place of steel, as well as to increase their recycling rates, in order to increase fuel efficiency through product weight reduction.

Finally, let us examine the green economy. According to the UN definition, "a green economy is one that results in improved human well-being and social equity, while significantly reducing environmental risks and ecological scarcities," so almost every aspect of the bioeconomy and circular economy are included in the green economy[10].

Included in the green economy but not included in the bioeconomy and circular economy are economic activities that produce and consume products with less environmental impact than conventional products, such as the production and use of hybrid and other fuel-efficient gasoline-powered vehicles and energy-saving home appliances. The production and use of hybrid vehicles does not use biomass or biotechnology and consumes gasoline produced from crude oil, so it does not fall under the bioeconomy or circular economy[11]. However, promoting the use of fuel-efficient gasoline-powered vehicles and reducing the consumption of fossil fuels will help reduce the environmental burden. Given that EVs, which do not use gasoline as fuel, currently result in more CO_2 emissions than gasoline-powered vehicles during the manufacturing process, it is desirable for the time being to promote the spread of hybrid and plug-in hybrid vehicles and gradually shift to EVs (Fig. 3). Similarly, low-carbonization through a shift in power generation from coal to natural gas and the introduction of thermal power generation facilities with extremely high generation efficiency will also be important until the necessary technologies for decarbonization are established.

Fig. 3 Lifecycle CO_2 emissions by vehicle type

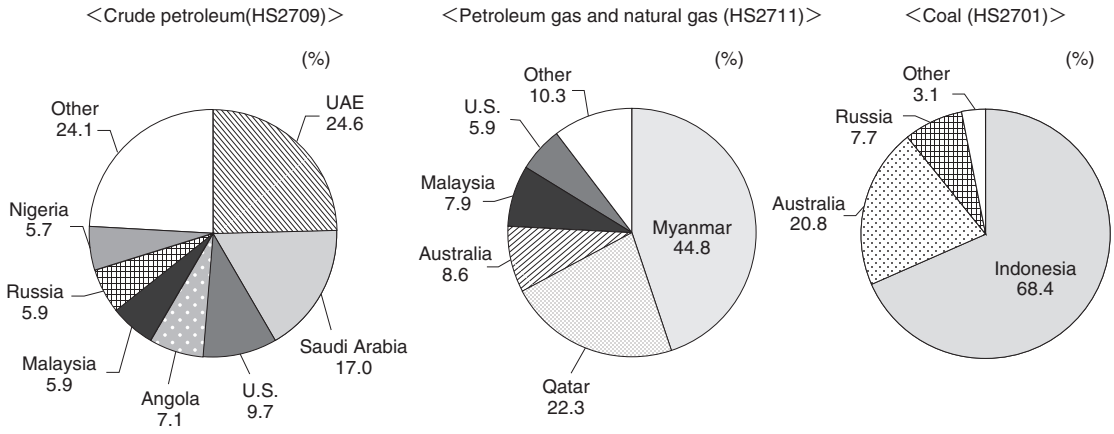


Notes: CO_2 emissions for the entire lifecycle of a medium-sized SUV running 200,000 km, including manufacturing, driving, and disposal.
Source: Prepared by JRI based on Mitsubishi Motors (Thailand) [2022], "Mitsubishi Motors's EV Strategy towards Carbon Neutral Society"

Thus, while the bioeconomy, circular economy, and green economy are not necessarily inclusive, they all share the common goal of environmental conservation and have many overlapping aspects. That is why the Thai government is trying to promote them as a single unit[12].

Expanding the BCG economy is important not only from the perspective of reducing greenhouse gas (GHG) emissions, but also from the standpoint of reducing energy risks and other economic security risks. Thailand relies on imports from the UAE and Saudi Arabia for oil and from Myanmar and Qatar for natural gas (Fig. 4), but against a backdrop of instability in the Middle East after the return of the Taliban regime, political and economic instability in Myanmar after the military coup, and an increasingly serious situation in Ukraine, energy supply is at risk of becoming unstable. Therefore, amplifying the adoption of renewable energy sources such as biofuels derived from domestically produced agricultural crops, solar power, and wind power, as well as expanding the recycling system for plastics and metals, will enhance the independence of the Thai economy

Fig. 4 Shares of Thailand's import partners for coal, crude oil, and natural gas (2020)



Source: United Nations "UN Comtrade"

by reducing its reliance on imports from abroad.

(3) Relationship between existing policies and the BCG economy

Moving on, I will summarize how the government is trying to promote the BCG economy, taking into account its relationship with the policies it has come out with so far.

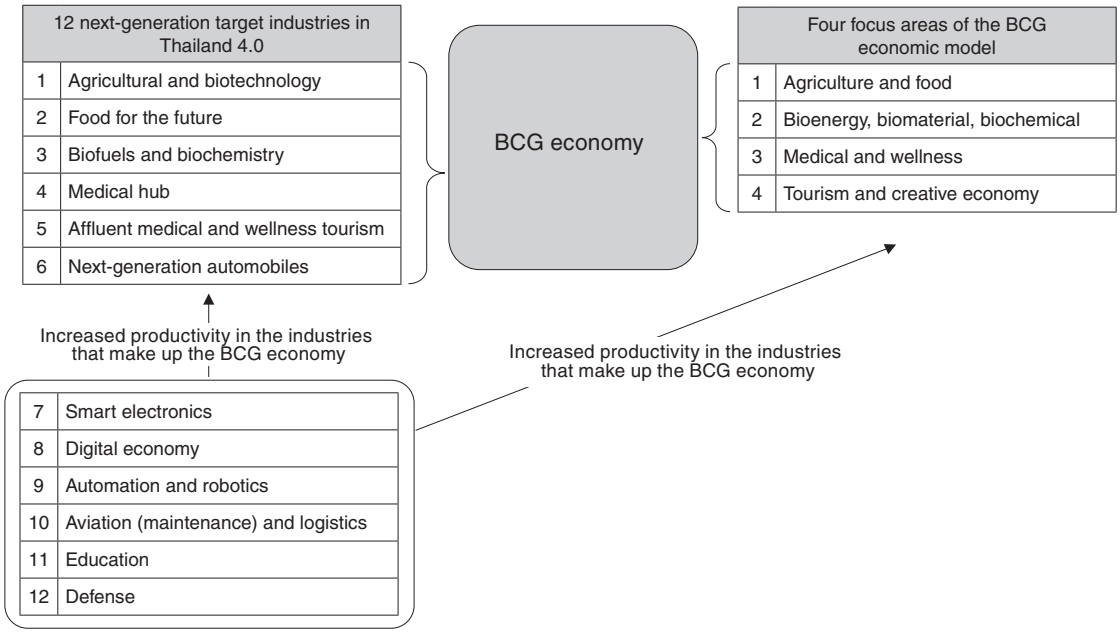
Policies that the Thai government has been focusing on even before setting out the BCG economy concept include industrial upgrading policies under the banner of "Thailand 4.0" and infrastructure development in the "Eastern Economic Corridor (EEC)." Thailand 4.0 is a long-term national strategy launched to overcome the "middle-income trap[13]" through innovation-driven growth. While the components of Thailand 4.0 include sustainable growth through inequality reduction and environmental protection[14], since the launch of Thailand 4.0 in 2016, the government has been rolling out related policies and taking steps to attract investment with an emphasis on industrial upgrading based on innovation. However, with the subsequent increase in environmental awareness both domestically and internationally, it has become all the more important to strengthen the link between industrial upgrading and environmental conservation.

While Thailand 4.0 remains the top policy priority, the government has positioned the BCG economy as part of its "national agenda" (key themes) for the future in order to stress its stance of emphasis on environmental protection.

The members of the BCG Committee, chaired by Prime Minister Prayut, include the Secretary-General of the Thailand Board of Investment, the Minister of Industry, the Minister of Energy, the Secretary-General of the National Economic and Social Development Council, and the Chairman of the Thai Chamber of Commerce. It is administered by the National Science and Technology Development Agency, which is under the auspices of the Ministry of Higher Education, Science, Research and Innovation. All this indicates that the government is serious about expanding the BCG economy through collaboration between industry, government, and academia.

Because of this background, the next-generation target industries in Thailand 4.0 are closely related to the BCG economy. Agricultural and biotechnology, Food for the future, Biofuels and biochemistry, Next-generation automobiles, Affluent medical and wellness tourism, and Medical hub industries roughly overlap with the BCG economic focus areas (Fig. 5). In addition, developing

Fig. 5 Relationship between the next-generation target industries in Thailand 4.0 and the focus areas of the BCG economic model



Source: Prepared by JRI based on data from the Thailand Board of Investment and other sources

Automation and robotics, Aviation maintenance and logistics, Digital economy, Smart electronics, and Education will be essential to increasing the productivity of the industries included in the BCG economy[15].

In January 2021, the BCG Committee indicated that it intends to promote the BCG economy while focusing on maintaining biodiversity, increasing the sustainability of natural resources, and creating high-value-adding industries. However, these are broad directions that follow existing policies, so for more specific initiatives, it is necessary to refer to individual policies formulated in line with Thailand 4.0.

For example, regarding agriculture-related policies, the Ministry of Agriculture and Cooperatives has developed, along with a long-term development plan, strategies for addressing individual themes such as digitization of agriculture and action on climate change, as well as policies related to key agricultural crops such as rice, natural rubber, and palm oil[16].

For energy-related policies, along with the Comprehensive Energy Plan, five individual policies have been formulated by the Ministry of Energy: (1) Power Development Plan, (2) Alternative Energy Development Plan, (3) Energy Efficiency Plan, (4) Gas Roadmap, and (5) Oil Roadmap. These are currently being reviewed in order to achieve carbon neutrality by 2065-2070.

For the proper disposal and recycling of waste, the Ministry of Natural Resources and Environment has developed a national waste management roadmap, a WEEE (Waste Electrical and Electronic Equipment) management strategy, and a national waste management master plan, and work on revising them is currently underway[17].

The National Electric Vehicle Policy Committee under the Ministry of Energy is responsible for policies related to environmental vehicles, and has declared the goal of "30@30" to increase the percentage of domestically-produced EVs to 30% by 2030[18].

To achieve these goals, the Thailand Board of Investment is trying to attract foreign companies with advanced technological capabilities by offering generous tax incentives. Tax benefits vary depending on the nature of the business. Knowledge-

intensive businesses, such as pharmaceuticals and fuel cell development, enjoy an eight-year corporate tax exemption, with additional incentives also offered depending on the region in which the investment is made (Table 2). On the other hand, the corporate tax exemption period is set shorter in fields in which there is already a certain degree of business activity in Thailand, such as waste disposal plants.

2. Current status of Thailand's BCG economy

Bioeconomy, circular economy, and green economy are all ambiguous concepts that have come into widespread use only recently, and their ambiguity has also limited the availability of statistics on them, so it is not easy to get a comprehensive picture of their realities. For this reason, the following section will explore trends in the BCG economy using related indicators and individual cases that have attracted attention as clues.

(1) Trends in the bioeconomy

First, the agriculture, forestry, and fisheries industry, the backbone of the bioeconomy, accounts for less than 10% of GDP (Fig. 6). Manufacturing industries that use products from agriculture, forestry, and fisheries as raw materials, such as food, beverages, tobacco, leather and leather products, rubber and plastic products, and paper and wood products, also make up under 10% of GDP. In addition, the wholesale and retail trade and food and beverage-related service sector, which are involved in the trade of agricultural, forestry, and fishery products and their processed products, account for about 20% of GDP. However, this includes added value that should not be included in the bioeconomy, and it is not appropriate to consider the simple sum of the added value of related industries as the size of the bioeconomy. For example, in the rubber and plastics manufacturing industry, the added value from production activities that use vegetable-based raw materials (e.g., natural rubber) should be recorded in the bioeconomy, while the added value related to production activities that use petroleum as a raw material needs to be excluded. Similarly, for wholesale and retail trade, only the added value associated with the trade of agricultural produce and food prod-

Table 2 Tax incentive categories for Thailand Board of Investment's promotion of BCG economy

Investment category	Businesses included in the categories listed on the left	Basic benefit with respect to corporate taxes	Bioeconomy -related investments	Circular economy -related investments	Green economy -related investments
A1	Knowledge-based businesses with a primary focus on design and R&D that will improve the country's competitiveness	Exemption for 8 years (No upper limit)	Research, development, and manufacture of biotechnology products (pharmaceuticals)	Energy-related services	Fuel cell production
A2	Infrastructure businesses that contribute to the development of the country, projects that use advanced technology to create added value, in which there is little investment in Thailand	Exemption for 8 years	Energy production from biomass, production of nutraceuticals	Fuel production from waste, proper treatment of waste	Manufacture of energy-saving components for automobiles and photovoltaic batteries
A3	Businesses for which there are already a small number of production sites in Thailand, but that use advanced technology that is important for the country's development	Exemption for 5 years	Production of crops in plant factories	Waste recycling (other than plastic)	Manufacture of polymer products with low environmental impact
A4	Businesses that are not as advanced as A1-A3, but that add value to domestic raw materials and strengthen the supply chain	Exemption for 3 years	Breeding or raising animals	Plastic recycling	Production of energy-saving home appliances

Source: Prepared by JRI based on data from the Thailand Board of Investment [2020][2021] and other sources

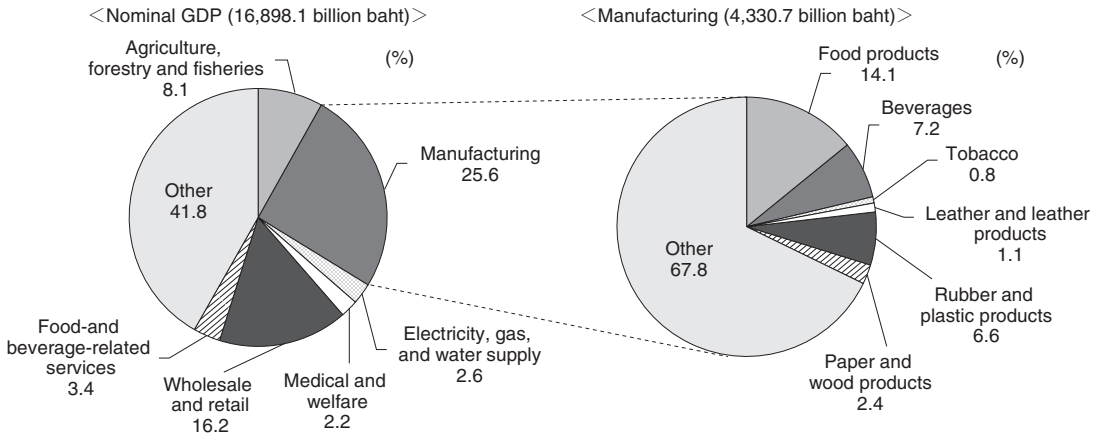
ucts should be included in the bioeconomy.

Therefore, using GDP by industry and input-output tables to estimate the added value of the bioeconomy[19], the added value in 2020 will be 14% of GDP (Fig. 7). Given that the government considers the BCG economy's share of GDP to be about 20%[20], the bioeconomy is judged to be the largest component of the BCG economy.

Although the size of the bioeconomy in terms of added value and share of GDP has remained flat in recent years, several indicators suggest that the bioeconomy may expand in the future.

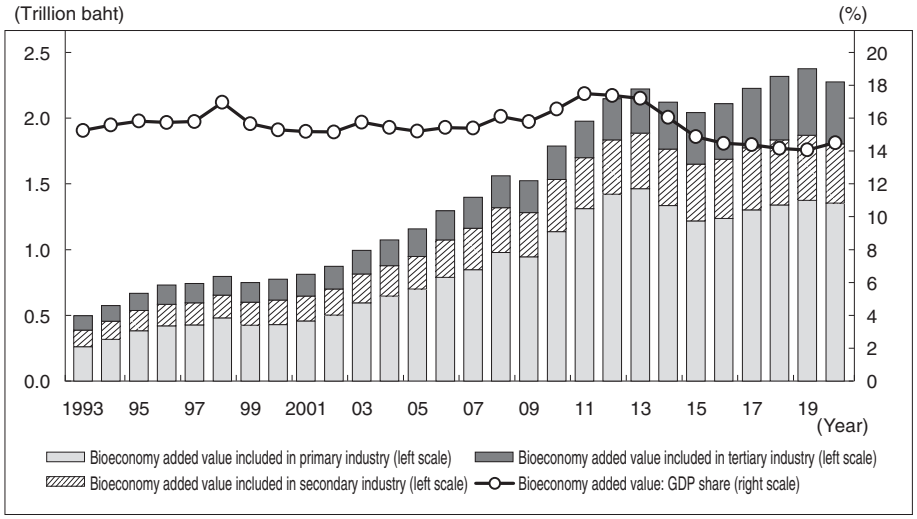
For example, in 2021, applications for investment in agriculture and food manufacturing sub-

Fig. 6 Share of GDP by Industry (2019)



Source: National Economic and Social Development Council

Fig. 7 Added value in Thailand's bioeconomy



Notes 1: For primary industry, all added value was included in the bioeconomy, while for secondary and tertiary industry, the added value of the bioeconomy was calculated based on the share of agricultural, forestry, and fishery products in the intermediate inputs.

Notes 2: Intermediate input ratios are calculated based on the 1990, 1995, 2000, 2005, 2010, and 2015 input-output tables. Intermediate input ratios for intermediate years are assumed to be linearly complementary, and intermediate input ratios for 2016 and beyond are assumed to be unchanged from 2015 input ratios.

Source: Prepared by JRI based on data from the National Economic and Social Development Council

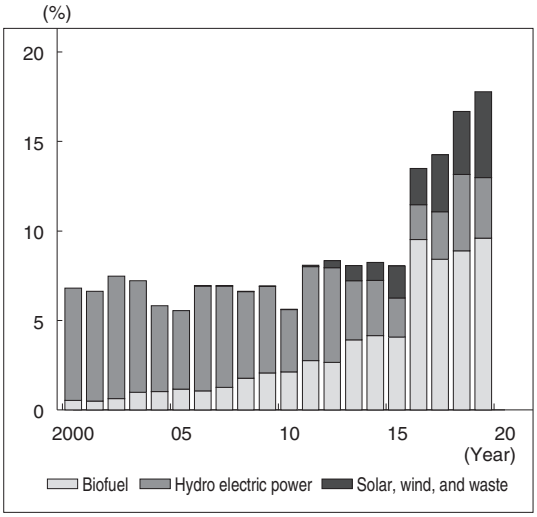
Table 3 High-profile projects related to Thailand's bioeconomy

Examples of initiatives	Features	Current issues (other than cost)	Examples of entry into the Thai market
Growing vegetables in plant factories	Pesticide-free cultivation is possible Production is not affected by weather factors Hygienic and have many edible parts Idle factories can be redeployed	Crops that can be grown are limited	Taikisha (major manufacturer of air conditioning-related equipment)
Production of biofuels, bioplastics, and plant-based protein-based materials	CO_2 is absorbed in the process of producing the crops used as raw materials Microorganisms cause decomposition after disposal, avoiding soil and marine pollution	Higher biodegradability reduces material durability	NatureWorks (affiliate of PTT)
			Mitsubishi Chemical (major chemical manufacturer)
			Spiber (Japanese new materials development and production company)
			Kaneka (major chemical manufacturer)
			Fruita Bio (local startup)
Development of functional food products	Healthier than conventional foods	Production tends to become more unstable as the scale of cultivation increases	Kyowa Hakko Bio (Kirin Group company)
Sale of "plant meat" derived from plants	Greenhouse gas emissions from livestock rearing can be reduced No risk of infection from livestock Low in fat and healthy, consumption by vegetarians possible	Tastes slightly different from meat There are elements that cannot be taken from meat	CP Group
			Thai Union Group
Development of food products using insect proteins as raw materials	Food waste is used as feed for insects, thus reducing food loss	Resistance to products using proteins derived from insects	Orgafeed
			Global Bugs Asia
			Suez Group

Source: Prepared by JRI based on various media reports

mitted to the Thailand Board of Investment increased by about 50% in monetary terms from the previous year, while the amount approved rose by around 10%[(21)]. The recent surge is partly due to a rebound from the decline that followed the emergence of the COVID pandemic, but it is also thought to reflect growing corporate interest in new and expanding environment-related business opportunities. Examples of high-profile initiatives include the operation of plant factories, production of bioplastics, development of meat substitutes and fiber materials derived from vegetable protein, and production of pet food using insect protein (Table 3).

Fig. 8 Share of renewable energy in electricity generation

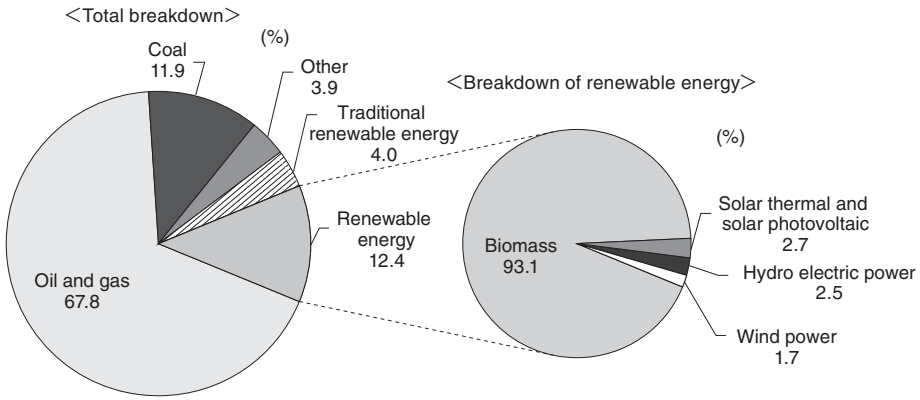


Source: IEA

(2) Trends in the circular economy

Next, let us look at the circular economy, which lies outside the bioeconomy. First, looking at the energy mix, since the mid-2010s, the share of electricity generation from solar and wind power has increased along with that from biofuels (Fig. 8). However, the share of renewable energy sources such as solar, hydro, and wind in primary energy supply is limited, due in part to the heavy consumption of fossil fuels in the transportation sector (Fig. 9). Therefore, the government aims to reduce dependence on fossil fuels through electrification of the transportation sector and digitaliza-

Fig. 9 Thailand's primary energy supply structure (2020)



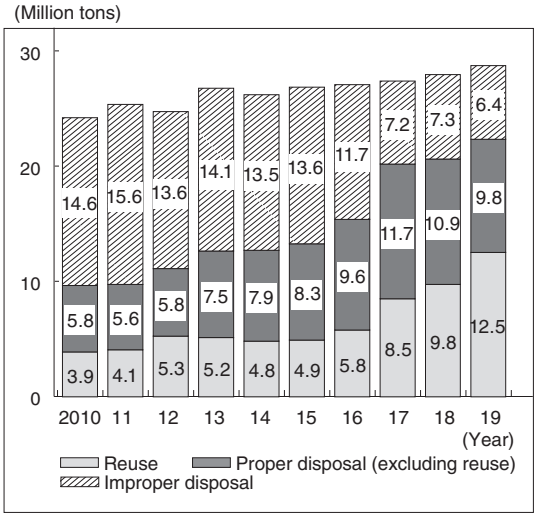
Notes: Traditional renewable energy sources mean wood, charcoal, etc.
Source: Ministry of Energy, "Thailand Energy Balance 2020"

tion of the economy, as well as through the further adoption of renewable energy.

Energy policy is being reviewed in line with the new National Energy Plan approved by the Cabinet in August 2021. Although the details are not yet clear, the government has outlined a policy under which some of the key themes are to (1) increase the share of renewable energy in new electricity sources to 50% or more, (2) improve energy efficiency by 30% or more through new innovations and technologies, and (3) implement 4D1E (Decarbonization, Digitalization, Decentralization (of power generation infrastructure), Deregulation (in connection with energy), and Electrification)[22].

Turning now to the situation with waste management, since the formulation of the National Waste Management Roadmap in 2014, there has been a marked decrease in the amount of waste managed under inappropriate conditions, such as burning or piling up in the open, as a result of progress being made with the proper disposal of waste as well as the establishment of recycling facilities and related rules (Fig. 10). In addition, the proportion of plastic waste recycled, which was previously only 30-40%, increased to 70-80% in the late 2010s[23]. In 2018, Chinese import restrictions caused a massive influx of plastic waste to Thailand, as it no longer had anywhere to go (Fig. 11), but Thailand subsequently tightened its own import restrictions as well, so imports plummeted in 2019[24]. Furthermore, in order to achieve the goal of increasing the recycling rate of domestically-generated plastic to 100% by 2027, the importation of plastic waste will be tightened, and free plastic bags have been banned in major supermarkets and convenience stores since January 2020, so action has been initiated. However, the rapid increase in the use of plastic containers following the emergence of the COVID pandemic

Fig. 10 Disposal of general waste in Thailand

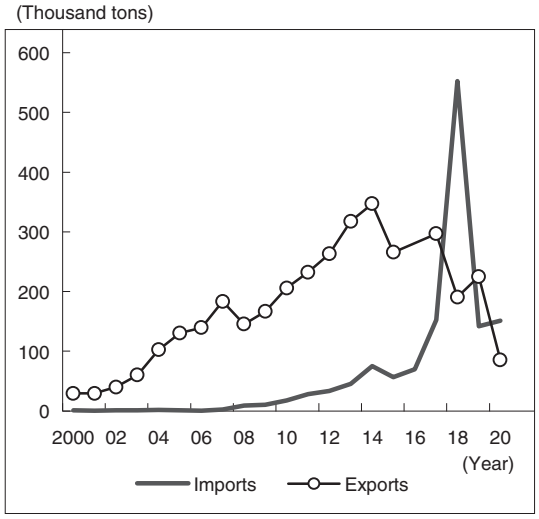


Source: Pollution Control Department
"Thailand State of Pollution Report 2019"

and the resultant surge in demand for food delivery has made it difficult to increase the recycling rate as originally planned.

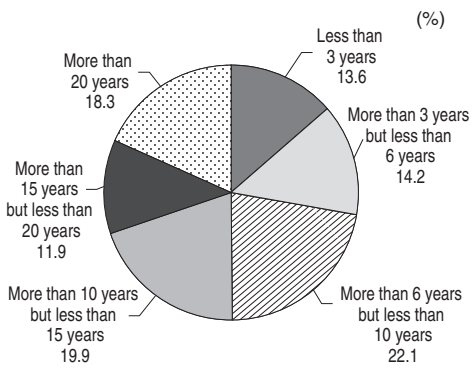
As for the recycling of metals, which like that of plastics, is also of great interest, the goal is to expand the recycling system, starting with the recycling of automobiles[25]. The number of vehicles over 20 years old is approximately four million, accounting for about 20% of all registered vehicles (Fig. 12), and a large amount of waste is expected to be generated as people replace their vehicles with eco-friendly ones (EVs, hybrids, and plug-in hybrids) that have a lower environmental impact. To respond appropriately to this situation, the Thai government, in cooperation with the New Energy and Industrial Technology Development Organization (NEDO) and Toyota Tsusho, is currently field-testing an efficient recycling system that is suitable for Thailand[26].

Fig. 11 Import/export of waste plastic (HS3915) in Thailand



Source: United Nations UN Comtrade

Fig. 12 Vehicle age composition of vehicles registered in Thailand (End of 2021)



Source: Department of Land Transport

(3) Trends in the green economy

Finally, let us examine the green economy. A high-profile sector outside the bioeconomy and circular economy is the production of EVs.

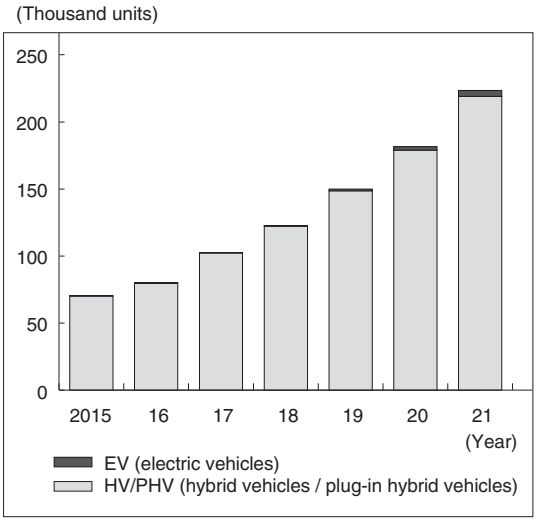
Until recently, Japanese companies, with their competitive gasoline-powered vehicles, had commanded a high share of the Thai automobile market for many years, but recently Chinese manufacturers, including SAIC Motor and Great Wall Motor, have begun to actively enter the EV market. In addition, PTT (Formerly known as the Petroleum Authority of Thailand) has announced a plan to produce EVs in a joint venture with Taiwan's Hon Hai Precision Industry, while Energy Absolute, a Thai startup company in the biodiesel and power generation business, has entered the battery-related business. So players from other sectors are starting to enter the EV industry.

The cumulative number of eco-cars registered at the end of 2021 was approximately 200,000, a significant increase from 70,000 in 2015 (Fig. 13). However, given that (1) most of the registered vehicles are hybrids and only a few are EVs, and (2) the overall number of four-wheeled vehicles registered, including gasoline-powered vehicles, is approximately 20 million, the uptake of eco-cars in Thailand is still in its early stages[27].

Going forward, the government intends to reduce GHG emissions in the transportation sector by pursuing two parallel initiatives: (1) reducing the environmental impact of gasoline-powered vehicles, and (2) shifting from gasoline-powered vehicles to EVs.

The former is expected to be achieved by gradually tightening emission regulations from the current Euro 4 to Euro 5 and Euro 6[28] as well as by

Fig. 13 Number of registered eco-cars in Thailand



Notes: Year-end values. Excluding motorcycles.
Source: Department of Land Transport

Table 4 Overview of new EV promotion package

	Passenger vehicles	Pickup trucks	Two-wheeled vehicles
Provision of subsidies	Up to 150,000 baht (depending on battery capacity)	150,000 baht	18,000 baht
Excise taxes	Reduction from 8% to 2%	Reduction from 10% to 0%	
Import duties	Up to 40% point reduction for complete vehicles priced at or below two million baht and 20% reduction for vehicles priced above two million baht and up to seven million baht		

Notes: A condition for receiving subsidies is that a certain percentage must be produced domestically in Thailand. Vehicles over two million baht and two-wheeled vehicles over 150,000 baht are not eligible for subsidies. The period during which subsidies will be provided is 2022-2025.
Source: Prepared by JRI based on data from the Royal Thai Government website and various other sources

altering automobile-related taxes.

For the latter, support measures are being strengthened to realize a goal of 30% of domestically-produced automobiles being EVs by 2030. Until now, the main incentive has been the tax breaks offered by the Thailand Board of Investment to companies producing EVs, but in February 2022, the cabinet approved a new package of incentives to stimulate consumer purchasing, including a subsidy benefit of up to 150,000 baht, a reduction in excise taxes, and a significant reduction in import duties on finished vehicles (Table 4).

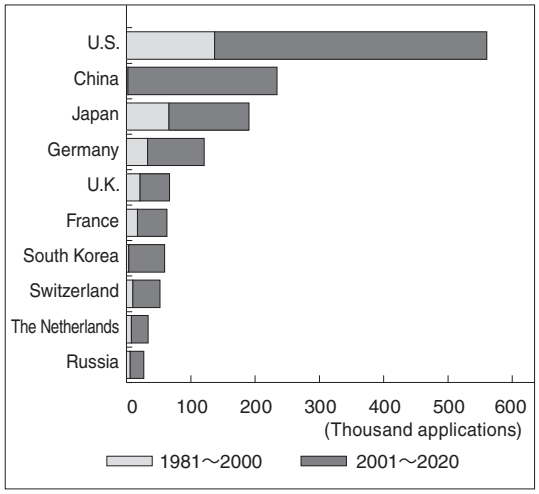
3. Challenges in promoting the BCG economy and implications for Japanese companies in Thailand

The government is trying to promote the BCG economy by attracting foreign investment through tax incentives and subsidies and by revising environmental regulations. However, as I point out below, there are many challenges, and it remains to be seen whether expansion will occur at the pace the government wants.

(1) There are fields in which it is difficult to attract foreign investment

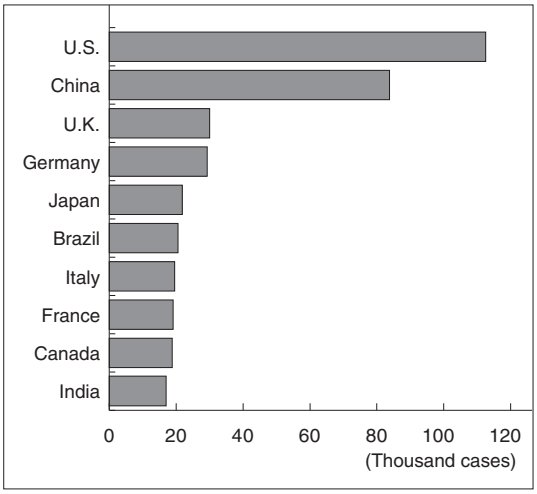
First, there are areas where it is difficult to attract foreign investment. A prime example is R&D-related projects. The Thai government is seeking to enhance the country's R&D capabilities through a raft of initiatives, such as (1) providing tax incentives to companies that conduct R&D or train STEM (science, technology, engineering, mathematics) personnel, (2) issuing "smart visas" to lure high-caliber foreign talent, and (3) developing the Eastern Economic Corridor of Innovation (EECi) as a hub for innovation. However, as suggested by the number of patent applications and academic papers, the facilities and human resources required for research and development of advanced technologies are concentrated in the U.S., China, Japan, Germany, and the U.K. (Figs. 14 and 15), and there is little incentive for foreign companies to actively conduct basic research in Thailand[29]. In Thailand, the bulk of research is likely to be in areas close to the pro-

Fig. 14 Number of biotechnology-related patent applications by country of application



Note 1: Total of "analysis of biological materials" and "biotechnology".
Note 2: Thailand made 189 patent applications in 1981-2020, putting the country in 65th place among the 153 countries/territories for which data was available.
Source: Prepared by JRI based on WIPO (World Intellectual Property Organization) statistics

Fig. 15 Number of papers in field of basic life science (2017-2019 average)



Source: Prepared by the JRI based on "Benchmarking of Scientific Research 2021 (Survey Data-312)" from the National Institute of Science and Technology Policy, Ministry of Education, Culture, Sports, Science and Technology

duction stage, such as localization, quality control, and manufacturing stabilization, which are necessary for introducing technologies already in commercial use to Thailand and other emerging Asian countries.

It is also difficult to attract smart agriculture-related industries to the north and northeast. The Thai government is trying to popularize smart agriculture in order to narrow economic disparities between regions and industries caused by low agricultural productivity, and as a means of addressing problems such a shortage of farmers in the future as the current generation of farmers ages. However, it is unlikely that farmers in the north and northeast, who have low labor costs but high levels of household debt, will actively embrace smart agriculture, which is expensive to implement[30].

Not only in Thailand, but also in other countries, the pace of expansion of smart agriculture in the future is expected to be affected by (1) the cost of labor compared to the cost of installing equipment, (2) the pace of aging in rural areas, (3) the ICT environment in rural areas, and (4) ICT literacy of farmers and the environment for obtaining the financing required for equipment installation. Therefore, companies that develop smart agriculture-related equipment and systems are expected to focus on developing their business in advanced countries, where income levels are higher and the population is aging at a faster pace than in Thailand. While it is conceivable that field-testing could be conducted in Thailand with a view to future business development in emerging Asian countries, only a few companies with ample financial resources will be able to do this[31].

The small size of the market also constrains the expansion of local production in Thailand. For example, given that the current number of registered EVs is less than 5,000, it would make more sense for emerging EV makers to expand their business in Thailand through exports. While Thailand's domestic EV sales are only a few thousand units per year, China's EV production in 2021 exceeded three million units. Even if Chinese manufacturers establish factories in Thailand, they will prefer to procure high value-added components from their own country, where there is a high concentration

of industry. Although EVs have a simpler structure than gasoline-powered vehicles, and thus economies of scale may begin to be seen at an earlier stage, it will take a considerable amount of time for EV sales to reach that scale in Thailand and in Australia, Thailand's main vehicle export destination[32].

Given these restrictions, whether or not the Thai government can successfully promote the BCG economy depends on whether or not it can also strengthen its efforts to become less dependent on foreign capital. Specifically, it is first necessary to reinforce the domestic R&D system by making steady efforts such as human resource development through educational reform, collaboration among local industry, government, and academia, and development of research infrastructure. It will also be necessary to promote the participation of local firms and universities in international joint research, and to create an environment in which local companies can invest in and acquire foreign companies that have cutting-edge technologies by further relaxing regulations on foreign direct investment.

(2) Increased costs are inevitable

Rising costs associated with changes in production methods are another constraint to the expansion of the BCG economy (Table 5).

Regarding smart agriculture, as previously mentioned, the high cost of implementation is a constraint for farmers with low income levels, as they need to install equipment such as remote sensors, which are necessary for obtaining agriculture-related data, and automatic transporters.

As for the production of plastic products using biomass, production costs are expected to be several times higher than those for plastic products derived from fossil fuels. As a result, companies concerned about losing customers due to increased costs and higher selling prices are unable to make the full switch from conventional plastics to bioplastics.

And with respect to power generation from renewable energy sources, the cost of adopting such sources has been declining significantly due to the proliferation of inexpensive Chinese-made power generation equipment. In addition, the recent rise in the price of crude oil and other mineral resources has also provided a tailwind for adoption. However, renewable energy sources cannot be the main source of electricity at this time because the

Table 5 Impact on costs of modification of production/consumption methods

Field	Impact on costs
Smart agriculture	The impact on costs varies greatly depending on what type of equipment is installed, but installation costs increase by several million yen or more
	<Typical cost of adopting smart agriculture-related equipment in Japan> Business and production management system (free of charge - initial cost of approx. 100,000 yen + monthly fee of 15,000 yen), robot tractor (approx. 10 million yen), automatic steering system (0.4-2.5 million yen), high-performance rice transplanter (3-5.5 million yen), remote control mower (1-1.3 million yen), high-performance combine harvester (11-18.5 million yen), agricultural drone (0.8-3 million yen), water management system (free of charge - initial cost of 750,000 yen + monthly fee of 10,000 yen), field and facility environmental monitoring system with environmental control functions (1-5 million yen)
Bioplastic	Compared to plastics derived from fossil resources, the unit price of PLA (polylactic acid) resin has increased by approximately 2 to 3 times, and the unit price of PBAT (polybutylene adipate terephthalate) resin by approximately 4 to 5 times (Ministry of the Environment) [2021])
EVs	Maintenance costs are lower for EVs than for gasoline vehicles, but vehicle prices are several million yen higher
	Battery prices will rise sharply with global EV proliferation
Steel products	Production costs are expected to increase significantly in the future with the introduction of the hydrogen reduction method in blast furnaces and the use of electricity and hydrogen produced from renewable energy sources
	The European Steel Association contends that production costs could increase by 35-100%, and Nippon Steel also states that production costs could more than double

Source: Prepared by JRI based on various sources

amount of power they generate depends on weather conditions. In addition, the development of the energy storage facilities and software necessary to stabilize supply and demand will require time and huge capital investment, and the question arises as to who will bear the production costs in the broad sense of the term, including those costs.

Metal recycling is also a problem, as the development of technology to remove impurities from scrap products and recycle them, as well as the introduction of new equipment, raises costs and undermines the sustainability of the business.

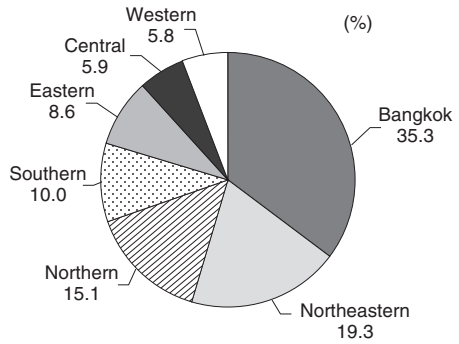
Production costs will inevitably increase for the production of hybrid vehicles and EVs as well. Although it is possible to avoid this problem by promoting the development of small, cheap EVs with fewer functions, the widespread use of small, cheap EVs will probably be limited to Bangkok, where population density is high and the cruising range per trip is short. Outside of Bangkok, the EV market will be slow to expand, as pickup trucks and SUVs are better suited to transporting large volumes of goods over long distances. As the price of lithium continues to rise on the back of global EV proliferation, the introduction of regulations on the recycling of metal products used in batteries and car bodies will further push up production costs[33].

Given these factors, while Bangkok, which accounts for about 40% of vehicle registrations, may see a shift from gasoline-powered vehicles to cheap EVs (Fig. 16), other regions are expected to remain dependent on gasoline-powered vehicles. In order to encourage a shift to EVs, it is conceivable to restrict the issuance of license plates for gasoline-powered vehicles, as happens in China, but introducing overly strict regulations in a country where EV infrastructure is still underdeveloped could adversely affect the daily lives of the people.

The government may expand various subsidy programs to curb production costs, but this would inevitably increase the budget deficit. Although Thailand's budget deficit and government debt to nominal GDP ratio are relatively low among emerging Asian economies, the debt level rose close to the 60% ceiling, mainly due to the economic downturn that occurred in conjunction with the COVID pandemic, which forced the government to raise the ceiling to 70% in September 2021[34]. Although the debt ceiling increase has opened up more room for spending expansion, the Ministry of Finance remains cautious about upping spending because it cannot afford not to be wary of a decline in tax revenues due to the future decrease in the working population and a rise in social security spending due to the increase in the number of elderly citizens.

For EVs, measures such as lower excise taxes and subsidies have been taken to close the price gap with gasoline vehicles, but there is limited fiscal capacity to further expand such schemes and introduce similar subsidies for other industries[35].

Fig. 16 Share by region of vehicle registered in Thailand(2021)



Source: Department of Land Transport

(3) Being too early/late to adopt environmental regulations will directly lead to a decline in export competitiveness

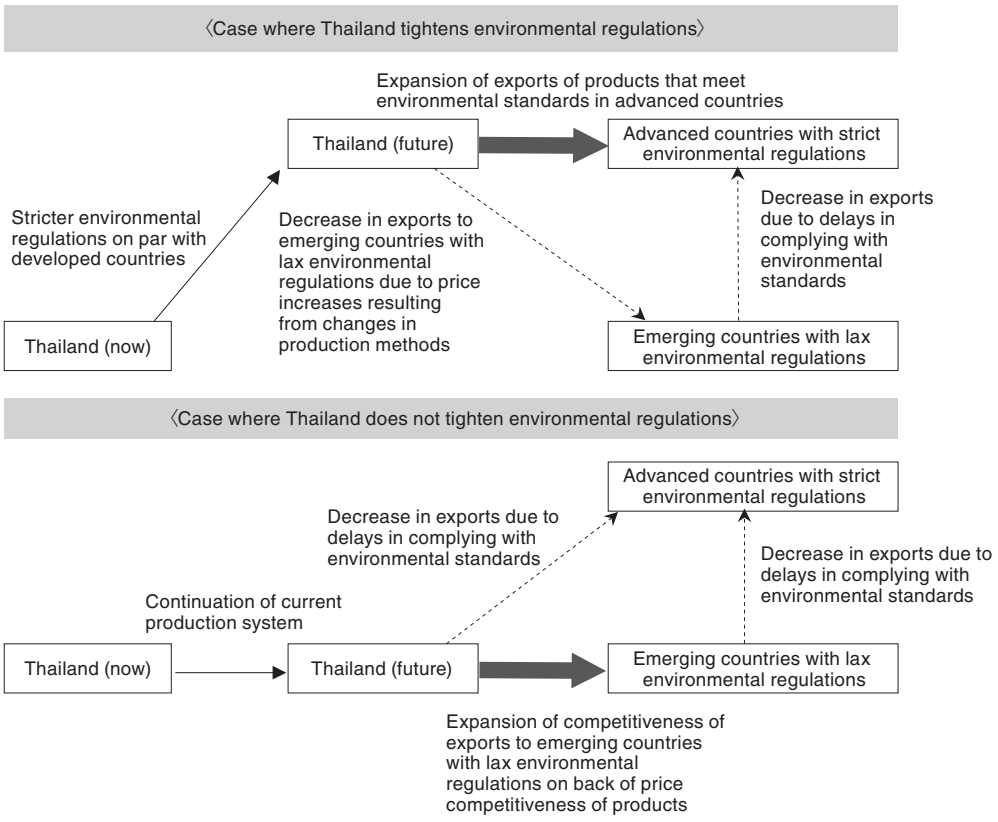
Shifts to less environmentally hazardous production methods generally exert upward pressure on production costs. So the transition cannot be made blindly, as how it will change Thailand's export competitiveness will be affected by the environmental regulations of export destinations and countries that compete with Thailand.

For example, if in Europe, which comprises environmentally advanced countries, regulatory changes such as increasing various tax rates and prohibiting domestic use of products with high environmental impact are made in the future, Thailand's prior shift to environmentally friendly production methods will help maintain and improve the competitiveness of its exports to Europe. In addition, if environmentally conscious companies and consumers increasingly select suppliers of products while taking into consideration the environmental impact caused by production processes abroad, demand for products made using methods with high environmental impact can be expected to taper off (Fig. 17).

However, it is important to note that export competitiveness could also decline as a result of being an early mover in tightening environmental regulations. In countries with lower income levels, the emphasis tends to be on low prices rather than the environmental impact generated outside the country. For example, it is unlikely that strict regulations on the use of gasoline-powered vehicles will be introduced in Cambodia, Laos, and Myanmar, which will need to rely on inexpensive gasoline-powered vehicles for logistics in the foreseeable future. In this context, if Thailand imposes stricter regulations on the production and export of gasoline-powered vehicles, these countries will import gasoline-powered vehicles from countries other than Thailand.

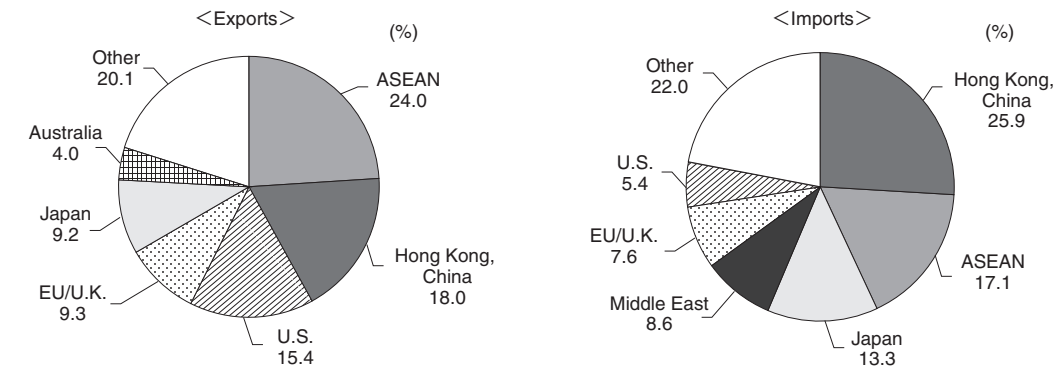
Thailand's exports account for about 60% of GDP, but the export destinations are diverse, with the U.S., Europe, Japan, China, and ASEAN each accounting for around 10-20% (Fig. 18). As its economic slump continues due to the prolonged

Fig. 17 Illustration of leading/lagging environmental regulations and export competitiveness



Source: Prepared by JRI

Fig. 18 Thailand's export/import partner countries/regions (2021)



Source: Bank of Thailand

COVID pandemic, Thailand will seek a realistic approach to environmental regulations while keeping an eye on the current and future status of environmental regulations in other countries so as to avoid economic deterioration caused by excessively strict environmental regulations. For the time being, the BCG economy is expected to expand at only a moderate pace, as suppliers of exports to advanced countries are encouraged to shift to new production methods to increase their competitiveness in terms of environmental friendliness, while suppliers of exports to emerging countries are expected to maintain existing production methods as strict regulations and taxation are curbed to enable them to maintain price competitiveness.

(4) Implications for Japanese companies in Thailand

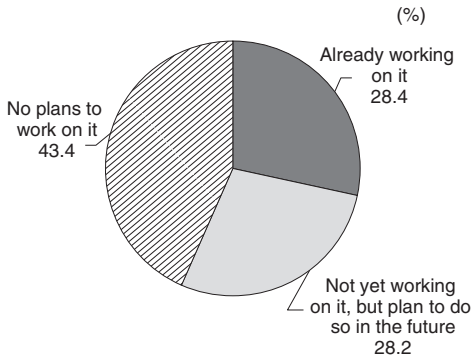
Based on the above, I will discuss three implications for Japanese companies in Thailand.

First, Japanese companies in Thailand need to be positive in considering how to adapt to the BCG economy. As already noted, the BCG economy faces no small number of challenges and constraints, but the growing environmental orientation is irreversible. Although political conflicts concerning the state of democracy and the royal family continue in the country, the broad policy framework for the BCG economy is not expected to be affected by a change of government, given that there are no major differences between the positions of the ruling and opposition parties on the importance of attracting foreign investment and ensuring environmental protection[36].

Japanese companies in Thailand need to carefully scrutinize not only the future opportunities for environment-related business, but also the business risks associated with delays in environmental response. According to a survey, about 30% of Japanese companies in Thailand have already started working toward decarbonization, and another 30% are considering doing so in the future. On the other hand, around 40% are not yet considering doing so (Fig. 19). Given that many Japanese companies operating in the ASEAN zone are taking steps toward decarbonization in line with the wishes of their Japanese headquarters (Fig. 20), the first step is for Japanese headquarters to deepen their understanding of the importance of pursuing environmental initiatives in Thailand.

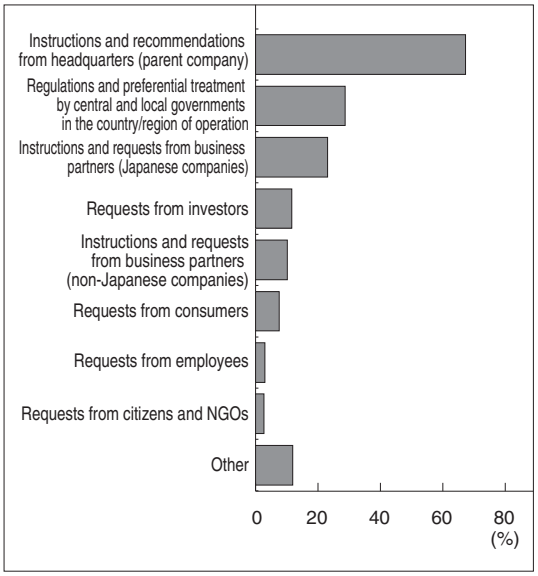
It should also be noted that new production methods being developed in Japan and other advanced countries may not be deployable as is in Thailand, where the business environment is different. In some areas, such as the disposal of home appliance waste, field-testing is underway with funding from NEDO (Table 6), and the introduction of guidelines based on Japan's Home Appliance Recycling Act is being considered. It is expected that industry, government, and academia

Fig. 19 Status of decarbonization efforts by Japanese companies in Thailand(FY2021)



Source: Prepared by JRI based on the Japan External Trade Organization's "2021 Survey on Business Conditions of Japanese Companies Operating Overseas (Asia and Oceania)"

Fig. 20 Reasons for decarbonization efforts by companies in ASEAN (multiple responses, FY2021)



Source: Prepared by JRI based on the Japan External Trade Organization's "2021 Survey on Business Conditions of Japanese Companies Operating Overseas (Asia and Oceania)"

Table 6 Examples of NEDO (New Energy and Industrial Technology Development Organization) projects in Thailand

	Project name	Project overview	Implementing company
Projects related to low carbon / decarbonization	Study on introduction of power generation business asset efficiency software for power companies in the ASEAN region and its standardization	Introducing digital solutions using AI and big data analytics to EGAT (Electricity Generating Authority of Thailand) thermal power plants to improve power generation efficiency	Marubeni
	Carbon reduction through ICT-driven online control of voltage and reactive power in transmission systems (OPENVQ)	Optimizing transmission system voltage and reducing transmission losses with highly accurate demand forecasting technology	Hitachi
	Field-testing of a high-quality industrial water supply system to realize an energy-saving industrial park	Aiming to improve energy efficiency in supplying high-quality industrial water to Amata Corporation industrial parks	Maezawa Industries
	Field-testing to realize a smart energy system and smart mobility system in Bang Sue smart city	Devising specific measures to improve energy efficiency in the Bang Sue district, where a redevelopment plan is underway	Pacific Consultants, Osaka Gas, Japan Environmental Technology, Toyota Thailand, TDEM
Projects related to promotion of circular economy	Construction of an efficient and appropriate resource recycling system for used materials generated in the Kingdom of Thailand	Incorporating the process of recovering CFCs, waste oil, and waste liquids into the dismantling process, and introducing a dismantling process that enables the disposal history of recovered materials to be traced	Toyota Tsusho
	Field-testing of energy-saving cellulosic sugar production system from excess bagasse feedstock	Utilizing Japanese separation membrane technology to produce polyphenols and oligosaccharides alongside the production of cellulosic sugars, which are raw materials for bioethanol, from sugarcane pomace after squeezing	Toray, Mitsui Sugar
	Field-testing of international recycling system for electrical and electronic equipment waste in Bangkok, Thailand	Efficiently recovering multiple metals contained in electrical and electronic equipment through the use of advanced Japanese recycling technology	ARBIZ

Source: Prepared by JRI based on data from the New Energy and Industrial Technology Development Organization [2022] and various media reports

in Japan and Thailand will work together to implement such initiatives in other areas[37].

Second, there is a need to reconsider how to utilize Thailand as an export base in Southeast Asia, taking into account the environmental regulations of each country. Since the main sales destinations for products from Japanese manufacturers in Thailand are Thailand itself and Japan, they will have to modify their production methods to comply with Thai and Japanese environmental standards (Fig. 21). If export competitiveness to emerging economies with lax environmental regulations declines as a result, it will be necessary to develop alternative export destinations and to consider relocating export bases[38].

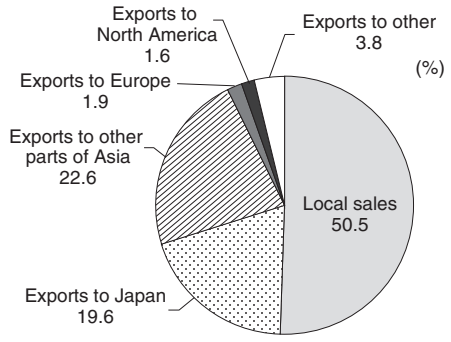
Third, companies should look to expand their BCG-related business to emerging Asian countries other than Thailand. The first reason for this is that the Thai economy is not expected to see an acceleration in its growth rate against the backdrop of a shrinking working population and high household debt levels. In addition, high growth cannot be expected for Japan, which is the main export destination for Japanese companies in Thailand today, due to reasons such as the declining population and other reasons[39].

On the other hand, since Asian emerging countries are expected to gradually become more environmentally oriented, business opportunities in the environmentally-friendly realm are projected to grow over the medium to long term. According to analysis by global insurance giant Swiss Re, Indonesia, the Philippines, and India have lower income levels than Thailand, but also face a higher risk of economic deterioration due to climate change than Thailand does (Fig. 22). Therefore, policies are expected to be strengthened to achieve both economic growth and environmental protection in the future, offerings from Japanese firms that draw on their experience in Thailand should prove attractive to the market.

Conclusion

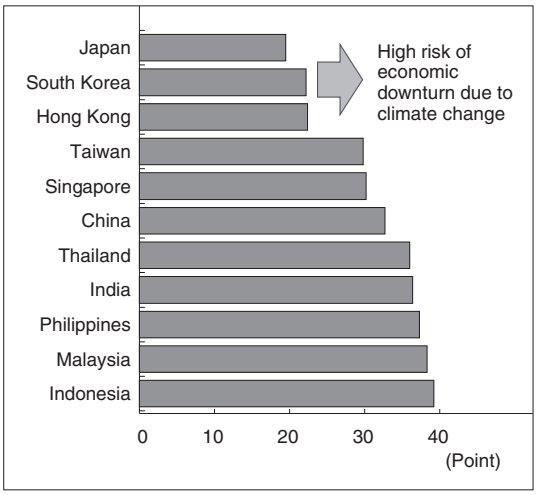
In January 2022, Minister of Economy, Trade and Industry Hagiuda visited Indonesia, Singa-

Fig. 21 Composition of sales of Japanese manufacturers in ASEAN4 (Thailand, Indonesia, Malaysia, and Philippines) (2020)



Notes: While the same survey published country-by-country figures for total sales, only the totals for the four ASEAN countries (Thailand, Indonesia, Malaysia, and the Philippines) were published for sales destinations. Since Thailand accounts for about 60% of ASEAN4 sales, the sales composition of ASEAN4 is considered to be similar to that of Thailand.
Source: Ministry of Economy, Trade and Industry, "50th Basic Survey on Overseas Business Activities"

Fig. 22 Economic impact on Asian countries/territories of climate change



Source: Prepared by JRI based on data from Swiss Re Institute [2021]

pore, and Thailand to announce the "ASIA-Japan Investing for the Future Initiative," which outlines a direction for cooperation between Japan and ASEAN in the post-COVID era. The three central themes are (1) improving the attractiveness of the region as a hub for global supply chains, (2) creating innovations to enhance sustainability and solve social challenges, and (3) accelerating energy transitions. Efforts in Thailand, which is becoming an industrial cluster for Japanese companies in the ASEAN zone, will be key to achieving these goals. Moves to strengthen cooperation with Thailand can be observed. For example, during the Minister's visit to Thailand, JETRO (Japan External Trade Organization) signed a memorandum of understanding with the Thailand Board of Investment and the EEC Secretariat for cooperation in promoting the BCG economy and carbon neutrality. The MOU also outlines a policy of providing information to Japanese companies that are considering investing in Thailand, promoting the sharing of environment-related technologies between Japan and Thailand, and developing human resources through such sharing.Going forward, attention will be focused on how this policy is actually implemented.

In addition to these efforts, Japan and Thailand are expected to work closely together to create an environment that facilitates the deployment of environmental technologies developed by Japanese companies in Thailand to other ASEAN countries in order to enhance the economic and environmental sustainability of Asia as a whole.

End Notes

1. For an overview of the BCG economy, I consulted Kumagai [2021a][2022], METI [2020][2021], Cabinet Secretariat [2020], OECD [2009][2021], STI [2019], UNEP [2011], World Economic Forum [2014], and other sources.

2. A similar term to bioeconomy is "bioindustry," but this is a narrower concept than the bioeconomy, referring solely to the development of biotechnology and the production of goods to which its is applied directly.

3. Royal Thai Government, January 2021 "PM: Govt to declare BCG economy a national agenda"

4. The production of chemically derived food colorings and artificial sweeteners are not part of the bioeconomy, but their share of the food manufacturing industry is limited.

5. Since the legalization of marijuana use for medical and research purposes in 2018, the government has also focused on nurturing the production of medical marijuana and medical tourism that utilizes it.

6. In Japan, tourism focused on rural development is called "green tourism/agritourism," while tourism focused on environmental conservation is distinguished as "ecotourism," but in Thailand the term green tourism is used for both.

7. There is a risk that further strengthening of redistributive policies will lead to increased political dissatisfaction and a decline in the desire to work.

8. According to Kirchherr, Reike, and Hekkert [2017], there are over 100 definitions of the circular economy. Common to all definitions are these elements: reduce (lower the amount of waste generated), reuse (use again), and recycle (convert into something else that can be used).

9. AFPBB News, June 3, 2018, "Whale dies after swallowing 80 plastic bags - southern Thailand"; BBC News, November 21, 2018, "115 plastic cups pulled out of dead whale - Indonesia"; BBC News, March 20, 2019, "40 kilograms of plastic recovered from stomach of dead whale," etc.

10. Agriculture that causes soil pollution, overfishing of marine products, etc. are included in the bioeconomy, but not in the circular and green economy.

11. Strictly speaking, there are aspects of the production and use of gasoline-powered vehicles that are included in the bioeconomy or circular economy, such as (1) the use of bioplastics for vehicle interiors, (2) the use of biodiesel blends, and (3) the recycling of metals contained in scrapped vehicle bodies.

12. Many countries, including Japan, are pursuing similar initiatives to those in Thailand, but the bureaucratic rivalry among ministries and agencies makes it difficult to see the overall picture of environmental policies and their relationship with other relevant policies.

13. The "middle-income trap" refers to a situation in which a low-income country, after transitioning to a middle-income country, is unable to transition to a high-income country for a long time because of a decline in the export competitiveness of labor-intensive industries due to rising labor costs and a lack of competitiveness in capital- and knowledge-intensive industries compared to advanced countries.

14. For more information on Thailand 4.0, see Suehiro [2018].

15 Agritech, which utilizes digital equipment and software, is necessary to improve productivity in the agriculture, forestry, and fisheries industries, which form the backbone of the BCG economy.

16. See Ministry of Agriculture and Cooperatives [2017] and Apichart Pongsrihadulchai [2019] for more information on Thailand's agricultural policy.

17. See Ministry of the Environment [2017].

18. The National Electric Vehicle Policy Committee is considering raising the percentage to 50% (National News Bureau of Thailand, March 13, 2021, "Energy Ministry Considers Setting New EV Production Target").

19. For bioeconomy estimation methodology, I referred to Kuosmanen, T, Kuosmanen, N, El-Meiligi, et al. [2020]. For primary industry, all added value was included, while for secondary and tertiary industry, the added value of the bioeconomy was calculated based on the share of agricultural, forestry, and fishery products in the intermediate inputs.

20. Details of how the Thai government defines the BCG economy and how it estimates its size are not available. In addition, because the definitions of the circular and green economies are more ambiguous than that of the bioeconomy, and because of data limitations are great, estimates of added value have not been made in this paper.

21. According to the Thailand Board of Investment, investment applications for BCG-related projects in 2021 was total 152.4 billion baht, double the 68.4 billion baht in 2020.

22. See Energy News Center (August 4, 2021).

23. See Sasaki [2019]. It should be noted, however, that recycling rates vary widely depending on how they are defined. For example, the World Bank states that Thailand's 2018 plastics recycling rate was only 17.6% (World Bank [2021]).

24. However, the export of plastic waste from Thailand has also become difficult, as other countries have followed Thailand in tightening restrictions on plastic waste imports.

25. See the statement of Minister of Industry Surya in NNA, March 24, 2021, "Ministry of Industry plans to pursue end-of-life vehicle recycling project."

26. In August 2021, NEDO signed a memorandum of understanding with the National Science and Technology Development Agency (NSTDA, Thailand) for cooperation in technological research and development related to the BCG economy, and this will see support provided for field-testing by Japanese companies in Thailand that will lead to the expansion of Thailand's BCG economy.

27. This does not necessarily mean, however, that efforts that would lead to an expansion of the green economy have not been pursued in the Thai auto industry to date. This is because the environmental burden associated with the use of gasoline-powered vehicles is being progressively reduced against a backdrop of stricter government emission and fuel efficiency standards and improvements in technology by automakers.

28. Many countries, including Thailand, have introduced exhaust gas regulations that conform to European standards, with Euro 5 and Euro 6 being stricter on emissions of NOx (nitrogen oxides) and PM (particulate matter).

29. High-caliber foreign personnel would prefer to work in Singapore, China, Europe, or the U.S., where salary levels are higher than in Thailand. In addition, given the high rate of job turnover in the Thai labor market, it is unlikely that companies will actively embark on time-consuming and costly human resource development.

30. The household debt problem in Thailand has become more serious in recent years, with outstanding household debt reaching approximately 90% of GDP. By region, the debt-to-income ratio is higher in the northeast and north, where income levels are lower.

31. See Sanyu Consultants [2020] for a discussion of the challenges for overseas development of smart agriculture by Japanese companies.

32. As for the production of gasoline-powered vehicles, economies of scale are said to appear when annual production per plant exceeds 100,000 units (Newsweek Japan, November 11, 2021, "China's Auto Industry Making the Leap from EVs to Autonomous Driving"). Given that EVs have only about two-thirds the number of parts of gasoline-powered cars, economies of scale may begin to kick in when annual production reaches around 60,000 units.

33. Current lithium-ion recycling rates remain in the single digits even in advanced countries. Therefore, the widespread use of EVs could lead to environmental degradation in countries where brine and ore, the raw materials for lithium, are mined and in countries where lithium is refined from these resources.

34. The ceiling has been voluntarily adopted by the Thai government for the sake of fiscal soundness.

35. In light of not only the widening budget deficit but also the economic slowdown associated with the changes in automobile demand following the end of the first-car tax cut implemented in 2011-2012, the government will likely take a cautious stance toward introducing subsidy policies that could eat into future demand.

36. The names of subsidy programs and the details of systems may be revised in accordance with political developments.

37. In addition, it will be necessary to incorporate into Thai operations the knowledge gained from field-testing in other emerging Asian countries.

38. If Thailand allows the production of both products with high and low environmental impact, Japanese companies may continue to produce two types of products in Thailand (e.g., allow the production of both gasoline cars and EVs). However, if the production of products with high environmental impact is banned there before other emerging countries, it will be necessary to consider shifting production bases.

39. See Kumagai [2021b] for a discussion of economic and political trends in Thailand after the COVID epidemic began to abate.

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