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Biofuel Programs in East Asia: Developments, Perspectives, and Sustainability

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1. Introduction

The governments of East Asian countries and the region are promoting biofuel programs to address energy security and environmental problems as well as to increase farm income. This chapter covers East Asian biofuel programs, including China (People's Republic of China), Japan, Korea (Republic of Korea), and Taiwan. China has 205 thousand kℓ of fuel bioethanol. It is the third-largest biofuel producing country after the U.S. and Brazil (F.O.Licht, 2010). Verification tests and large-scale projects for biofuel production are currently underway in China. With Chinese oil imports rising rapidly as a result of motorization, the Chinese government is expected to expand its bioethanol program in the future. This expansion is expected to mitigate the country's dependence on oil imports and reduce air pollution problems. Although corn is the main feedstock for bioethanol production, the Chinese government aims to diversify bioethanol production, especially from cassava, instead of relying on expanded grain-based bioethanol production.

Japan has a long history of producing bioethanol. However, the technologies it once used were forgotten and remained unused for more than half a century. The enforcement of the Kyoto Protocol required Japan to start a biofuel program and influenced the start of biofuel programs in Korea and Taiwan. Japan promotes biofuel production from rice straw, wooden biomass, and algae. The R&D of second-generation biofuel that is developing in Japan includes improving varieties of energy resource crops, developing technologies for manufacturing biofuel, and developing cultivation methods.

The governments of East Asian countries and the region are promoting biofuel programs that rely on various feedstocks (Table 1), but this reliance and the escalating consumption of biofuel is competing with food and feed in these countries and the region. Consequently, the governments of East Asian countries and the region are developing biofuel programs that will not compete with their food availability.

Several studies have addressed East Asian biofuel production and programs. Koizumi and Ohga (2007) and Koizumi (2008) examined an economic analysis of the available supplies of domestically produced biofuel in Asian countries. Wang et al., (2009) examined the distribution and development of biofuel crops and the bioenergy industry in China. Chaves et al., (2010) reviewed technical and policy development of Chinese biofuel, while more recently Wang (2011) reviewed non-food biofuel commercialization in China.

Matsumoto et al., (2009) reviewed biofuel initiatives, strategies, policies, and the future potential of biofuel in Japan. Koizumi (2009) used econometric models to examine how Chinese bioethanol imports would impact the Brazilian and world sugar markets.
However, these studies for Japan and Asian countries need to update R&D for second-generation biofuel production. In addition, none of these studies has covered sustainability criteria for biofuel production. This chapter reviews not only East Asian biofuel production and programs, but also R&D for second-generation biofuel production and sustainability criteria for biofuel production in East Asian countries and the region. It also examines the impacts Chinese and Japanese biofuel import expansion would have on world sugar markets by applying developed econometric models. The next section covers biofuel production and policies in East Asian countries and the region. The third section discusses the impact of biofuel programs on agricultural markets. The fourth section discusses securing biofuel production, R&D for second-generation biofuel, and the sustainability of biofuel production. The last section summarizes the conclusion.

	Fuel Bioethanol		biodiesel	
	Annual Production (1,000kℓ)	Current Main Feedstock	Annual Production (1,000kℓ)	Current Main Feedstock
China	2,050	Corn, Wheat and Cassava	191	Used cooking oil
Japan	0.2	Sugarcane molasses, wheat unsuitable for food consumption, and others	10	Used cooking oil
Korea	—	—	300	Soybean oil, palm oil and used cooking oil
Taiwan	—	—	36	Used cooking oil

Table 1. Fuel biofuel production and feedstock in East Asia
Source: Chinese and Taiwan's biofuel production data were derived from F.O.Licht (2010), Japanese biofuel production data were derived from Ministry of Agriculture, Forestry and Fisheries (2010), and Korean biofuel data were derived from USDA-FAS (2010).
Note:
1. Chinese bioethanol production was 7.3 million kℓ, Japanese bioethanol production was 100 thousand kℓ, Korean bioethanol production was 169 thousand kℓ and Taiwan's bioethanol production was 10 thousand kℓ in 2009 (F.O.Licht, 2010). However, these data nclude industrial, fuel, and other uses.
2. "- " means unknown.

2. Biofuel production and policies in East Asia

2.1 China

2.1.1 Chinese biofuel program

In China, petroleum consumption is increasing rapidly and imports of crude oil are rising. The increase in petroleum consumption is causing a serious air pollution problem. In addition, excessive stocks of grain, especially corn, were crucial problems from 1996 to 2000. To deal with energy security, air pollution, and excessive grain stocks, the Chinese government strongly promoted the national bioethanol program.
As a result of high economic growth in China, the number of cars there is increasing rapidly. From 1990 to 2008, the market for passenger cars grew from 0.51 to 9.38 million. The Chinese car market has overtaken that of Japan to become the second-largest car market in the world, with sales of 7.28 million vehicles in 2006 (Wang, 2011). Chinese petroleum

consumption increased from 164 million tons in 1990 to 553 million tons in 2008; and crude oil imports rose from 2.9 million tons in 1990 to 178.9 million tons in 2008 (National Bureau of Statistics of China, 2009). After the USA, China is the second-largest petroleum consumer in the world (International Energy Agency (IEA), 2008). Increasing oil consumption led China to become a net oil importer from 1994. The IEA has projected that Chinese oil consumption for transportation use would increase by 5.3% per annum from 2006 to 2030 (IEA, 2008). It is assumed that Chinese oil consumption will expand in the future. However, a shortage of energy, including petroleum, has been a serious problem since the 1990s. Proved oil reserves in China amounted to only 1.2% of the total world proved oil reserves at the end of 2008 (BP, 2009). In addition, rising crude oil prices since 2003 have had a negative impact on Chinese energy markets, as well as other regions.

The increase in petroleum consumption has caused air pollution problems. Next to the USA, China is the largest CO_2 emission country in the world (IEA, 2008). The Chinese Environmental Protection Agency estimated that 79 percent of air pollution originated from vehicle exhausts (Institute of Chinese Affairs, 2010). The Chinese government wants to improve the air pollution situation. From 1996 to 2000, it is estimated China had excessive ending stocks for grain, especially for corn. China is now estimated to have 123.8 million tons of corn ending stock, which is equivalent to 92.6% of the production level in 1999/2000 (USDA-FAS, 2011). Dealing with excessive ending stocks was one of the crucial problems for the Chinese government at that time.

In China, the concept of alternative energy was expressly stated in the Five-Year Plan of 1982. In 2001, the promotion of biomass energy was expressly stated in the Five-Year Plan for the period 2001-2005. In June 2002, the Chinese government started to mandate the use of bioethanol blend gasoline in five cities of Heilongjiang and Hernan. In October 2004, the government introduced the compulsory use of a 10 percent blend of bioethanol to gasoline (E10) in all areas of Heilongjiang, Jilin, Liaoning, Hernan, and Anhui. The government expanded the E10 program in 27 cities of Shandong, Jiangsu, Hebei, and Hubei from 2006.

2.1.2 Biofuel production

In the Chinese government, the Energy Bureau of the National Development and Reform Commission (NDRC) leads this whole program; the Ministry of Science and Technology takes part in technical affairs; the State Grain Administration takes part in the supply of agricultural feedstock; and the Ministry of Agriculture participates in the rural energy policy. In China, corn and wheat comprise a major part of the feedstock for bioethanol. Bioethanol is produced from corn in Heilongjiang, Jilin, and Anhui. It is also produced from wheat in Hernan. In addition, bioethanol is produced from cassava in Guangxi. Currently, five bioethanol production plants in China (Table 1) have operating licenses from the government.

China also produces biodiesel for fuel use. There are four major plants in Fujiang, Jiangsu, Hebei, and Beijing. Although China's production capacity has been estimated at 954.2 thousand kℓ (USDA-FAS, 2009a), it produced only 191 thousand kℓ in 2009, because of a lack of feedstock availability. The main feedstock for biodiesel is used cooking oil. Although Chinese mills prefer to produce biodiesel from vegetable oil, securing vegetable oil for biodiesel use can be difficult because China is a net importer of oilseed and vegetable oil. Securing feedstock is a crucial problem for expanding biodiesel production in China. Biofuel is sold only to two state-owned companies, China Petroleum and Chemical Corporation

(Sinopec) and China National Petroleum Corporation (CNPC) for blending with gasoline (Zhou and Thomson, 2009).

Location	Company	Main Feedstock	2008 Production (Estimated : tons)	2009 Production Capacity (tons)	Supply Location
Heilongjiang, Zhaodong	China Resources Alcohol Co.	Corn	163,296	163,296	Heilongjiang
Jilin, Jilin	Jilin Fuel Ethanol Co.	Corn	426,384	453,600	Jilin and Liaoning
Henan, Nanyang	Henan Tian Guan Fuel-Ethanol Co.	Wheat	371,952	408,240	Henan, Hubei (9 Cities) and Hebei (4Cities)
Anhui, Bengbu	Anhui BBCA Biochemical Co.	Corn	362,880	399,168	Anhui, Shandong (7 Cities), Jiangsu (5 Cities) and Hebei (2 Cities)
Guangxi	Guangxi COFCO Bioenegry Co.	Cassava	108,864	181,440	Guangxi
Total			1,433,376	1,605,744	

Table 2. Current Bioethanol Production
Source: USDA-FAS (2009a).
Note: Rice is partly used for bioethanol production in Heilongjiang.

2.1.3 Production costs and subsidies

In China, the cost of corn-based bioethanol is 4,937 Yuan/ton and the feedstock cost of corn is 3,456 Yuan/ton (Table 3). The feedstock cost of cassava is 1,716 Yuan/ton and the cost of cassava-based bioethanol is 4,259 Yuan/ton. The feedstock cost of corn stover is 1,500 Yuan/ton and total cost is 5,800 Yuan/ton. The Chinese bioethanol production cost from corn is equivalent to 1.022 US$/ℓ[1], while the U.S. bioethanol production cost from corn was 0.492 US$/ℓ (F.O.Licht, 2008). The cost of Chinese bioethanol production from cassava is equivalent to 0.882 US$/ℓ[1], while Thailand's bioethanol production cost from cassava is 0.300 US$/ℓ (F.O.Licht, 2008). Thus, the cost of Chinese bioethanol production is much higher than that of the U.S. and Thailand.

Because of high feedstock prices, all bioethanol producers receive subsidies to cover operating losses. The government subsidy is necessary to produce bioethanol. The average subsidy for fuel bioethanol production set by the government reached 1,836 Yuan/ton in 2005, 1,625 Yuan/ton in 2006, 1,374 Yuan/ton in 2007, and 1,754 Yuan/ton in 2008[2]. The average subsidy decreased gradually between 2005 and 2007. However, it increased from 2007 to 2008 because of high feedstock prices resulting from soaring international grain prices at that time.

In addition, value-added tax (17%) of these plants has been removed (Wang, 2011), five percent consumption tax on bioethanol has been exempted, and approximately 100 Yuan in profit is guaranteed for each stock on a preferential basis. Stock grain subsidies are determined by referencing market prices in each relevant area. The government will cover any loss incurred as a result of adjustment, transportation, or sale of E10. The Ministry of Finance will provide a specified amount of compensation. It is estimated that the removal of Value Added Tax and Consumption Tax totaled 190 million Yuan (US$28 million), and the

[1] It is calculated that 1US$ is equivalent to 6.57 Yuan (2011.3).
[2] This bioethanol cost is estimated from USDA-FAS (2009a).

direct financial subsidy totaled 2 billion Yuan (US$294 million) for grain-based bioethanol plants from 2002 to 2008 (Lang et al., 2009).

All supporting policies are directed toward state-owned enterprises, whereas only a few of them are accessible by private enterprises. Currently, five licenses have been issued in China. In some cases, the lack of supporting policy is the main reason for the failure of private enterprise investment in biofuel plants (Wang, 2011).

Feedstock	Feedstock cost (Yuan/ton)	Production Cost (Yuan/ton)	Location
Corn	3,456	4,937	Jilin
Cassava	1,716	4,259	Guanxi
Sweet Potato	2,240	3,200	Henan
Potato	3,735	5,335	Yunnan
Jerusalem artichoke	2,292	3,274	Shandong
Sugarcane	2,295	3,278	Guanxi
Sweat Sorgam	2,000	4,400	Shandong
Sugarbeet	3,675	5,250	Xinjiang
Corn Stober	1,500	5,800	Henan

Table 3. Bioethanol production cost in China
Source: Song et al., (2008) and, Huang and Yabe (2010).

2.1.4 Feedstock for bioethanol production

The Chinese bioethanol industry used corn as a feedstock for 80 percent of its 2005 production. The government limited the use of inferior agricultural products as feedstock for bioethanol to mitigate the impact on the agricultural market at the first stage of operation. The government prohibited the use of standard corn, traditionally used for feed, food, and other industrial materials[3], as a feedstock for bioethanol. Inferior corn[4] for bioethanol can come from reserve stocks after a period of two to three years. The supply of this inferior corn and wheat has been decreasing since 2001, because of decreased production. In addition, the government has promoted effective food marketing systems and tried to reduce these inferior agricultural foods since 2001. In the mid 2000s there was not enough inferior corn to meet bioethanol demand in China. All bioethanol facilities in Heilongjiang and Jilin have used standard corn as a feedstock for the production of bioethanol, because they can't get enough inferior corn to produce it. Wheat is the main feedstock for bioethanol at the Henan plant. However, wheat is a staple food in China and has a high domestic consumption. The government policies shy away from the use of grain-based feedstock materials for bioethanol production, and the government will not expand bioethanol production from wheat.

Guangxi, Guangdong, Hainan, Fujian, Yunnan, Hunan, Sichuan, Guizhou, Jiangxi, and nine other provinces are suitable for cassava growth. In 2007, total output of cassava in China was about 7 million tons (Wang, 2011). Cassava-based bioethanol plants are operating in the Guangxi in Southern China. Its production capacity in 2009 was 181.4 thousand tons (USDA-FAS, 2009a). In addition to these crops, bioethanol productions from sweet sorghum, crop stalks and straw, sugarcane, sweet potatoes, rice, sugar beet, woody biomass, and others are at an experimental stage.

[3] Other industrial feedstocks are used for adhesives, gummed tape, polished goods, and other products.

[4] Inferior corn is unsuitable for food use and is delivered from reserved stock to the market after a 2-3 year reserved period.

2.1.5 Developments and perspectives of the Chinese biofuel program

The utilization and development of renewable energy in China is a very crucial national program that not only contributes to energy security and improves environmental problems, but also develops rural areas, promoting new industries and technical innovation. In January 2006 the government enacted the "Renewable Energy Law" to promote renewable energy utilization and production. The government promotes biomass energy policy, which is divided into four categories: biofuel, rural biomass, biogas, and bioelectricity. The national bioethanol program was started in 2001, and the government strongly promoted the bioethanol program to provide an alternative fuel for gasoline. It is assumed the government will promote the bioethanol program in the future, because of the increasing gravity of the energy security problem and the air pollution problem.

Corn is the main feedstock for bioethanol production in China. Chinese corn consumption for feed and starch use has increased since 1990 and the domestic corn price has also increased since December 2004. Chinese corn ending stocks decreased dramatically from 123,799 thousand tons in 1999/2000 to 36,602 thousand tons in 2006/07 (Figure 1). When the government started to expand the corn-based bioethanol program, corn ending stocks were abundant and the government tried to manage the decrease in these stocks.

In China, the domestic corn wholesale price increased from 1,190 Yuan/ton in February 2005 to 1,547 Yuan/ton in September 2006[5], because the Chinese corn supply and demand situation was very tight. Corn consumption for bioethanol was competing with corn consumption for feed, food, and other industries. In this regard, the NDRC started to regulate corn-based bioethanol expansion on December 21, 2006. This regulation allowed the current bioethanol production level in Heilongjiang and Jilin, but limited further expansion of corn-based bioethanol production. This regulation will apply to wheat-based bioethanol production as well.

Instead of expanding corn-based bioethanol production, the government wants to diversify bioethanol production, especially from cassava. Cassava-based bioethanol production was 108.9 thousand tons in 2008 and in 2009 production capacity was 181.4 thousand tons. Total cassava production in China was 3.9 million tons in 2009, which is much smaller than cassava production in Thailand (22.8 million tons in 2008[6]). Although Guangxi is trying to increase cassava production, it is assumed that it is difficult to produce enough cassava in China to meet domestic consumption for bioethanol production. If China is to expand bioethanol production from cassava, it will have to rely on cassava imports from Thailand. China has mastered cassava-based bioethanol technology by constructing a demonstration project in Guangxi, but with regard to liquefaction, saccharification, fermentation, separation process, and sterilization devices, it still lags behind advanced international levels (Wang, 2011). A key to success for developing cassava-based bioethanol production in China is technical innovation for mass production.

Sweet sorghum can grow under dry conditions in saline alkaline soil. Although a number of provinces are trying to increase sweet sorghum production, its production is much lower than corn[7]. In addition, Chinese sweet sorghum-based bioethanol production has a technical

[5] It was derived from Institute of Agricultural Economics, Chinese Academy of Agricultural Science (2007.10).

[6] This data was derived from FAOSTAT Data (FAO, 2011).

[7] In 2010/11, sorghum production is 1.5 million and corn production is 28.6 million tons (USDA-FAS, 2011).

problem. It is technically immature and bioethanol content is so low (20%) that it cannot be used as fuel (Wang, 2011). At present, biofuel productions from non-food resources such as cassava and sweet sorghum are still in the pilot scale project stage in China.

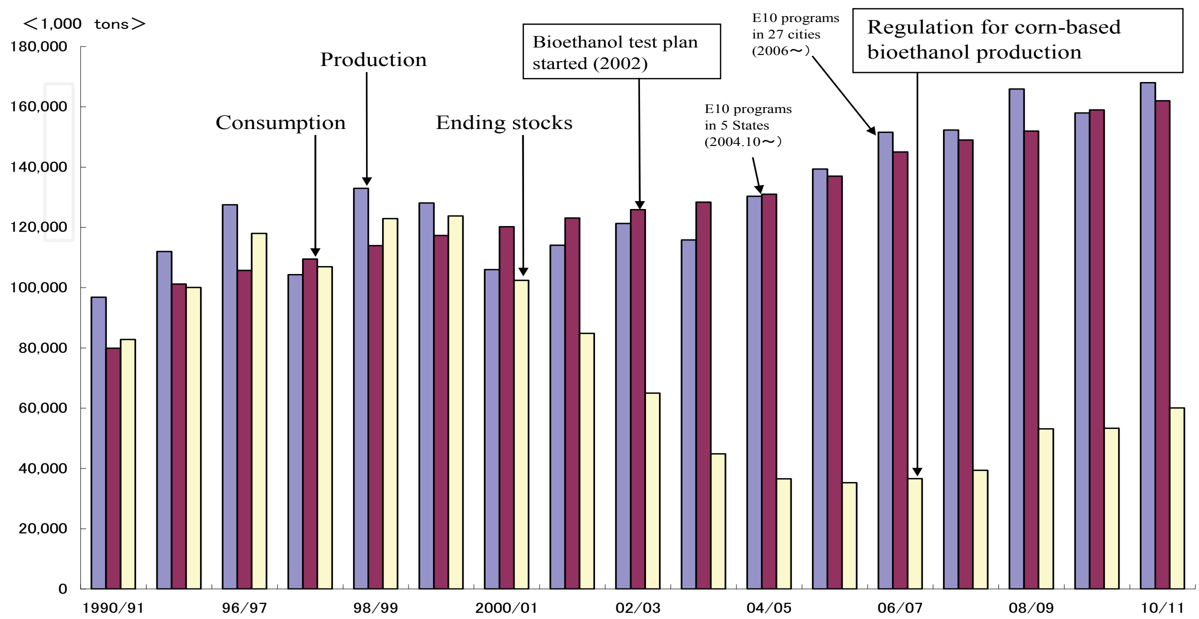

Fig. 1. Chinese corn ending stocks: production and consumption
Source: Data were derived from USDA-FAS (2011)

The NDRC provided a mid- to long-term plan for renewable energy in September 2007. This plan indicated that hydroelectric power generation would increase from 190 million kW in 2010 to 380 million kW in 2020, wind-power generation would increase from10 million kW in 2010 to 150 million kW in 2020, biomass generation would increase from 5.5 million kW in 2010 to 30 million kW in 2020, and solar energy generation would increase from 0.3 million kW in 2010 to 20 million kW in 2020. The plan indicated that bioethanol from non-food grade would be 2 million tons in 2010 and 10 million tons in 2020. The plan also indicated that biodiesel production would be 0.2 million tons in 2010 and 2 million tons in 2020. The Chinese government will promote the expansion of biofuel production from non-food grade in the future. In this plan, the government will promote agricultural resources that can be grown in waste land. In the long term, the National Energy Research Institute has projected that renewable energy will dominate more than 30% of the total primary energy supply in 2030 and 50% in 2050 (Kaku, 2011). This projection indicates that renewable energy will become a leading factor in the Chinese energy supply.

2.2 Japanese biofuel production and programs

2.2.1 The history of Japanese biofuel production and biomass storage

The history of bioethanol production in Japan dates back to 1889, when a factory was built in Hokkaido to produce bioethanol using potatoes as feedstock through malt saccharification.[8] After that, the office of the governor general of Taiwan (during Japan's colonial rule from 1895 to 1945) took the lead in developing bioethanol technologies. In 1937,

[8] As for Japanese biofuel production and programs, it depends on Koizumi (2011).

an alcohol monopoly system was launched to produce bioethanol from potatoes to meet military demand, and by 1944 Japan produced 170 thousand kℓ of bioethanol per year (Daishyo and Mitsui & Co., 2008). During World War II, bioethanol-blended fuel was used for airplanes as an alternative to gasoline, and a significant quantity of bioethanol-blended fuels was used for fighter-attack and trained airplanes at the end of WWII. It is estimated that bioethanol constituted 26.7% of total liquid fuels in 1945[9] because petroleum import lines from the Pacific area were broken at the end of the war. Biodiesel from soybean oil was also produced and used for naval fleets, mainly destroyers. Jatropha curcas-based biodiesel was developed by former army-related petroleum refiners and used for tank fuel and lamps. Japan's biofuel resources were developed as emergency alternative fuel for gasoline and diesel during WWII. The quality and production cost of biofuel were not suitable for commercial use after WWII. Most of these technologies were abandoned and forgotten after that. After WW II, Japan continued to produce bioethanol from imported molasses. However, the two oil crises in the 1970s shifted the focus of Japan's energy policy to energy savings and to reducing the country's reliance on oil,[10] with the result that the adoption of biofuel was not considered until recently. However, under the Kyoto Protocol, Japan was committed to cutting greenhouse gas emissions by 6% from 1990 levels before the end of the first commitment period (2008-2012). The decision to promote the recycling of various types of resources, including biomass, was enacted as the "Basic Law on Promoting the Formation of a Recycling-Oriented Society" in 2001. The first time the government announced a plan to promote biofuel production and utilization of biofuel was in the Biomass Nippon Strategy[11], which the Cabinet adopted in December 2002.

The Kyoto Protocol Target Achievement Plan, adopted by the Cabinet in April 2005, calculated that the new energy input in 2010FY[12] resulting from the implementation of the new energy countermeasures would be equivalent to 19.1 million kℓ of crude oil, which was projected to result in a reduction of 46.9 million tons of CO_2 emissions. The goal was to achieve a reduction in CO_2 equivalent to 500 thousand kℓ of crude oil[13]. When the Kyoto Protocol came into force in April 2005, Japan determined that, to meet its targets, it would be necessary to convert biomass energy into useful forms of energy, such as transportation fuels, and to draw a roadmap for the adoption of domestically produced biomass as transportation fuel. In March 2006, the Cabinet adopted the revised Biomass Nippon Strategy, the most striking features of which were that biofuel became the main force among various biomass products.

The Biomass Nippon Strategy categorizes biomass into three types: waste biomass, unused biomass, and energy crops. Based on data as of 2008, Japan stored 298 million tons of waste biomass and 17.4 million tons of unused biomass. The provisional estimate for the energy potential of unused biomass is approximately 14 million kℓ in crude oil, and the provisional estimate for the energy potential of energy crops is approximately 6.2 million kℓ in crude oil (Ministry of Agriculture, Forestry and Fisheries, 2010). Thus, there is potential to expand the production of biofuel in Japan.

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[9] This figure is estimated from Miwa (2004).
[10] Japan relied on oil for 77.4% of energy consumption in 1973, and 71.5% in 1979, but this dropped down to 49.4% in 2001 (Ministry of Economy, Trade and Industry, 2009).
[11] Nippon means Japan in Japanese.
[12] FY means fiscal year from April to March of next year.
[13] 500 thousand kℓ of crude oil is equivalent to 800 thousand kℓ of bioethanol.

2.2.2 Developments and perspectives of the Japanese biofuel program

The Japanese government has been promoting bioethanol production and its use for automobiles since 2003. The Japanese bioethanol production level was estimated at 200 kℓ in March 2009 (Ministry of Agriculture, Forestry and Fisheries, 2010). At present, verification tests and large-scale projects for bioethanol production have been launched at ten locations in Japan. Demonstration projects include large-scale projects that began in 2007 to collect data for domestic transportation biofuel and to support a model project for the local utilization of biomass. The Ministry of Economy, Trade and Industry is promoting biofuel programs from an energy security incentive, while the Ministry of Agriculture, Forestry and Fisheries is promoting it mainly from the perspective of rural development, and the Ministry of Environment is promoting it for environmental reasons.

Hokkaido Bioethanol Co. Ltd in Shimizu Town, Hokkaido, produces bioethanol from surplus sugar beets and substandard wheat. Its facility's capacity is 15 thousand kℓ/year. Oenon Holdings, in Tomakomai City, Hokkaido, produces bioethanol from nonfood rice, and its facility's capacity is 15 thousand kℓ/year. JA Agricultural Cooperatives in Niigata City, in Niigatas Prefecture, produces bioethanol from nonfood rice with a capacity of 1.0 thousand kℓ/year (Ministry of Agriculture, Forestry and Fisheries, 2010). In addition to these projects, the soft cellulose-based bioethanol project has been promoted since 2008 to use rice straw and wheat straw to produce bioethanol. Rice and wheat straw-based bioethanol is produced at 3.7ℓ/day in Hokkaido, and rice straw and rice husk-based bioethanol is produced at 200ℓ/day in Akita Prefecture. Rice straw and other cellulose material-based bioethanol is produced at 100ℓ/day in Chiba Prefecture, and rice straw and wheat straw-based bioethanol is produced at 16ℓ/day in Hyogo Prefecture (Ministry of Agriculture, Forestry and Fisheries, 2010).

The municipal government and non-governmental organizations are promoting the production of biodiesel from used cooking oil blended with diesel used for public buses, official cars, and municipal garbage trucks. The total amount of biodiesel production was estimated at 10,000 kℓ as of March 2008 (Ministry of Agriculture, Forestry and Fisheries, 2010). Most of their biodiesel production levels are smaller than those of the bioethanol facilities since NGOs and local governments produce biodiesel in small plants using recycled rapeseed oil as the main feedstock. Twenty biodiesel fuel projects have started since 2007.

In February 2007, seven ministries and the cabinet office released a "roadmap" to expand biofuel. The goal was to produce 50 thousand kℓ of biofuel domestically per annum by 2011 FY. If appropriate technical development is achieved, such as reducing the costs of collection and transportation, developing resource crops, and improving bioethanol conversion efficiency, a significant increase in the production of domestic biofuel can be feasible by around 2030[14]. The budget in 2008 FY to enlarge Japanese biofuel production was 8 billion JPY. These measures included developing technologies for low-cost and highly efficient biofuel production, demonstrating the efficient collection and transportation of rice straws, and establishing technologies to manufacture biofuel from cellulose materials. The budget in 2009 FY to increase Japanese biofuel production was 20.3 billion JPY. To promote bioethanol production and utilization, a tax privilege for bioethanol production and utilization was also established in 2008. First, a 50% reduction in fixed assets tax for biofuel manufacturing

[14] The Ministry of Agriculture, Forestry and Fisheries calculated the production of domestic biofuel at 6 million kℓ to the year 2030.

facilities was applied for three years. Second, a tax reduction was established for the portion of bioethanol in bioethanol-blended gasoline; in the case of 3% bioethanol blended in gasoline, 1.6JPY/ℓ is tax exempted.
In 2009 the Ministry of Economy, Trade and Industry and the Ministry of Agriculture, Forestry and Fisheries set up a study panel for cellulose-based biofuel production to the year 2020. The panel released its estimates of biofuel production potential using Japanese technology in 2009: domestic cellulose-based bioethanol can be produced at about 330 thousand kℓ (crude oil equivalent); starch and glucose-based bioethanol can be produced at about 30 thousand kℓ; and biodiesel can be produced at about 50 thousand kℓ. Thus, domestic biofuel can be produced at about 400 thousand kℓ. The panel defined imported biofuel developed in Asian countries as "quasi domestic biofuel," which can be produced at about 100 thousand kℓ in 2020, based on their refineries' technologies and production scale.
In 2010, the Ministry of Economy, Trade and Industry set up the target amount of bioethanol utilization for oil refineries based on Notification No.242 of the Ministry of Economy, Trade and Industry. The target amount will be 210 thousand kℓ in 2011 increasing to 500 thousand kℓ in 2017.

2.2.3 Cost of bioethanol production and securing feedstock

The domestic costs of bioethanol are much higher than those of gasoline and imported bioethanol because of expensive land usage. The feedstock cost of sugarcane molasses is 7 JPY/ℓ, the processing cost is 83.4 JPY/ℓ, and gasoline tax is applied at the rate of 52.2 JPY/ℓ [15](Figure 1). The cost of sugarcane molasses-based bioethanol is 142.6 JPY/ℓ, and the production cost of rice from bioethanol use is 146.2 JPY/ℓ. There are two types of bioethanol utilization in Japan: a direct 3% blend with gasoline and ETBE (Ethyl Tertiary-Butyl Ether)[16] use. Bioethanol from sugarcane molasses and rice for bioethanol use in Niigata are used for direct blending with gasoline. The direct-blended gasoline has to be sold at the same price as standard gasoline to compete. The gasoline wholesale price is 59.6 JPY/ℓ, and gasoline tax is applied to 53.8 JPY/ℓ, so the total gasoline price is 113.4 JPY/ℓ. The price difference between sugarcane molasses for bioethanol use and the gasoline price is 29.2 JPY/ℓ, and the price difference between rice for bioethanol use and the gasoline price is 32.8 JPY/ℓ.
The production cost of bioethanol from non-food-grade wheat is 150.2 JPY/ℓ. This type of bioethanol is used in Hokkaido for ETBE production. The price of bioethanol for ETBE use is based on the imported Brazilian bioethanol price, determined by the Petroleum Association of Japan (PAJ). The total price of bioethanol from Brazil is 127.3 JPY/ℓ, and the price difference between that of non-food wheat and the Brazilian bioethanol price is 22.9 JPY/ℓ. Food-based biofuel is not produced in Japan, so these biofuel production costs are theoretical figures (Fig.2). It is not realistic to produce bioethanol from food use grains in Japan, because production costs are high.
These price differences present crucial challenges to the goal of expanding biofuel production in Japan. At present, bioethanol producers are bearing the price deficiencies using subsidies. However, these subsidies have been limited to between 3-5 years, and at present no bioethanol producers can operate their production facilities without subsidies.

[15] The tax reduction was established for the portion of bioethanol out of bioethanol-blended gasoline in February 2009. In the case of 3% bioethanol blended in gasoline, 1.6JPY/ℓ is tax exempted.
[16] ETBE (Ethyl Tertiary-Butyl Ether) is made from bioethanol and isobutylene.

Reducing the cost of producing bioethanol is the key to increasing its domestic production, but it will be difficult to reduce the domestic bioethanol cost to the level of gasoline prices and imported bioethanol prices in a short period. If the government wants to maintain domestic bioethanol production levels, policy measures to diminish their price deficiencies will be necessary, at least in the short term.

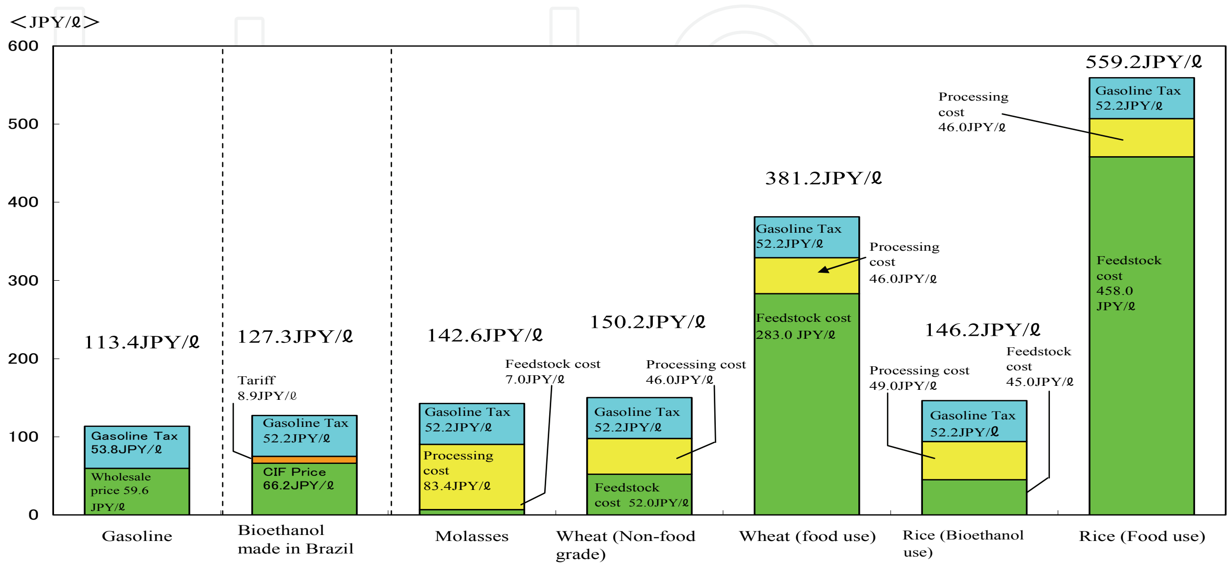

Fig. 2. Japanese bioethanol production cost

Note:

1. Production cost includes capital cost and variable cost. Retail price includes transportation cost and consumption tax. These data are based on Ministry of Agriculture, Forestry, and Fisheries of Japan (2010).
2. The wholesale price of gasoline is the average March 2010 price from the the Oil Information Center of Japan.
3. The Brazilian bioethanol CIF price is the average March 2010 price from trade statistics. The custom tariff is 13.4%

At present, ten bioethanol production projects are operating. It is difficult for most of these facilities to increase their production levels because of limited feedstock. In addition, agricultural products are strongly influenced by the weather, and Japan is a net food-importing country. What's more, there is strong critical opinion that food-based biofuel may damage domestic and world food availability. Thus, in order to increase the volume of domestically produced bioethanol in Japan, it is necessary to produce biofuel from cellulose materials and unused resources.

2.3 Other countries and regions

The government of Korea promotes biofuel utilization to eliminate GHG emission. The presidential committee for green growth has released a plan to cut GHG emissions by 4% until 2020, compared with the 2005 level. The Korean government strongly promotes a national renewable energy program. At present, the biodiesel program is the leading project in the program.

The Korean biodiesel production level was 300 thousand kℓ in 2009. Of that amount, 75-80 percent was imported soybean oil and palm oil, while the remainder was mainly domestically used cooking oil (USDA-FAS, 2010). The Korean government has set the biodiesel targeted blend ratio at 2.0% but plans to increase this to 3.0% in 2012. To meet biodiesel demand, Korea will have to increase biodiesel production in the future. The government is exploring research for alternative feedstock for biodiesel, such as rapeseed oil, animal fats, and other sources. However, it is difficult to increase the production and yield of rapeseed, and further R&D is needed for animal fats-based biodiesel. Ensuring feedstock is a crucial problem in expanding biodiesel production and utilization in Korea.

The government of Taiwan has promoted the B1 (1% biodiesel blend to diesel) mandate program since 2008. The main incentive for promoting the biodiesel program in Taiwan is to cut GHG emission. Although Taiwan is not a member of the Kyoto Protocol, it has tried to pursue the global trend of cutting GHG emission. Biodiesel production in Taiwan was estimated at 36 thousand Kℓ in 2009 (F.O.Licht, 2010). The feedstock of biodiesel production is used cooking oil. Taiwan's demand for biodiesel is estimated at 45 thousand kℓ per year (USDA-FAS, 2009b). The gap between domestic demand and supply depends on biodiesel imports from the EU. The government plans to increase the biodiesel blend ratio in the future.

3. Impacts of East Asian biofuel policies on food markets

3.1 Impacts of Chinese bioethanol imports on world sugar markets

3.1.1 Methodology and baseline projection

This study examines the impacts Chinese bioethanol import expansion from Brazil would have on Brazilian and international sugar markets by applying the World Sugar Market Model[17]. This model was developed in order to analyze how bioethanol, energy, or environmental policies in major sugar-producing countries affect not only domestic and world bioethanol markets but also corresponding sugar markets. The model was developed as a dynamic partial equilibrium model that extends to the world sugar and bioethanol markets. The world sugar market consists of 11 major sugar-producing countries, namely: Brazil, the U.S., the EU27, Australia, Mexico, Japan, India, China, Thailand, the former USSR, and the rest of the world. The Brazilian bioethanol market is involved in the model.

Brazil is the world's largest producer of sugarcane and sugarcane-based bioethanol. More than half of the sugarcane produced in Brazil goes towards bioethanol production, and the remainder goes to the bioethanol market, meaning developments in Brazil have considerable implications for global sugar and bioethanol markets. In the model, these two markets are inter-linked through the Brazilian sugar and bioethanol markets. In the Brazilian market, a "sugarcane allocation ratio variable" is defined as the relative proportions of sugarcane going to bioethanol production and sugar production respectively. Each country market consists of production, consumption, exports, imports, and ending stocks activities up to the year 2020/21. The sugar market activities are defined on a raw sugar equivalent basis. The baseline projection is based on a series of assumptions about the general economy, agricultural policies and technological changes in exporting and importing countries during the projection period. It is assumed that the Chinese

[17] As for the World Sugar Market Model, refer to Koizumi and Yanagishima (2005).

government doesn't import bioethanol from Brazil. Based on these assumptions, world sugar production is projected to increase by 2.0% and its consumption is projected to increase by 2.5% per annum from 2006/07 to 2020/21, while world sugar exports and imports are projected to increase by 1.8% per annum during this period.

3.1.2 Impacts of Chinese bioethanol imports on world sugar markets

The bioethanol mid-to long-term plan for renewable energy indicated that bioethanol production from non-food grade would be 2 million tons in 2010 and 10 million tons in 2020 (Table 4). According to this plan, bioethanol is not produced from corn and wheat, and produced from non-food grade feedstock. However, it is assumed to be difficult to expand bioethanol from non-food grade feedstock in China. In this scenario, it is hypothesized that during the projection period technological innovation for bioethanol production will not be developed and non-food grade feedstock for bioethanol supply will not expand. Thus, it was assumed bioethanol production from non-food grade would not expand from 2007/08 in this scenario.

The Chinese bioethanol production cost was 0.827US$/ℓ in 2007, while the Brazilian bioethanol production cost was 0.30 US$/ℓ in 2006/07 (F.O.Licht, 2008). The CIF price of bioethanol landed in China is estimated at 0.63 US$/ℓ[18], which is lower than the domestic production cost. The Chinese bioethanol production cost is higher than that of Brazil, which has a large capacity for exporting bioethanol. If the Chinese government promotes the utilization of alternative fuels, it may consider importing Brazilian bioethanol in the future. It is assumed that both bioethanol trades will expand in the future. The Chinese government will import bioethanol from Brazil as a mid-to long-term goal to address the deficiency in domestic production. As a result, bioethanol imports will total 1,700 thousand tons in 2010/11 and 9,700 thousand tons in 2020/21.

As a result of Chinese bioethanol imports from Brazil from 2010/11, the Brazilian sugar price (Domestic crystal sugar price) is predicted to increase by 24.8% in 2020/21 and the world raw sugar price (New York No.11) is predicted to increase by 15.9% in 2020/21 (Table 5). This can be concluded from analysis using the econometric model, that expanded bioethanol imports from China to Brazil would have an impact not only on the Brazilian sugar market, but also on world sugar markets. A higher world raw sugar price will also benefit other sugar-exporting countries. Other sugarcane-based sugar exporters are expected to materialize benefits with a two-year time lag, because of the agricultural conditions associated with the growth of sugarcane. Brazilian bioethanol and sugar producers are assumed to materialize benefits from relatively higher domestic bioethanol and sugar prices, because more than 60% of Usina (local sugar producers) have both bioethanol and sugar facilities in Brazil.

However, some developing countries may decrease their imports and consumption due to the relatively high sugar price. The expansion of Chinese bioethanol imports from Brazil can have a negative impact on some countries, due to the higher sugar prices[19]. In addition, the expansion of Chinese bioethanol imports from Brazil can cause an increase in the volatility of the world sugar price.

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[18] Freight from Brazil to China, including insurance, is 0.21US$/ℓ, estimated from Sao Paulo Esalq and 1.9 DT Chemical tanker. The tariff equivalent is 0.1235 US$/ℓ (Tariff rate 2207.1 0-1 90).

[19] For detailed model simulation, please refer to Koizumi (2009).

	Feedstock	2008 Production (tons/year)	2009 Production Capacity (tons/year)	2010 Target (tons/year)	2020 Target (tons/year)
Heilongjiang	Corn	180,000	180,000	0	0
Jilin	Corn	470,000	500,000	0	0
Henan	Wheat	410,000	450,000	0	0
Anhui	Corn	400,000	440,000	0	0
Guangxi	Cassava	120,000	200,000	200,000	200,000
Hubei	Inferior grains	0	0	100,000	100,000
Total (1)		1,580,000	1,770,000	300,000	300,000
National Target (2)		–	–	2,000,000	10,000,000
Domestic defficiency (3)=(2)-(1)		–	–	1,700,000	9,700,000

Table 4. Chinese mid- to long-term plan and bioethanol production (Scenario)
Source: NDRC, Mid-long term plan of renewable energy (September 2007) and author's estimation

	2020/21
World raw sugar price (New York, No.11)	15.9%
Brazil crystal sugar price	24.8%
World white sugar price (London, No.5)	15.9%

Table 5. Impact on sugar prices (Scenario/baseline)
Source: Koizumi (2009)

3.2 Impacts of the biofuel and feedstock import on world agricultural markets in other countries and region

It is estimated that Japan will import bioethanol from Brazil to meet its goal. It is hypothesized that Japan will start the E3 (3% of bioethanol blend in gasoline) program in 2012 and will depend on imported bioethanol from Brazil. As a result of the E3 program in all areas of Japan from 2012, the Brazilian sugar price (Domestic crystal sugar price) is predicted to increase by 1.5% and the world raw sugar price (New York No. 11) is predicted to increase by 1.4% in 2015 (Koizumi, 2007). In addition to this analysis, it is hypothesized that Japan will import 3 million kℓ of Brazilian bioethanol starting in 2010[20]. As a result of the 3 million kℓ of bioethanol imported from Japan to Brazil, the Brazilian sugar price is predicted to increase by 4.4% and the world raw sugar price is predicted to increase by 3.1% in 2015 (Koizumi, 2007). As a result of the analysis using the econometric model, it is concluded that an expansion of bioethanol exports from Brazil to Japan would have an impact not only on the Brazilian sugar market, but also on world sugar markets[21].

Korea imports soybean oil as feedstock for biodiesel use from Argentina and Brazil, and imports palm oil as feedstock for biodiesel from Malaysia and Indonesia. Taiwan imports biodiesel from the EU. It is estimated that Korean soybean oil imports from Argentina and

[20] It is hypothesized that Japan will import 3 million kℓ of Brazilian bioethanol for thermal power generation if technical and transportation problems are resolved via cooperation between Japan and Brazil.
[21] For this model simulation, refer to Koizumi (2007).

Brazil can impact the soybean and soybean products markets in these countries; Korean palm oil imports from Malaysia and Indonesia can impact their palm oil markets; and Taiwan's biodiesel imports from the EU can impact biodiesel and oilseed markets in the EU. However, the amount of their imports is very small; it is estimated that their impacts on world vegetable oil and related markets are quite small and limited.

4. Future directions for the biofuel program in East Asia

4.1 Securing biofuel production and R&D for second-generation biofuel production

Governments in Asian countries and the region are promoting biofuel programs to deal with energy security, environmental problems, and agricultural problems. Securing feedstock for biofuel is the most crucial problem in expanding biofuel production in East Asia. In addition, high production costs and an unstable production system caused by a lack of feedstock supply are also obstacles to the expansion of biofuel production in East Asia.

At present, it is difficult to expand food-based biofuel production in East Asia. In the future, the most crucial factors for promoting biofuel production will be technological innovation in producing biofuel from rice straw or wooden biomass efficiently, and the development of crops that can produce bioethanol in large quantities. The R&D of second-generation biofuel that is developing in Japan includes improving varieties of energy resource crops, developing technologies for manufacturing biofuel, and developing cultivation methods. The sugar and corn starch yield of genetically engineered varieties is higher than that of conventional varieties. In addition, technologies have been developed to manufacture bioethanol more efficiently from non-food resources, such as woody biomass, rice straws, and energy crops. Japanese research institutes are also working on increasing the efficiency of cellulose-based bioethanol production[22]. Some Japanese universities and private companies are researching the production of biodiesel from algae, such as *pseudochoricystis ellipsdoidea* and *Botryococcus braunii* for automobile fuel and jet fuel.

In the future, China will have to diversify feedstock for biofuel production. China has switched from grain-based biofuel to non-food grade biofuel, such as sweet sorghum and cassava. However, biofuel production from non-food resources such as cassava and sweet sorghum are still in the pilot scale project at present and it is difficult to expand bioethanol from cassava and sweet sorghum, because of the difficulty securing feedstock. In addition, China is exploring second-generation biofuel production from corn stalk and algae. The Tianguan Group Co. Ltd., has constructed a pilot cellulose bioethanol production line, with a capacity of 300 tons/year. China National Cereals, Oils and Foodstuffs Corp. (COFCO), Sinopec, and Novozymes signed a new agreement to advance cellulose bioethanol technology in 2009 (Wang, 2011).

At present, high enzyme cost is one of the problems in expanding cellulose-based bioethanol production around the world. As for cellulose-based bioethanol production, the main research area is reducing the cost of enzymes in cooperation with the U.S. and private European companies. China is conducting R&D for biofuel production from algae in collaboration with private U.S. companies and government. While Chinese R&D for second-

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[22] In 2006 RITE (Research Institute of Innovation Technology for the Earth) and Honda R&D Co., LTD. developed the *RITE strain*, which substantially reduces the harmful influence of fermentation inhibitors. RITE is also developing high STY (Space Time Yield), which promotes productivity in a unit of reaction volume per hour and simultaneous utilization of C6 and C5 sugars.

generation biofuel production has just begun, its R&D can be active in the future. Korea is conducting researches into producing biofuel from seaweed and Taiwan is conducting research into cellulose and agricultural waste-based bioethanol production. However, their researches are also at an experimental stage.

4.2 GHG reduction from domestic bioethanol production

Japanese bioethanol production is in an experimental stage, and is not mature enough to decide on a default ratio for LCA analysis of GHG emissions from domestic bioethanol production[23]. However, the Japanese government has released reference LCA results for domestic bioethanol production to introduce sustainable criteria for biofuel[24]: High-yield rice with changes for water management emitted 91 gCO2/MJ; high-yield rice without changes for water management emitted 57 gCO2/MJ; minimum-access rice emitted 60 gCO2/MJ; non-food grade wheat emitted 44 gCO2/MJ; surplus sugar beets emitted 39 gCO2/MJ; sugar beets for bioethanol use emitted 60 gCO2/MJ; wasted wood emitted 8 gCO2/MJ; and sugarcane molasses emitted 55 gCO2/MJ (Table 6). It is estimated that Japanese gasoline emitted 81.7 gCO2/MJ. As for the GHG elimination ratio compared with gasoline, the ratio of domestic bioethanol to gasoline ranges widely from -11% to 90%. The ratio of high-yield rice with changes for water management is -11%, and the ratio of wasted woods is 90%. It will be necessary to examine these LCA analyses again whenever bioethanol-related technological developments occur, because Japanese biofuel production is in an experimental stage.

(gCO2/MJ)

	Feedstock production	Feedstock transportation	Biofuel production	Biofuel transportation	Total	GHG elimination ratio compared with gasoline
High yield rice with change for water management	53	1	33	4	91	-11%
High yield rice without change for water management	19	1	33	4	57	30%
Minimum-Access Rice	21	1	33	4	60	27%
Wheat (Non-food grade)	7	1	32	4	44	46%
Surplused sugar beet	7	5	24	4	39	51%
Sugar beet for bioethanol use	28	5	24	4	60	27%
Wasted woods	0	1	3	4	8	90%
Sugarcane molasses	0	0	51	4	55	33%

Table 6. Reference study results of GHG emission and reduction for Japanese bioethanol
Source: Data were derived from the Ministry of Economy, Trade and Industry, Japan (2010)

4.3 Establishing sustainability criteria for biofuel

East Asian countries and the region are importing or will import biofuel and feedstock for biofuel from other countries. To ensure the sustainability of biofuel not only in their

[23] In this study, GHG covers CO2, CH4 and N20. The GHG emission was equivalent to CO2 emission. The GWP (Global Warming Potential) is 21(CH4) and 310(N20).

[24] The Japanese Government didn't release the default ratio for LCA analysis of GHG emissions from domestic biodiesel production. The governments of China, Korea, and Taiwan didn't release the reference and default ratio for LCA analysis of GHG emissions from domestic biofuel production.

countries and region but also on a global scale, they have to take care of the environment, food availability, and the social consequences among their trading partner countries. Thus, establishing sustainable criteria is crucial in promoting biofuel utilization and production in these countries and the region. The Sophisticated Methods of Energy Supply Structures Law, enacted in July 2009, required oil refiners (petroleum and gas enterprises) to use biofuel and biogas. To decide sustainable criteria for the use of biofuel in Japan, the government organized a study panel to discuss the introduction of the criteria in 2009, and in November 2010 the criteria were finally stipulated in Notification No. 242 of the Ministry of Economy, Trade and Industry.

The criteria included several issues: First, the biofuel should eliminate 50% of GHG, compared to gasoline or diesel. Second, oil refiners should pay attention to ensure food availability, and not to impair such availability in the course of promoting biofuel utilization.[25] Third, oil refiners should recognize the impact of biofuel production on biodiversity and obey domestic laws and regulations related to these areas.[26] Fourth, oil refiners should promote cellulose-based and algae-based biofuel R&D and utilization. These sustainable criteria took into account not only domestic biofuel production, but also imported biofuel. At present, most of the domestic biofuel production does not satisfy the criteria (50% GHG reduction), with the exception of waste woods and sugar beet for bioethanol use[27]. However, these criteria are applied to each project if the project is fairly evaluated as a demonstration project. This means these criteria will not apply for most of the domestic project for the time being, because Japanese biofuel production is in an experimental stage. The notification recognized it would be necessary to examine domestic criteria for these LCA analyses, whenever bioethanol-related technological developments occur.

The government of Japan decided on mandatory sustainable criteria for biofuel. The criteria cover the limitation of GHG emission, while paying attention to biodiversity and food availability. However, the criteria do not cover social consequences and other environmental issues, such as air quality, water availability, and others. On this account, Japan has been contributing to discussions in the Global Bioenergy Partnership (GBEP) to establish international guidelines for sustainable criteria for biofuel with the Food and Agricultural Organization of the United Nations (FAO) and other countries since 2007. The category of proposed sustainable criteria in the GBEP are much wider than those of Japan. [28] Although China, Korea, and Taiwan have not introduced sustainability criteria, it has been strongly

[25] If they are concerned that bioethanol production of the trading partner country will dramatically decrease, oil refiners should report their situation to the Japanese Government.

[26] If they are concerned that the biodiversity of the biofuel trading partner country will be damaged dramatically, oil refiners should report their situation to the government.

[27] In the case of Brazil, the panel reported that bioethanol production from existing crop land could eliminate 60% more GHG emissions than gasoline. It means that Brazilian bioethanol production from existing crops land can pass the draft criteria. The panel also reported that bioethanol production from converted pasture land could increase GHG emissions 8% over those of gasoline.

[28] GPEP brings together public, private, and civil society stakeholders in a joint commitment to promote bioenergy for sustainable development. The proposed criteria covers environmental (GHG emissions, productivity capacity of the land and ecosystems, air quality, water availability, use efficiency and quality, biological diversity, land-use change, including indirect effects), social, economic and energy related security (March 2011).

recommended they do so to comply with international sustainable criteria for GBEP, when the GBEP criteria are finalized and released.[29]

5. Conclusion

The governments of East Asian countries and the region are promoting biofuel programs to address energy security and environmental problems, and problems related to agriculture and rural development. Their main incentives to promote biofuel are different and produce various resources. Their feedstock for biofuel production includes various agricultural products. In China, energy security is the main incentive to promote its biofuel program. The enforcement of the Kyoto Protocol influenced the start of the biofuel programs in Korea and Taiwan and required Japan to start a biofuel program.

Verification tests and large-scale projects for biofuel production have been launched in China and Japan, but current biofuel production have experienced some problems because of high production costs and securing feedstock. In particular, securing feedstock for biofuel is a crucial problem, because this feedstock comprises various agricultural products that are used as food sources. Increasing biofuel consumption is exacerbating this problem. The gap between domestic demand and supply of biofuel has created a reliance on imported biofuel. Although bioethanol imports from Brazil will have an impact on the world sugar price, this impact differs from the impact of grain and staple food.

To ensure energy security, biofuel should be produced domestically in the long term. The governments of East Asian countries and the region are working on biofuel programs that will not compete with food availability. It is expected that the introduction and development of second-generation biofuel can mitigate the competition between food and energy. Japan, China, Korea, and Taiwan are promoting the production of biofuel from cellulose and unused resources, and Japanese R&D for second-generation biofuel production is very active. These countries and the region will have to continue to assist on these research projects in the mid to long term, so these governments can increase their domestic biofuel production and imports in the future. There are no international frameworks for the R&D of second-generation biofuel in East Asia and other regions. Establishing international cooperation to develop second-generation biofuel is needed in East Asia and other region.

However, there is still uncertainty about whether second-generation biofuel production can be economically viable. For the time being, some countries and regions may have to depend on imported biofuel and its feedstock from other regions to meet their national goals. East Asian countries and the region are importing biofuel or feedstock for biofuel from other countries and region. Because the biofuel program was introduced from environmental incentives in East Asian countries and the region, the introduction of these biofuels should improve environmental conditions not only in their countries and the region, but also globally. When countries promote a biofuel program, they have to pursue sustainability simultaneously. To pursue the sustainability of biofuel, they have to take care of the environment, food availability, and the social consequences in their trading partner countries. Thus, establishing sustainable criteria for biofuel, which determine the limitations of GHG emissions, and paying close attention to biodiversity, food availability, and social

[29] At present (March 2011), GBEP doesn’t decided final guidelines for sustainable criteria for biofuel.

consequences, are needed for East Asian countries and the region. Japan decided the mandated criteria for oil refiners in 2010. However, further researches and dialogue with related countries will be required to realize the sustainability of biofuel. East Asian countries and the region, especially China and Japan, have put emphasis on promoting the expansion the amount of biofuel production until now. It is time to change this emphasis to pursuing the sustainability of biofuel, rather than expanding the amount of production. International cooperation in the region is needed to realize the sustainability of biofuel.

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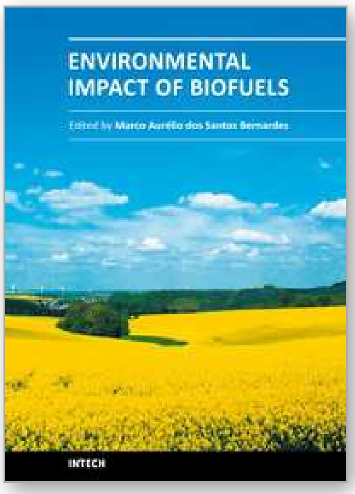

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This book aspires to be a comprehensive summary of current biofuels issues and thereby contribute to the understanding of this important topic. Readers will find themes including biofuels development efforts, their implications for the food industry, current and future biofuels crops, the successful Brazilian ethanol program, insights of the first, second, third and fourth biofuel generations, advanced biofuel production techniques, related waste treatment, emissions and environmental impacts, water consumption, produced allergens and toxins. Additionally, the biofuel policy discussion is expected to be continuing in the foreseeable future and the reading of the biofuels features dealt with in this book, are recommended for anyone interested in understanding this diverse and developing theme.

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