Current Status of Policies on Transportation Biofuels in Key Countries

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1. Introduction

The majority of transportation fuels that are currently used by mankind are dependent on fossil fuels. The supply of oil is forecasted to last for roughly another 50 years, and work is being done to commercialize renewable fuels as an alternative to finite fossil fuels.

The use of renewable fuels is part of security measures to eliminate dependency on oil through diversification of energy sources, and further contributes to the reduction of carbon dioxide (CO_2) emissions in addressing climate change, while potentially creating jobs in new industries.

This report examines the current status of and policy trends in countries around the world to further the mandate of transportation renewable fuels, such as Renewable Fuel Standard (RFS) programs.

2. Characteristics of Renewable Fuels for Automobiles

The types of renewable fuels are bioethanol (either a direct mixture of bioethanol, or mixture by conversion to ethyl tertiary butyl ether or ETBE) for automotive gasoline, biodiesel blended in diesel, and biomethane (biogas) blended in natural gas.

These renewable fuels are produced from biological organisms and are considered sustainable fuels. Furthermore, the raw materials used for these fuels (such as corn, sugar cane, beans, rapeseed, and waste edible oil) absorb CO_2 that is the main cause of climate change, while producing oxygen (O_2) as they grow. Accordingly, use of these renewable fuels can be considered a type of carbon neutrality. In order to stimulate the production of energy crops and fuel-related industry, countries around the world including the United States, Brazil, and European nations are actively encouraging renewable fuels as an alternative to oil, setting national targets and working toward their adoption.

Total global production of biofuels was approximately 100 million kiloliters in 2013, comprising approximately 80% bioethanol and the remaining 20% biodiesel.

Bioethanol has a research octane rating (RON) of roughly 107 and is a renewable fuel that can be used in place of conventional methyl tertiary butyl ether (MTBE) as an oxygenated base ingredient. In the United States, E10 (gasoline containing 10% ethanol by volume) was obligated and has been used since the oil crisis in the 1970s, as part of that country’s energy policy and to stimulate agriculture.

While there were problems during the initial introduction period such as corrosion of fuel components, these issues were resolved by changing the quality of the materials. One issue that remains with bioethanol is that it only has approximately 70% of the energy of automotive gasoline, resulting in slightly lower fuel economy. Aside from E10, there is currently a trend toward increased adoption of dedicated E85 vehicles and flexible fuel vehicles (FFVs).

Brazil established a policy to use bioethanol for fuel in 1931, and has been using gasoline blended with 5–10% bioethanol for its public vehicles. The use of gasoline blended with approximately 20% bioethanol resulted in problems such as spark plug damage as well as excess carbon monoxide (CO) and hydrocarbon (HC) emissions due to a denser air/fuel ratio. However, because of the policy, all automobiles imported into Brazil are improved to conform to ethanol blended gasoline, and today approximately 90% of all gasoline vehicles in Brazil are currently FFVs.

The advantages of biodiesel are that it enables the reuse of waste cooking oil while reducing air pollutants such as CO, total hydrocarbons (THC), and particulate matter (PM), and reducing greenhouse gas emissions. Furthermore, biodiesel offers superior biodegradability and lubricity compared with fossil-based fuel, and is considered to be an environmentally friendly fuel. However, biodiesel is made from various vegetable oils, and depending on the properties of the raw materials, may have poor low-temperature properties or poor long-term storage stability. In terms of quality, biodiesel made from European rapeseed has the highest quality. Biodiesel made from palm oil sourced from Southeast Asia freezes easily in the winter, which can cause fuel supply problems. Biodiesel made from waste edible oil can easily oxidize due to thermal denaturation. To compensate for these shortcomings, South Korea and key countries in Southeast Asia (Thailand, Malaysia, and Indonesia) are working to reduce problems with biodiesel quality and properties by applying the European EN 14214 standard, as Europe leads the way for biodiesel use.

Biomethane is produced through anaerobic digestion of organic waste raw material such as raw garbage, livestock manure, and sewage sludge. However, in order for biomethane to be used for transportation fuel, it must be purified to 95% methane or greater by removing contaminants such as CO_2 and siloxanes. For this reason, biomethane has been used as a fuel to run heaters and generators to capture thermal energy. In parts of Europe such as Sweden and Germany, biomethane is partially used as an automotive fuel. However, the lower output and fuel economy from using pure methane needs to be resolved along with finding automotive technology solutions. There is also the critical problem of building infrastructure including the need for more dedicated fueling stations.

3. Policy Trends for Supply of Renewable Fuels in Key Countries

The supply of renewable fuels in countries around the world is based on energy crops that are produced in the climate and soil of that country. In North America, bioethanol is produced from starch in corn, while in South America, bioethanol is produced by fermenting sugar cane that readily grows in the tropical climate. In Europe, biodiesel is produced from rapeseed that readily grows in the soil

and environment there. Policies that encourage the production, distribution, and consumption of these renewable fuels vary slightly for each country, but share the objectives of eliminating dependency on fossil fuel, reducing greenhouse gas emissions, and promoting domestic industry.

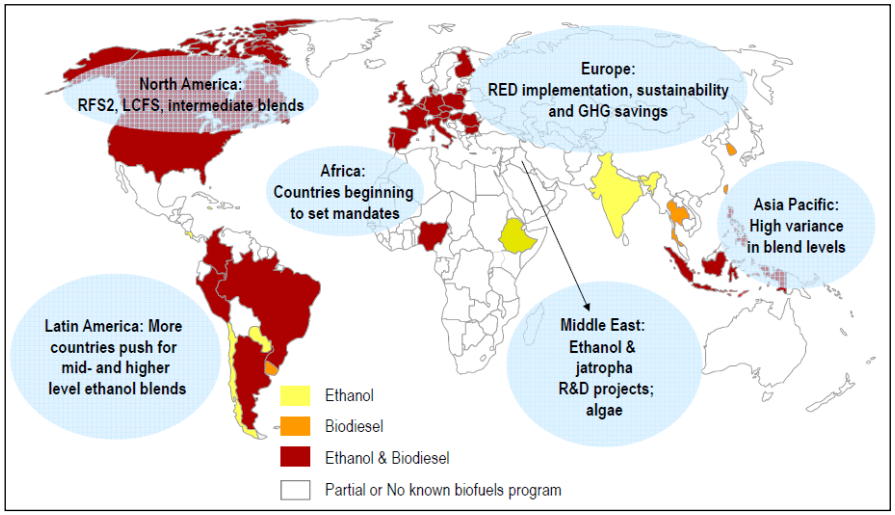
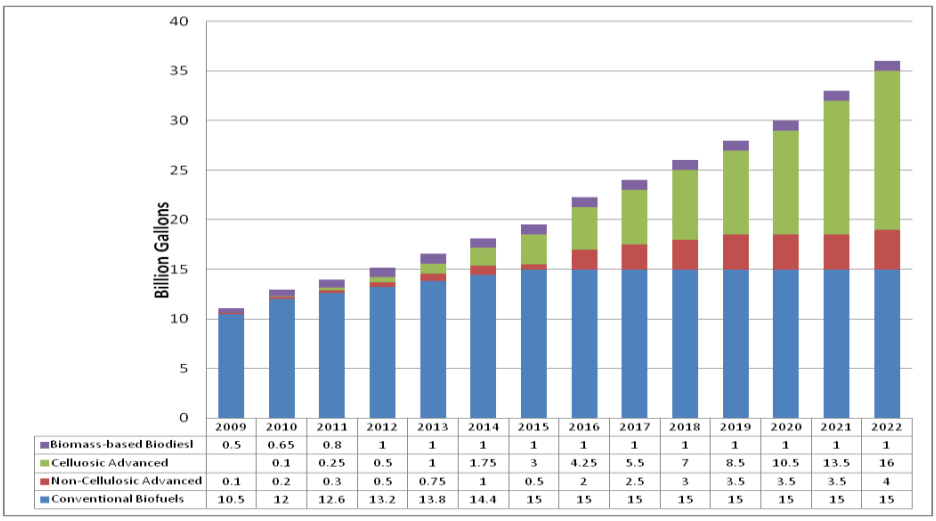


Fig. 1. Current Status of Mandates for Biofuel Use

(Source: Hart Energy's *Global Biofuels Outlook 2025*, 2013)

3.1 United States

The following sections examine policy trends for the supply of renewable fuels by country. In the United States, the federal government announced a plan to reduce gasoline consumption by 20% by 2020, through expanded use of bioethanol and increasing biofuel use to comprise 20% of transportation fuels. As a practical measure, the U.S. Environmental Protection Agency (EPA) established the Renewable Fuel Standard (RFS) program in 2007, which mandates certain levels of bioethanol and biodiesel use for suppliers of light oil and other transportation fossil fuels, encompassing oil refineries, oil importers, and oil and fuel blenders. Since 2010, the United States has adopted sustainability standards and instituted an RFS2 program to encourage the use of cellulosic bioethanol that further reduces greenhouse gas emissions compared with corn-based bioethanol.



	2009	2010	2011	2012	2013	2014	2015	2016	2017	2018	2019	2020	2021	2022
Biomass-based Biodiesl	0.5	0.65	0.8	1	1	1	1	1	1	1	1	1	1	1
Celluosic Advanced		0.1	0.25	0.5	1	1.75	3	4.25	5.5	7	8.5	10.5	13.5	16
Non-Cellulosic Advanced	0.1	0.2	0.3	0.5	0.75	1	0.5	2	2.5	3	3.5	3.5	3.5	4
Conventional Biofuels	10.5	12	12.6	13.2	13.8	14.4	15	15	15	15	15	15	15	15

Fig. 2. Mandated Use of Renewable Fuels under RFS2 Program (Source: EPA, 2012)

Bioethanol produced from corn inevitably competes with food. For this reason, active research is being conducted on cellulosic (wood-based) bioethanol as a next-generation biofuel. However, there are a number of issues that need to be overcome to achieve commercialization. The process for producing cellulosic bioethanol requires physical and chemical pretreatment to effectively remove components such as wood-based lignin that hinder saccharification. Under the process, cellulose is converted to sugars using enzyme through enzymatic saccharification, and these sugars are subjected to microbial fermentation using microbes (such as yeast and bacteria), to obtain bioethanol. Since bioethanol is obtained by a more complicated process than the existing process for producing bioethanol from corn or sugar cane, the production cost is higher, making it difficult for cellulosic bioethanol to be profitable. To supply biofuels more efficiently, it will take the completion of biorefineries, by stimulating related industries such as biomedicine that extracts human pharmacological active substances for medicine and biochemistry that produces biodegradable bioplastics, all from biomass.

3.2 Brazil

Adoption of renewable fuels is increasing in South America, based on biofuels that are produced from raw materials in each country. In particular, Brazil was the first country in the world to mandate the blending of biofuels for transportation. The 1973 oil crisis and collapse of international sugar prices crippled the Brazilian economy, and the government reacted by instituting a national alcohol program in 1975 to comprehensively promote bioethanol. The national alcohol program was discontinued in 1990, but today all automotive gasoline produced in Brazil must contain approximately 20% bioethanol.

3.3 European Union

In North and South America, policies implemented for the supply of biofuels center on bioethanol. By contrast, in the European Union (EU), biodiesel is primarily used as a fuel alternative to light oil. EU Directive 2009/28/C on the promotion of the use of energy from renewable resources sets a target of using 10% renewable fuels for transportation by 2020, compared with 1990 levels.

EU member states set their own targets according to the energy environment in their own countries. The United Kingdom has adopted a Renewable Transportation Fuel Obligation (RTFO) program that is similar to the RFS program in the United States. Suppliers of transportation fossil fuels are obligated to a certain total volume of renewable fuels (biodiesel, bioethanol, and biogas), and the program is implemented as a low-carbon energy policy aimed at reducing greenhouse gas emissions. In conjunction with the RTFO program, the U.K. government in June 2014 set a target for 4.75% of transportation fuels (3% of transportation energy) to come from renewable resources in 2014/15, increasing to 6.5% in 2015/16, 8.25% in 2016/17, 10.0% in 2017/18, and 11.75% in 2018/19, with an end target of 10% by 2020 (13% of transportation energy). The scenario in EU Directive 2009/28/EC calls for a combination of E10 to be used for gasoline and B7 for diesel, as a way to achieve targets over the next five years with usable vehicles and infrastructure.

Meanwhile, Germany has adopted a Biofuel Quota Act that applies a minimum biofuel quota for gasoline and light oil transportation fossil fuels respectively. For 2015 and beyond, the act stipulates a minimum reduction of greenhouse gas emissions (3% for 2015–2016, 4.5% for 2017–2019, 7% for 2020 and beyond) to be achieved for transportation fuels that are shipped to market.

3.4 Japan

In Japan, Sophisticated Methods of Energy Supply Structures mandates that electricity, oil, and gas business operators use non-fossil energy sources and efficiently use fossil energy sources. To promote the use of non-fossil energy sources, the oil industry has set a target of using biofuels equivalent to 3% or more of all gasoline in the country. As short-term targets, the oil industry has set a target of using 500,000 kiloliters of crude oil equivalent in fiscal 2017, increasing from 210,000 kiloliters in 2011 and 2012 respectively, to 260,000 kiloliters by fiscal 2013 and further increasing by 60,000 kiloliters each year beyond that. The obligation stipulates that biofuel must satisfy certain sustainability standards and reduce at least 50% of greenhouse gas emissions throughout the life cycle (from extraction to fuel production and transport), compared with gasoline. The only biofuels to satisfy these conditions are bioethanol produced from sugar cane grown on existing agricultural land in Brazil, bioethanol produced from Japanese sugar beets, and bioethanol produced from construction waste materials.

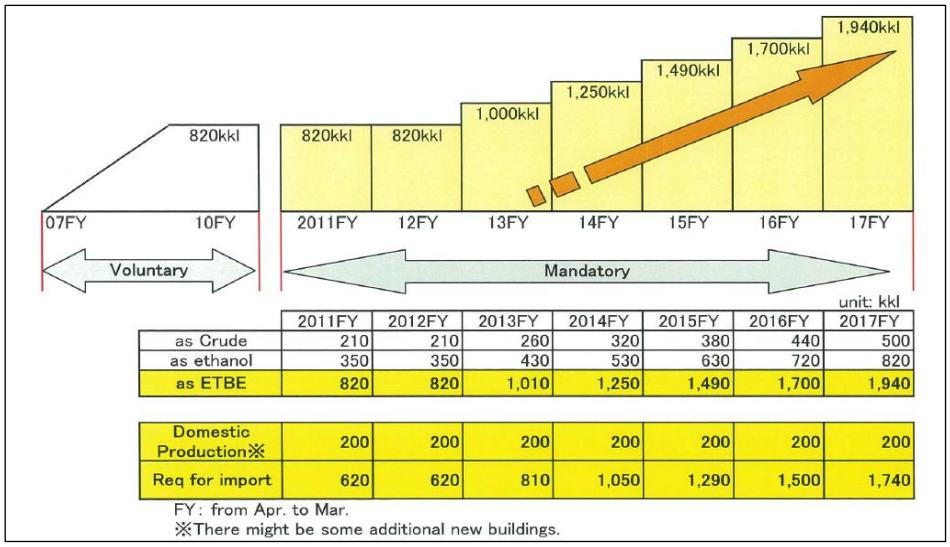


Fig. 3. Japanese Government Targets for Use of Biofuels (Source: Ministry of Economy, Trade and Industry, Japan, 2013)

The Japanese government has yet to decide on a plan and targets for use of biofuels in transportation for 2018 and beyond, but it is expected that the sustainable use of biofuels will be one of the means available to achieve the national target of reducing greenhouse gas emissions by 26% by 2030, compared with 2013 levels. The Ministry of Economy, Trade and Industry has established a Committee for the Study of a Process Leading to Introduction of Bio Jet Fuel for the 2020 Summer Olympic Games and Paralympic Games in Tokyo, that began working in July 2015 toward the goal of realizing airplane flights using bio jet fuel in time for the Games. Three issues have been identified for introducing bio jet fuel: production of bio jet fuel, establishment of a supply chain, and resolving issues with actual use of bio jet fuel. By resolving these three issues, flights using bio jet fuel will be realized at the 2020 Olympics and Paralympics, and will lead to future commercialization.

3.5 South Korea

South Korea has sought to increase the use of biodiesel centering on public vehicles since 2002, and through the implementation of a pilot adoption project that lasted for approximately four years, expanded the use of biodiesel in all light oil automobiles in the country. The national government and oil wholesalers reached a voluntary agreement in March 2006, under which biodiesel producers enter into annual supply contracts with oil wholesalers to blend automotive light oils with 0.5% biodiesel content throughout the country starting from July 2006. The blend percentage increased by 0.5% every year, so that starting from 2010, automotive diesel blended 2.0% biodiesel. As a result, consumption of biodiesel in South Korea has reached approximately 400,000 kiloliters.

South Korea has studied adoption proposals and detailed implementation plans through policy research, for the introduction of an RFS program for renewable fuels. The government issued a notice

on quality standards for the act on oil and oil alternative fuel business, which stipulates that automotive diesel are to be blended with 2-5% biodiesel content. Based on its policy research, South Korea incorporated an RFS program into the act to promote the development, use, and spread of new energy and renewable energy (new renewable energy act), which was passed into law and took effect in July 2015, and has begun the supply of BD2.5.

Under Paragraph 2 of Article 23 of the new renewable energy act, oil refineries and oil import/export business operators are obligated to supply oil products that are blended with a certain percentage of renewable fuel. Administrative agencies (Korea Petroleum Quality & Distribution Authority and Korea Energy Agency) provide guidance and supervision, and report their findings to the government (Ministry of Trade, Industry and Energy), which oversees the general implementation.

Table 1. Blending of Biodiesel in Automotive diesel in South Korea

	2015	2016	2017	2018	2019	2020
Percentage of new renewable energy fuel blended in transportation fuel (%)	2.5	2.5	2.5	3.0	3.0	3.0

Type of transportation fuel: Automotive diesel
Type of new renewable energy fuel: Biodiesel
(Source: Ministry of Trade, Industry and Energy, South Korea, announced June 15, 2015)

Consumption of biodiesel was at approximately 400,000 kiloliters in 2014, of which 172,000 kiloliters (approximately 43%) was from consumption of transportation biodiesel through the collection of waste edible oil as a waste resource. South Korea is severely limited in its energy resources and is dependent on imports for 96% (in 2014) of its overall primary energy needs. This makes it highly desirable for South Korea to have projects that recycle domestic waste resources and convert them into resources. Also highly favorable for South Korea are proposals that use biogas for transportation fuels, as a resource that can be obtained from organic waste without being solely dependent on imports. Some local governments in South Korea are at the center of projects to produce biogas from raw garbage, livestock manure, and sewer sludge, improving the quality for use in regional taxis and buses. It is hoped that there will be further stimulation of these projects. The City Gas Business Act has been revised to enable biogas to be blended into city gas, and it is hoped that natural gas vehicle (NGV) buses will also be used in the country.

South Korea's RFS policy sets mandates for transportation fuel businesses, but in terms of vehicles, the policy only affects approximately 38% of diesel vehicles out of the approximately 20 million vehicles in South Korea. It is hoped that in the near future,

bioethanol will be used for gasoline vehicles, which account for approximately 48% of all vehicles in South Korea, and that bio jet fuels will also be used mirroring global trends. Currently, there is no stimulus for using biofuels in liquid petroleum (LP) gas vehicles, which account for approximately 14% of all vehicles in the country. However, biofuels such as BioPropane and BioDME that are currently in research and development will need to be commercialized and adopted into the market.

3.6 Southeast Asia

In Southeast Asia, Thailand, Malaysia, and Indonesia mandate the use of biodiesel produced from palm oil, which is suited to the tropical climate and soil conditions in these countries. The food and renewable fuel industries that are based on the palm oil industry are contributing to employment. Bioethanol is partly subsidized to encourage the use of bioethanol. Incentives are considered to be necessary during the initial period of introduction due to the difficulty of penetrating markets, but once the industries are stimulated and firmly established, there will need to be a transition to taxation of the industries.

Table 2. Current Status of Biofuel Use in Southeast Asia

	Thailand	**Malaysia**	**Indonesia**
Biodiesel (from palm oil)	BD7 *Use mandated in 2014	BD7 (from January 2014) *Started supply of BD5 in 2011	BD10 *BD20 starting in 2016
Bioethanol (from sugar cane and sugar beets)	E10, E20, E85 Supplied at lower price than gasoline (subsidized)	No plan to supply bioethanol	E10 Poor sales due to pricing issues

*BD7 = Biodiesel 7% + diesel 93% by volume

*E10 = Bioethanol 10% + gasoline 90% by volume

4. Conclusion

This report examined the ways in which expanded use of renewable fuels is being promoted, for its immediate economic benefits in countries around the world, as well as for long-term energy security (diversification of energy sources) and to stimulate related industry and reduce greenhouse gas emissions.

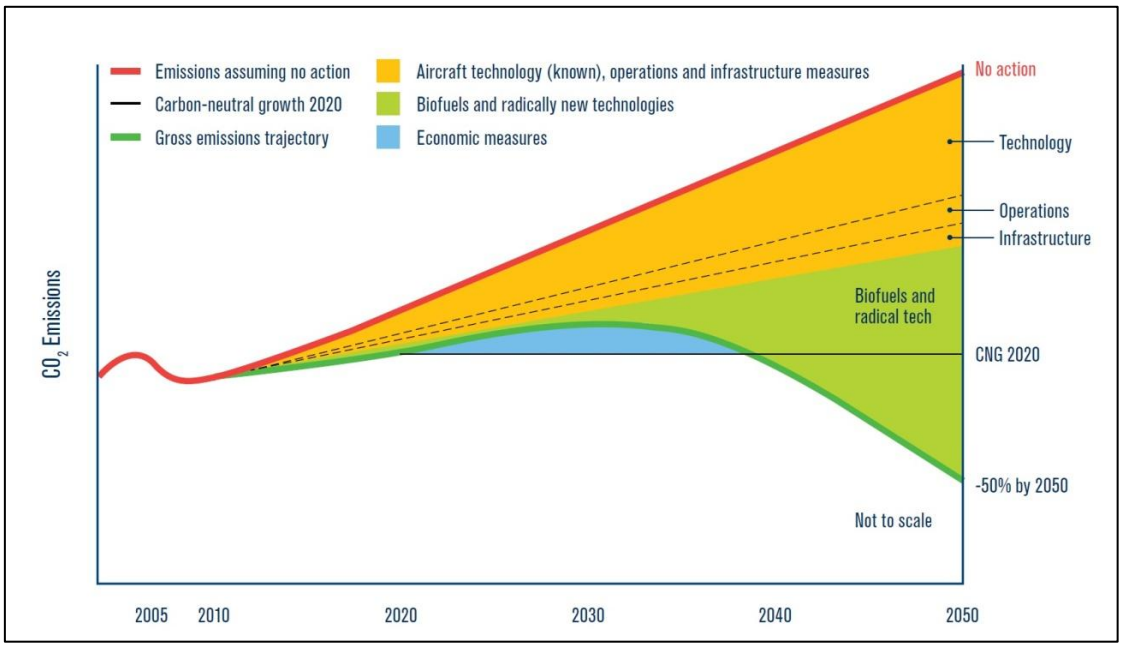


Fig. 4. CO_2 Reduction Targets for International Airline Industry (Source: International Air Transportation Association, 2015)

Many raw materials (such as corn, sugar cane, and palm oil) that are currently used to produce renewable fuels are in competition with food, which is problematic. At the same time, technology development is being conducted for bio jet fuels that use non-food source microalgae. The related industries claim that it will be possible to supply bio jet fuels that are competitive with oil-based fuels by around 2020. Furthermore, it is projected that by around 2050, bio jet fuels will contribute toward approximately half of the reduction target for CO_2 emissions set by the International Air Transportation Association (IATA).

It is hoped that efforts to develop and supply renewable fuels in anticipation of the future depletion of finite fossil fuels, will lead to the diversification of energy that is usable by the next generation, extending their use and stimulating related industries.

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