ERIA-DP-2011-03

ERIA Discussion Paper Series

Harmonizing Biodiesel Fuel Standards in East Asia: Current Status, Challenges and Way Forward*

Xunpeng SHI**

Economic Research Institute for ASEAN and East Asia (ERIA), Indonesia

Shinichi GOTO

Research Center for New Fuels and Vehicle Technology (NFV), National Institute of Advanced Industrial Science and Technology (AIST), Japan

May 2011

Abstract: This paper discusses the development of and policy towards biodiesel fuel (BDF) in the East Asia Summit (EAS) Region (hereafter East Asia), with a focus on activities related to harmonizing BDF standards. It finds that the EAS countries have actively promoted the development of BDF for a variety of reasons. To minimize problems with engines arising from the use of BDF, most EAS countries have established their national BDF standards. However, these diverse standards cause barriers for BDF trade and act against the regional interest in maximizing benefits from BDF production and utilization. Therefore, the EAS policy makers decided to harmonize BDF standards, and a regional benchmark standard has been published. Through a comparative review of existing national standards against the benchmark, it finds that the harmonization is beneficial economically and environmentally, and is technically feasible but practically stalled due to the lack of political determination. Therefore, among a few policy implications, the key message to deliver is a call for political determination to implement the harmonization in the EAS region. Since harmonization of BDF standards has been tried in other regions, the findings of this paper may supplement the literature, enhance understanding of the EAS case, and provide lessons and implications that may be helpful in advancing similar harmonization elsewhere.

***Keywords*:** Biodiesel Fuel; Standardization; Harmonization; East Asia Summit; East Asia

JEL Classification: Q16, Q28, Q42

* The paper was initially presented in the 12th meeting of AEM-METI Economic and Industrial Cooperation Committee (AMEICC) Working Group on Automobile Industry, 24-25 January 2011, Hanoi, Vietnam. The authors would like to thank comments from the participants of the meeting. The authors are also grateful to the members of ERIA's Working Group on "Benchmarking of Biodiesel Fuel Standardization in East Asia", Fukunari Kimura, and Mitsuo Matsumoto, for their comments. The views expressed in this paper are those of the authors and do not necessarily reflect the views of the organizations.

** Corresponding Author. Address: ERIA Annex Office, Sentral Senayan II 6th floor, Jl. Asia Afrika no. 8, Senayan, Jakarta Pusat 10270, Indonesia. Tel: +62 21 5797 4460 ext. 307, Fax: +62 2 5797 4464, Email: xunpeng.shi@eria.org; xunpeng.shi@gmail.com

1. Introduction

Increasing concern over climate change has led to a push for cleaner and more environmentally friendly fuels, for example shifting from fossil fuels to alternative fuels. However, biofuels are being actively promoted due not only to climate change, but also to other comprehensive reasons, such as soaring oil prices, national energy security, and development of agriculture and the rural economy. Development of biofuels has multiple benefits: reducing carbon emissions, improving the living standards of farmers, creating new export opportunities for developing countries, and increasing regional energy self sufficiency, thus enhancing energy security (ADB, 2009, UNCTAD, 2009, BEFS, 2011). Biofuels can also substitute expensive imported oil as in the case of the Philippines (Sagisaka, 2010). In particular, with the transportation sector accounting for one quarter of global CO_2 emissions and with limited alternatives to conventional fuels, biofuels have been highlighted as a means of reducing emissions from the sector (Lee *et al*., 2008).

However, the use of biofuels may compromise engine performance due to its impurities and the problem of oxidation. Biodiesel Fuel (BDF) inherently suffers from poor cold-flow properties and inferior oxidation stability compared with mineral diesel, because Fatty Acid Methyl Ester (FAME) made from room-temperature solid raw materials is also solid at room temperature (Goto *et al*., 2010). The problems of low-temperature flowability become apparent not only in vehicles but also in storage and flow processes. In addition, BDF is less powerful than fossil fuel due to its higher water content, as demonstrated by a small scale case in Shanghai, China (Goto *et al*., 2010).

Therefore, quality control of BDF in the actual market is very important from the viewpoints of safety, environment, and trade. Fuel quality plays an important role in maintaining the safe operation and environmental performance of engines. The safety concern is straightforward, and the environmental aspect is also obvious because biofuels could be carbon intensive if not well managed (BEFS, 2011), such as when BDF is produced from rainforest, or when the waste gas from a biofuels plant is not properly recovered and reused (WWF, 2007). In addition, a successful trade in biodiesel needs its specifications, testing, and its use to be regulated by means of internationally accepted standards[1] (APEC, 2008).

Since the characteristics of BDF depend on its feedstocks, the quality of BDF is influenced by the specific refining process used (Goto *et al*., 2010), and the standards are decided by policy such as emission regulations, BDF standards differ from country to country. Diverse systems of BDF standards lead to unnecessarily high costs for the adoption of BDF, as each nation has to build its own infrastructure to ensure that BDF quality conforms to its local standard. This also makes it difficult to trade BDF and thus hinders the establishment of an East Asian market. Such a market could encourage biodiesel to be produced at the cheapest places with the minimal negative impact on the environment, and utilized in places where it would have the highest value. The diverse standards also create a barrier for the integration of the automotive industry, which may have to modify engines to suit individual national standards. Such modification will reduce the chance of reaping benefits from economies of scale and will further undermine regional economic integration.

On the other hand, a harmonized performance-based standard would facilitate the use and trading of high-quality biodiesel fuel in several ways, such as by making contracts easy to negotiate (APEC Biofuels Task Force, 2007), boosting demand, and forming a common regional BDF market, which would be able to meet increasing

---

[1] For the purposes of comparison across countries, in this study the standard used is limited to B100, intended for low level blending with diesel fuel. In the national markets, there are many BDF standards for blended diesel, in which the ratio of biodiesel is often between 1 and 5%. One important reason for studying B100 is that it is often the traded commodity in the wholesale markets, while blended products are not.

demand for BDF and provide stable expectations for producers and consumers. It could also provide East Asia with a means of establishing its own prices for biofuels, in particular in the case of coconut and palm oils, which are unique to the region. To establish such a regional biofuels market, common technical standards for biofuels are necessary. A common recognition of vehicle manufacturers is that the supply of globally harmonized clean fuels is essential for achievement of the target of cleaner air quality and environment protection worldwide (Goto *et al*., 2010).

Considerable regional and global efforts are being made to harmonize[2] BDF standards, mainly aiming at facilitating trade. The WWFC Committee published a "World Wide Fuel Charter -Biofuel Guidelines" in March 2009 which aims to provide a benchmark standard for harmonization (Goto *et al*., 2010). The Asia-Pacific Economic Cooperation (APEC) is also developing a performance-based BDF standard to enhance trade among its 21 member economies (APEC Energy Working Group, 2007), through no standard has yet been published. Brazil, the European Union (EU), and the United States, the world leading Biofuels producers and consumers, also formed the Tripartite Task Force in 2007 to address these standardization issues (Tripartite Task Force, 2007).

Harmonization of BDF standards in the East Asia Summit (EAS)[3] region has been initiated. A benchmark standard, the EAS-ERIA BDF Standard: 2008 for B100 FAME (hereafter ERIA standard or benchmark standard)[4], has been published.

---

[2] Harmonization is actually not only limited to fuel quality but also covers facilities (including vehicles, engines and parts) giving due consideration to the issue of compatibility.

[3] The East Asia Summit (EAS) comprises the 10 member countries of the Association of Southeast Asian Nations (ASEAN), namely: Brunei, Cambodia, Indonesia, Laos, Malaysia, Myanmar, the Philippines, Singapore, Thailand, Vietnam, and 6 other countries: Australia, China, India, Japan, the Republic of Korea and New Zealand. Although some EAS countries are not located in geographical East Asia, this region is often collectively named East Asia. The US and Russia will join the EAS in 2011. However, the current paper will only focus on the ASEAN+6 countries.

[4] The Standard has been developed by the ERIA (Economic Research Institute for ASEAN and East Asia)'s Working Group on "Benchmarking of Biodiesel Fuel Standardization in East Asia" under mandate from the East Asia Summit Energy Cooperation Task Force (ECTF).

Thailand has harmonized its national standard with this benchmark standard, and the Philippines and Vietnam are reportedly revising their national standards according to this benchmark.

The harmonization efforts and affiliated challenges in the EAS are unprecedented and unique, and deserve a detailed specific study. Other cases of harmonizing BDF standards at regional level are not as significant as the EAS case. In the case of APEC, the effort is to establish guidelines for the development of biodiesel standards, rather than establishing a reference standard for harmonization (APEC Energy Working Group, 2007). The European case is less challenging as its implementation has been aided by the EU and thus is more akin to a national action than a regional action. The Tripartite Task Force (2007) formed by Brazil, the US and the EU, has identified that greater compatibility could be achieved in support of the global commoditization of biofuels through a review of existing bioethanol and biodiesel standards, but no benchmarking standard has been attempted. The World Wide Fuel Charter (WWFC) is the automotive industry's guiding document towards improved and harmonized fuel quality, but is not mandated from any official organization. In contrast, in the EAS region, the harmonization of BDF standards has been initiated, a benchmarking standard has been set up, and a few countries have started to revise their standards against the benchmarking standard.

This paper tries to improve the understanding of BDF standardization activities and the attempts to harmonize these BDF standards in the EAS region. It summarizes the policy, development status and standards of BDF in East Asia, highlights the rationales for a EAS harmonized BDF standard, analyses the current diverse BDF standards, and proposes possible ways to promote harmonization. One clear message of this paper is that the harmonization is beneficial in many aspects and is technically feasible but practically stalled due to lack of political determination.

The contributions of this paper are as follows: a comprehensive survey of current BDF development and government policy in the EAS region adds value to the literature; the critical comparative analysis of national BDF standards and identification of problems have not been performed elsewhere. The prospects of harmonization, and proposed measures to implement it in East Asia can inform East Asian policy makers. In particular, a call for political determination to harmonize BDF standards in the EAS can stimulate further policy debates. The findings of this paper may supplement the literature, enhance the understanding of the EAS case, and provide lessons and implications that may be helpful in advancing similar harmonization elsewhere.

The rest of the paper is organized as follows: the next section will briefly outline the development of BDF and the government policy in East Asia. Section 3 introduces the development of BDF standards and the current initiative towards harmonization in the EAS region. Section 4 presents further discussions and policy implications, and the last section concludes.

2. Development of Biodiesel Fuel in the EAS Region

Traditionally, biofuels have served as alternatives to fossil fuels and thus have been developed to diversify energy supply and thereby enhance energy security. The history of bio-fuels is fairly long: they were already investigated as automotive fuels in the latter half of the 19th century. However, even though biofuels were promoted actively during the first oil crisis period, their development was only accelerated after 2000, stimulated by government policy and by the oil price surge in 2008 (ADB, 2009). The world annual production of biodiesel grew from negligible in 1975, to 0.8 million tons (mt) in 2000, 9 mt in 2007 (ADB, 2009), and to 12.9 million tones oil equivalent in 2009 (IEA, 2010).

Demand for biofuels is expected to increase continuously over the next two decades, but fossil fuels will still dominate the transportation sector. In the new policy scenario, in which both existing policies and declared intentions are taken into account, the world total daily biofuels consumption, dominated by biodiesel, will rise from 1.11 million barrels (mb) in 2009 to 2.3 mb and 4.4 mb in 2020 and 2035, respectively. Even in the current policy scenario, which assumes no change to existing policies, world daily biofuels consumption in 2035 will be 3.5 mb (IEA, 2010). Under the new policy scenario, the average annual growth rate of biofuels use between 2009 and 2035 in China is twice as fast as that in mature markets such as the US , Brazil, and the EU countries (IEA, 2010). The importance of biofuels has also been recognized by the EAS leaders in the Cebu Declaration in which standardization is encouraged (Cebu Declaration, 2007). In addition, harmonization of standards within the East Asia region has also been initiated.

The dominance of fossil fuels in transportation energy use is due to the difficulty in finding alternatives for the transportation sector. The current energy infrastructure makes it extremely important that any new alternative fuel is compatible with the corresponding conventional petroleum fuel, because it is not economical and realistic to change our energy infrastructure, such as gas stations, storage tanks, and engines, at any given point in time. Therefore, alternative liquid fuels that can be blended with petroleum fuels, such as biofuels, have advantages over other alternatives to fossil fuels, such as electric power for cars.

Recently, Biodiesel has been highlighted by the emerging global concerns over climate change issues. Biofuels have the advantage of being carbon neutral if managed properly[5]. ERIA's study on energy saving potential shows that biofuels will

---

[5] The Kyoto Protocol emphasized the concept of "carbon neutral" – that vehicle emissions of carbon dioxide (CO_2) are offset by using biofuels produced from plant materials which have absorbed CO_2. The neutrality of BDF, however, is debatable.

play an indispensable role if East Asia wants to achieve sustainable growth (Kimura, 2010). European countries have also embarked on a CO_2 reduction effort with the introduction of BDF, and we observe a widespread increase in support for diesel powered passenger cars.

Southeast Asian countries are actively promoting BDF because these countries have abundant feedstocks for it, such as palm oil, coconut oil, Jatropha Curcas oil, and so on. Most Southeast Asian countries are significant agricultural producers and have excess production of commodities that could be used for biodiesel production. Malaysia and Indonesia are the largest palm oil producers in the world. Although production is significantly lower than the top two, as the third largest palm oil producer, Thailand is catching up. Since palm oil has significant cost advantages over other popular feedstocks such as soy bean oil and rapeseed oil (Kojima *et al.*, 2007), this indicates huge potential for biodiesel production in Southeast Asia. In addition, the Philippines is the world's largest coconut producer and exporter.

Furthermore, many EAS members are agriculturally-based countries that are able to grow various kinds of crops as feedstocks to produce biofuels. For example, rice bran oil, which could become the next generation of biofuels feedstock, is abundant in China, Thailand, and Vietnam. Asian countries: China, India, Indonesia, Bangladesh, Vietnam, Thailand, and others, account for approximately 92% of the world's annual production of rough rice, which was about 662 million tons in 2008 (Global Biofuels Center, 2009). Five EAS countries, India, China, Thailand, Vietnam, and Indonesia account for about 70% of world rice production (Goto *et al.*, 2010).

North East Asian countries, such as Japan and South Korea, which lack sufficient land to produce oils domestically and may depend on foreign biodiesel and/or feedstocks, are promoting BDF from concern about climate change, air pollution, volatile fossil oil prices, and energy security.

Industries in various regions of the world are producing biodiesel from the most readily available fat or fatty oil resource in their respective areas (Goto *et al*., 2010), and palm and coconut oils are used in tropical Asian countries. In eight EAS members (China, Indonesia, Malaysia, New Zealand, the Philippines, Singapore, South Korea, and Thailand), the existing total annual capacity for biodiesel production is 14.04 billion litres (2008) with a further 6.4 billion litres per year capacity under construction in China, Indonesia, and Malaysia alone (Global Biofuels Center, 2009).

Recently, however, many attempts have been made to develop non-edible raw material sources for biodiesel in the region, and elsewhere in the world, because of a concern over the potential effects of biofuel production on soaring food prices. In the past, biodiesel production was advanced with the help of price supports and agricultural promotion policies utilizing surplus production of rapeseed in Europe and soy beans in the US. However, as BDF demand has recently increased, the price of rapeseed oil, soy bean oil, and palm oil for food has spiked, and thus the competition between fuel and food has become a problem (BEFS, 2011). Presently, Jatropha Curcas is probably the most popular oil-yielding tree that avoids competition with food[6] (Goto *et al*., 2010).

Although biofuels trade is minor within the EAS region (APEC, 2008) and will be affected by the balance between climate change and energy security issues in national policy[7] (UNCTAD, 2009), there will be substantial opportunities for exports from Malaysia, the Philippines, Indonesia, and Thailand to the US, the EU, China, South Korea, and Japan, which are potentially significant importers (APEC, 2008).

---

[6] However, most farmers in Indonesia (at least) are reluctant to grow it because, after widespread trial plantations instigated by irresponsible politicians, the farmers realized that cultivating the plant did not yield an adequate financial return. The principal problems are the low per hectare yield of the seeds and high harvesting cost. The lack of an established market is an extra obstacle.

[7] The climate change concern will favor biofuels with low carbon footprints, while the energy security concern will favor domestic production and thus undermine the opportunities for trade.

Targets for blending rates (B“x” standards for “x” per cent) and the total amount of BDF utilization are the two frequently used policy instruments to promote the adoption and utilization of biofuels (Table 1). Mandates in the region include B1 mandates in Indonesia and B3 mandates in Thailand (2008), the Philippines (Feb 2009), and South Korea (2010). In Malaysia a B2 mandate was set in February 2009. B2 was initially only used in government agencies’ own depots, and was extended to industrial sectors and to the transport sector in January 2010. The target for Thailand is to mandate B5 in 2011. These measures can create stable and predictable biofuels markets and thus attract investments, but their inflexibility can lead to undesired impact on agricultural commodity prices and reduce the potential contribution of biofuels in tackling global warming (UNCTAD, 2009).

There are some local initiatives in countries without national policy to promote the use of biodiesel. In Australia, a B2 mandate was announced by the New South Wales (NSW) Government in December 2008 and was expected to be in place by January 2010. The NSW Government has indicated an increase to 5% (B5) in 2012 or as supply becomes available. At this stage it is planned that there will be sustainability criteria provisions linked to this mandate (Goto *et al*., 2010).

Other EAS countries are either in the preparation stage of biodiesel utilization or have no activities yet. China has a target to replace from 5% to 20% of total petrodiesel consumption with biodiesel, and Japan has a target to introduce 500,000 kl-crude oil equivalent of biofuels (including bio-ethanol) by 2010 and 2 million kl-crude oil equivalent of biofuels by 2020 (Goto *et al*., 2010). However, no national mandate has been set in China or Japan. India has a target for blending of biodiesel up to 10% by 2017. Myanmar has a target of planting 2.3 million ha of Jatropha Curcas for biodiesel production by 2009, but no targets for biofuels development have been set (ADB, 2009). There is no official activity regarding biodiesel utilization in Brunei, Cambodia, Laos, or Singapore.

Table 1. BDF Mandates, Targets and Main Feedstocks in EAS Countries

Country	Targets	Main Feedstocks
Australia	B5 is allowed but not mandated nationally. NSW mandate- B2 (2010); B5 (2012) as supply is available	Tallow, WCO*, Soy
China	National Goal : 2 M tons at 2010; 12M tons at 2020; No national mandate for blending	WCO, Jatropha
India	B5 (2012) ; B10 (2017) No compulsory biodiesel blending requirements	Jatropha
Indonesia	up to 10% BDF usage 10.22 million kilo liter (KL) in 2025	Palm
Japan	Up to 5% in diesel fuel but mandated nationally Target to reduce crude oil dependence in the transportation sector to about 80% in 2030	WCO
Malaysia	5% (2010)	Palm
New Zealand	Up to 5% for retail sales (not compulsory)	Tallow, Rapeseed, WCO
Philippines	B1 from 2004 for government-owned and controlled vehicles, and from 2007 for all compulsorily. B2 (2009) for all diesels	Coconut, Jatropha
Republic of Korea	B0.5 (2007), increasing 0.5%/ year until B3 in 2012. But mixed by voluntary agreement between government and petroleum companies	Soybean, Palm oil, WCO
Thailand	B2 (2008); B3 (2010); B5 (2011) (4.5 ML/D in 2022 target)	Palm oil
Vietnam	B5 (by 2010)	Basa fish

* WCO: Waste cooking oil; Bx represents x% of BDF in total diesel consumption by volume.

Sources: Goto *et al*. (2010); Global Biofuels Center (2009); Indian National Policy on Biofuels (MNRE, 2009); the table was also checked by members of ERIA's Working Group on "Benchmarking of Biodiesel Fuel Standardization in East Asia".

Other policy instruments applied in the region include common measures such as tax holidays, subsidies (direct and indirect) for biofuels production and R&D investments, and specific measures such as "Pioneer Status", which allows a 5-year partial exemption from income tax (Malaysia), duty-free importation of renewable machinery, equipment and materials (the Philippines), and compensation from the Oil Fund (Thailand) (Goto *et al*., 2010). In countries such as Indonesia, Malaysia, Thailand, and India, the aim of respective government policy is for domestic biodiesel production to substitute diesel imports and be a support mechanism for the agricultural sector (Goto *et al*., 2010).

Mandates, incentives and proper regulations on the environment are essential policy instruments for the sustainable development of BDF. Financial support for biodiesel development is essential, as its production costs are higher than for the petroleum alternatives and extra costs are incurred in modifying infrastructure (ADB, 2009). The demonstrably low performance of engines run on BDF, set against the environmental benefits, justify the need for financial assistance to encourage the usage of BDF. Considering problems arising from the inflexibility of mandatory usage, a better alternative could be the introduction of a carbon dioxide (CO_2) price (UNCTAD, 2009).

3. Benchmarking BDF Standards in East Asia

BDF standards, mainly based on the oil/fats available in each country, have been established in many East Asian countries to protect passengers' safety and engine performance. In East Asia, at least 11 out of the 16 EAS member countries have set national BDF standards, with Brunei, Cambodia, Laos, Myanmar, and Singapore as exceptions. However, the diversity of BDF standards among nations works against the interests of East Asia.

East Asia needs its own benchmark standard to harmonize BDF standards because the main feedstocks in East Asia are different from those influencing major benchmark standards elsewhere in the world. These are the US ASTM D6751 and the EU EN14214 standards, which have been intensively referred to by East Asian national BDF standards. The US and EU standards, however, may not be appropriate for the EAS countries because they were developed for selected feedstocks only: ASTM D6751 for soybean oil and EN14214 for rapeseed oil, and their climate and other local conditions are different from East Asia. Properties and behaviors of different biodiesel feedstocks vary, and thus these standards and their test methods cannot just be adopted for different feedstocks in East Asia, such as coconut and palm oils.

In East Asia, the harmonization of BDF standards was initiated by the "Cebu Declaration on East Asian Energy Security" in January 2007 and is undertaken by the EAS Energy Cooperation Task Force (ECTF) (Cebu Declaration, 2007). At the first ECTF meeting, issues toward harmonizing the standardizations of biodiesels were assigned to be studied, and later a Working Group (WG) on "Benchmarking of Biodiesel Fuel Standardization in East Asia" was established by the Economic Research Institute for ASEAN and East Asia (ERIA) in 2007. The WG published its first benchmark standard, the "EAS-ERIA BDF Standard 2008" for B100 FAME, which was set based on the European standard (EN14214). The EAS-ERIA standard was welcomed by the Ministers in the Second EAS Energy Ministers' Meeting (EMM) held on 7 August 2008 in Bangkok, Thailand as a valuable benchmark reference in developing the respective national standards of EAS countries (ASEAN website, 2008).

This EAS-ERIA standard, although based on the EU standard (EN14214), is different from the European standard. Unlike the EU standard which only considers rapeseed oil as a feedstock, the EAS-ERIA standard also consider other feedstocks used in the East Asian region, such as coconut and palm oil. Table 2 shows the specification compared to other existing standards.

Table 2. Comparison of EAS-ERIA BDF Standards: 2008 to Other Major Standards

Parameters	Units	U.S.	EU	WWFC	EAS-ERIA
		ASTM D6751	EN14214:2010		EEBS:2008
Ester content	mass%	-	96.5 min.	96.5 min.	96.5 min.
Density	kg/m3	-	860-900	Report	860-900
Viscosity	mm2/s	1.9-6.0	3.50-5.00	2.00-5.00	2.00-5.00
Flashpoint	deg. C	93 min.	120 min.	100 min.	100 min.
Sulfur content	mass%	0.0015 max.	0.001 max.	0.001 max.	0.001 max.
Distillation, T90	deg. C	360 max.	-	-	-
Carbon residue (100%) or Carbon residue (10%)	mass%	0.05 max. -	- 0.30 max.	0.05 max. -	0.05 max. 0.3 max.
Cetane number		47 min.	51.0 min.	51.0 min.	51.0 min.
Sulfated ash	mass%	0.02 max.	0.02 max.	0.005 max.	0.02 max.
Total contamination	mg/kg	-	24 max.	24 max.	24 max.
Copper corrosion		No.3	Class-1	-	Class-1
Oxidation stability	hrs.	3 min.	8.0 min.	10.0 min.	10.0 min.
Iodine value		-	120 max.	130 max.	N.D.
Methyl Linolenate	mass%	-	12.0 max.	12.0 max.	12.0 max.
Polyunsaturated FAME (with 4+ double bonds)	mass%	-	1 max.	1 max.	N.D.
Monoglyceride content	mass%	-	0.80 max.	0.80 max.	0.80 max.
Diglyceride content	mass%	-	0.20 max.	0.20 max.	0.20 max.
Triglyceride content	mass%	-	0.20 max.	0.20 max.	0.20 max.
Total glycerol content	mass%	0.24 max.	0.25 max.	0.25 max.	0.25 max.
Phosphorous content	mg/kg	10 max.	10.0 max.	4.0 max.	10.0 max.

Note: Six parameters water content, acid value, methanol content, free glycerol content, NA+K and Ca+Mg, have equivalent specifications across the list of standards and thus were omitted from the table. N.D.: Need data check and further discussion.

Sources: Modified from Goto *et al.* (2010).

Among the four standards listed in Table 2, the EAS-ERIA standard is the most restrictive while the US standard is the least restrictive. The US standard has specifications on fewer parameters than other standards and centane number, oxidation stability and copper erosion parameters are also noticeably lower than in other standards. The ERIA standard, on the other hand, is more restrictive than the EU standard in terms of oxidation stability and restriction on carbon residues. Polyunsaturated FAME with more than 4 double bonds was also not allowed in the EAS-ERIA standard because it accelerates oxidation degradation and sludge production (Goto *et al*., 2010), while both the EU and WWFC standards accept it. The WWFC standard, however, has the highest requirements in parameters such as sulfated ash and phosphorous content.

Even when based on similar international standards, the BDF standards among East Asian countries are diverse, and hence harmonization will be difficult. Comparisons of the limit values for each property between the EAS-ERIA BDF standard (hereafter "benchmark standard") and each existing national BDF standard in the EAS region are summarized in Table 3. The parameters shown in deep grey indicate those national limit values which have been harmonized with the EAS-RIA benchmark standard, and those in light grey indicate those which are almost harmonized with the benchmark standard.

Among the 26 parameters with reported values, six have been harmonized. Three parameters, sulfated ash, water content, and free glycerol content have the same values across all the national standards and the EAS-ERIA standard. The other three parameters, flashpoint, total glycerol content, and the upper boundary of density have national values falling into the limits of the benchmark standard.

Five parameters, ester content, lower boundary of density, carbon residue (10%), copper corrosion, and prosphorous content are almost harmonized with the benchmark standard. In each of these parameters, only up to two national standards are slightly different from the benchmark standard, or have values missing. In the case of ester content, copper corrosion and prosphorous content, only one national standard is different from the benchmark standard.

Table 3 Comparison of National BDF Standards with the EAS-ERIA Standard

Parameters		**Units**	**EAS-ERIA**	AU	CN	ID	RI	JP	MY	NZ	PH	KR	TH	VN
Ester content		mass%	≥96.5	√	-	√	√	√	√	√	√	√	√	√
Density	min	kg/m3	860	√	820	√	850	√	√	√	√	√	√	√
	max		900	890	√	√	890	√	√	√	√	√	√	√
Viscosity	min	mm2/s	2	3.5	1.9	2.5	2.3	3.5	3.5	√	√	1.9	3.5	1.9
	max		5	√	6	6	6	√	√	√	4.5	√	√	6
Flashpoint		℃	≥100	≥120	≥130	≥120	√	≥120	≥120	√	√	≥120	≥120	≥130
Sulfur content		mass%	≤0.001	√	≤0.005	≤0.005	√	√	√	√	≤0.05	√	√	≤0.05
Carbon residue,%	100	mass%	≤0.05	-	-	√	√	-	√	√	√	-	-	√
	10		≤0.3	√	√	≤0.05	√	√	√	√	-	≤0.1	√	-
Cetane number			≥51.0	√	≥49	√	√	√	√	√	≥55	-	√	≥47
Sulfated ash		mass%	≤0.02	√	√	√	√	√	√	√	√	√	√	√
Water content		mg/kg	≤500	√	√	√	√	√	√	√	√	√	√	√
Total contamination		mg/kg	≤24	√	-	√	-	√	√	√	-	√	√	-
Copper corrosion	3hr @50°C		Class-1	√	√	√	≤3	√	√	√	√	√	√	√
Acid value	mgKOH/g		≤0.50	≤0.80	≤0.80	√	≤0.80	√	√	√	√	√	√	√
Oxidation stability		hrs.	≥10.0	≥6	≥6	≥6	-	(*)	≥6	√	≥6	≥6	√	≥6
Methyl Linolenate		mass%	≤12.0	-	-	-	-	√	√	√	-	-	√	-
Methanol content		mass%	≤0.20	√	-	√	-	√	√	√	√	√	√	-
Monoglyceride content		mass%	≤0.80	-	-	√	-	√	√	√	√	√	√	-
Diglyceride content		mass%	≤0.20	-	-	-	-	√	√	√	√	√	√	-
Triglyceride content		mass%	≤0.20	-	-	-	-	√	√	√	√	√	√	-

Table 4(Continued). Comparison of National BDF Standards with the EAS-ERIA Standard

Free glycerol content	mass%	≤0.02	√	√	√	√	√	√	√	√	√	√	√
Total glycerol content	mass%	≤0.25	√	≤0.24	√	≤0.24	√	√	√	≤0.24	≤0.24	√	≤0.24
Na+K	mg/kg	≤5.0	√	-	-	-	√	√	√	√	√	√	√
Ca+Mg	mg/kg	≤5.0	√	-	-	-	√	√	√	√	√	√	√
Phosphorous content	mg/kg	≤10.0	√	-	√	√	√	√	√	√	√	√	√

Note: √ represents the value being the same as that in the benchmark standard; a grey cell shows that the parameter has been harmonized with, but is not necessary the same as, the benchmark standard; *: to be agreed by sellers and buyers.

Source: prepared by the authors based on information from Goto *et al.* (2010) and internet research; checked by members of ERIA's Working Group on "Benchmarking of Biodiesel Fuel Standardization in East Asia" WG members on BDF standardization. Web addresses of Standards, except India, can be provided upon request.

In six parameters there are not more than three values in the national standards which are different from the benchmark. Those parameters are: lower boundary viscosity, cetane number, acid value, methanol content, Na+K and Ca+MG. However the difference in the lower boundary of viscosity is extremely small; i.e. 1.9 against 2 in the benchmark standard.

The remaining parameters are more diverse. Iodine value (IV), which is the commonly used measurement for oxidation stability, has not been specified in the benchmark standard and four national standards. There is an argument that higher IV values do not necessarily indicate an unsuitable stability property for biodiesel (Prankl *et al.,* 1999), and thus the need for such specification is questionable.

The New Zealand standard is completely harmonized with the EAS-ERIA benchmark standard. BDF standards in Thailand and Japan are almost harmonized with the benchmark standards. The Thailand standard was benchmarked to the EAS-ERIA standard, and the harmonization is expected. Considering the fact that the 10 hours oxidation stability is recommended by the Japanese manufacturers, the difference of the Japanese standard to the benchmark standard is not significant in practice.

Harmonization seems not to be difficult. All those countries with BDF standards have referred to the EU EN14214 standard, which is also the base for the EAS-ERIA standard. This means that the frameworks of the BDF standards in most countries are similar. This can be observed from Table 3, where most countries share the same parameters in the table. The difference is in the value of each parameter. Therefore, to harmonize these similar standards, the only thing needed is to adjust or set the value of each parameter.

For new feedstocks, or for countries that have not set their BDF standards, future standards should be encouraged to target harmonization from the outset. This will obviate any future need for harmonization and thus reduce unnecessary adjustment costs.

One sub-optimal choice instead of the full harmonization of BDF standards is to set the benchmark as an optional standard in some nations. Producers may voluntarily comply with the benchmark standard if they want to participate in the regional biodiesel market. Such a measure could ease the concerns of BDF producers while meeting demand from consumers and maintaining the regional BDF market. It is possible to prioritize parameters in BDF standards and allow countries to start the harmonization first with the indispensable standards, before moving on to the less important ones.

4. Debates over Oxidation Stability

The specification of oxidation stability, the most important parameter in the context of possible problems with engine parts, is similar among national standards but divergent from the benchmark standard. Only the EAS-ERIA, New Zealand and Thailand standards set the minimum time at 10 hours, while seven EAS countries including Australia, China, India, Malaysia, the Philippines, South Korea, and Vietnam follow EN14214:2003 and set the value at 6 hours (Table 3). Indonesia did not specify it. Japan leaves it to be decided by producers and distributors.

In general, the EAS-ERIA standard and the WWFC Guidelines, in which the oxidation is set at 10 hours minimum, require more stringent control than the US and EU standards. The minimal requirement was in the United States BDF standard, which is three hours minimum. One reason for the difference between the US and EU standards, which were the two pioneering BDF standards, is the difference of feedstocks in the US and EU. Rapeseed oil is the predominant feedstock for BDF in the EU market, and 6 hours oxidation stability value is comfortable for rapeseed oil, but would exclude soybean, the major US feedstock, from the BDF markets. However, there seems to be a trend towards increasing the minimal requirement of oxidation stability in the EU. The EU standard initially set it at 6 hours minimum but an increase in the value to 8 hours was under consideration (Costenoble *et al*., 2008), and the 2010 version of EN14214 has specified an 8 hours minimum.

One justification for the longer requirement of oxidation stability in the EAS-ERIA standard than that in US and EU standards is the difference in fuel tanks between Europe and East Asia. In Europe, fuel tanks are mainly made of plastics or resin, while in Asia 80% of fuel tanks are metallic, with varying material quality. Therefore, a more strict requirement is set to prevent metal tank corrosion and to reduce risk of formation of gums, sludge, and other insoluble compounds (Goto *et al*., 2010).

Another reason for the longer requirement in the EAS-ERIA and WWFC standards is that the current specification was in the interest of car manufacturers. It was originally proposed by the Japan Automobile Manufacturing Association (JAMA). The WWFC, which accepts the specification, is also a group of manufacturers[8].

Since this 10 hour requirement is a manufacturers' preference, it may not be endorsed by BDF producers. Producers will find it difficult to meet the requirement using feedstocks such as Soybean, Jatropha and waste cooking oil. The Vietnamese case is extremely difficult, as BDF produced from Basa fish oil would be extremely unlikely to meet this specification. Therefore, even one government is questioning the 10 hour specification. For example, in the 12th meeting of AEM-METI Economic and Industrial Cooperation Committee (AMEICC) Working Group on Automobile Industry, a Vietnamese senior official argued that 6 hours should be enough while a 10 hours

[8] WWFC is proposed by a group of car manufacturers, including four major automotive industry organizations: the European Automobile Manufacturers Association (ACEA), the Alliance of Automobile Manufacturers (AAM), the Engine Manufacturers' Association (EMA) and JAMA, and also associate members of other countries' relevant organizations.

specification would incur additional and even unnecessary costs; additives to meet this specification may have side effects and less developed EAS countries, such as Cambodia, Laos, Myanmar, and Vietnam may be disadvantaged[9].

The Philippines and Vietnam, updated by the ERIA WG members, are voluntarily in the process of updating their B100 standards to conform with the proposed benchmark, especially on oxidation stability, but considerable work still needs to be done to harmonize this parameter in East Asia.

The value for oxidation stability needs to be further studied. Since the EAS-ERIA standard proposes the most restricted value, more technical information has to be prepared to persuade stakeholders to accept the 10 hour limitation. An additional and third party independent test would be desirable in order to persuade policy makers to accept the 10 hour specification. It is also important to provide cost and benefit information for BDF made from the prevailing stocks. This information will facilitate standard-making, which will need to balance various factors including economic ones.

5. Policy Implications

Harmonization will face challenges from various stakeholders, in particular biodiesel producers, and thus it is important to deepen the understanding of benefits among the stakeholders. For car manufacturers, the stricter the standard the better. A restrictive standard may seem to be against the interests of producers as they need more capacity, investment, and equipment to meet the restrictive standard than otherwise. However, it is actually in the producers' interest as well: first, the costs can be passed on

[9] This is a summary of the arguments made by a Vietnamese senior officer as he responded to the presentation of this paper.

to consumers; and secondly, in the long run, producers can access larger markets where the highest possible safety standard is a high priority.

The resources required to monitor the implementation of BDF standards should also be taken into consideration in relation to the harmonization of standards. Each parameter needs a specific piece of test equipment which may not be available in all countries. Therefore, it is necessary to make sure that every county has access to the necessary equipment. In the case of monitoring the quality of blended BDF in the retail market (not B100 itself), a mobile laboratory would improve the effectiveness of monitoring.

Harmonization of BDF in East Asia has not properly begun although it has been agreed by policy makers. The EAS-ERIA benchmarking standard is only treated as a reference, and the harmonization is considered to be a voluntary action. However, no plan towards the regional harmonization has been discussed at the East Asian regional level. One possible reason is political sensitivity in relation to national sovereignty over the development of standards. Over the regional forums, policy makers have sought to avoid the issue of harmonization, which is understandable in terms of political sensitivity, but is against the regional interest.

Even though harmonization is politically sensitive and difficult, policy makers should not avoid its discussion. Firm political determination to harmonize national standards should be a priority. The harmonization is a logical follow up of the leaders' initiative for developing a benchmark BDF standard. Since the energy ministers have agreed to study the issue of a benchmark standard and the benchmark has in fact been produced, it is reasonable to move further to encourage member countries to adopt the benchmarking standard.

Policies for the greater usage of biodiesel are in place, but a better balance between the encouraging and restricting policies is needed. We have seen quite a lot of supportive policies and mandates in the EAS countries which are desirable as otherwise they will not be able to create a national biodiesel market (UNCTAD, 2009). However, we should be aware that biofuels, including BDF, may affect food prices, exacerbate degradation of the environment, and even increase greenhouse gas emissions if not managed properly (Lee *et al.*, 2008). Certificating sustainability and labeling for carbon footprints of individual biodiesel products would be a few sample measures to minimize its negative impact (Shi, 2010).

6. Concluding Remarks

BDF has been progressively promoted in East Asia in the past decades. Significant development of BDF, and policy and other support measures have been implemented. The potential for future growth, utilization, and trade of BDF is also promising.

BDF standards have been set in most EAS countries. Among the eleven national BDF standards, differences are significant but not unconquerable. Actually, because only two international standards, the US and the EU standards, were referred to during the process of developing these national standards and the EU standard has been used as a basis by a large number of countries, the roadmap towards harmonization is clear.

The goal of benchmarking BDF standards in East Asia has been agreed for several years, and a regional standard has actually been developed, but real steps toward harmonization have not been taken due to a lack of political determination. Attempts to harmonize BDF standards have to be backed by technical facility for monitoring biodiesel quality directly, and by necessary policies to promote the usage of BDF in a broader context.

In summary, the harmonization of BDF standards is economically and environmentally beneficial and technically feasible, but the process is practically stalled due to a lack of political determination. Therefore we should clearly call for the political determination for actual implementation of the harmonization in East Asia.

References

ADB (ASIAN Development Bank) (2009) *Global and Regional Development and Impact of Biofuels: A focus on the Greater Mekong Subregion.* Mandaluyong City, Philippines: Asain Development Bank.

APEC (Asia-Pacific Economic Cooperation) (2008) *The Future of Liquid Biofuels for APEC Economie*s. APEC Energy Working Group.

APEC Biofuels Task Force (2007) *Report to the Eighth Energy Ministers Meeting (EMN-8)*. Darwin, Austrlia: APEC.

APEC Energy Working Group (2007) *Establishment of the Guidelines for the Development of Biodiesel Standards in the APEC Region*.

ASEAN Website (2008) *Joint Ministerial Statement of the Scond EAS Energy Ministers Meeting* [Online]. Jakarta: Association of Southeast Asian Nations. Available: http://www.aseansec.org/21853.htm [Accessed 15 January 2011].

BEFS (The Bioenergy and Food Security Project) (2011) Bioenergy and Food Security --the BEFS Analytical Framework. *No. 16 of the Environment and Natural Resource Management Series.* Rome: UN Food and Agricultura Organizaiton.

Cebu Declaration (2007) *Cebu Declaration on East Asian Energy Security Cebu*. the Philippines.

Costenoble, O., Mittelbach, M., Schober, S., Fischer, J. & Haupt, J. (2008) *Improvements needed for the biodiesel standard EN 14214.* The European BIOScopes Project.

Global Biofuels Center (2009) *Asia Pacific: Update on Biofuel Production Capacity*.

Goto, S., Oguma, M. & Chollacoop, N. (2010) *EAS-ERIA Biodiesel Fuel Trade Handbook: 2010*. Jakarta: Economic Research Institute for ASEAN and East Asia.

IEA (International Energy Agency) (2010) *World Energy Outlook 2010,* Paris, International Energy Agency.

Kimura, S. (2010) "Analysis on Energy Saving Potential in East Asia." *ERIA Research Project Report 2009.* Jakarta: Economic Research Institute for ASEAN and East Asia.

Kojima, M., Mitchell, D. & Ward, W. (2007) *Considering Trade Policies for Liquid Biofuels*. Washington DC: The World Bank.

Lee, H., Clark, W. C. & Devereaux, C. (2008) *Biofules and Sustainable Development: Report of an Executive Seesion on the Grand Challenges of a Sustainability Transition*. Cambridge, Massachusetts: Sustainability Science Program, Center for International Development, Harvard University.

MNRE (Ministry of New & Renewable Energy) (2009) *National Policy on Biofuels.* New Delhi: Ministry of New & Renewable Energy, Government of India.

Prankl, H., W Rgetter, M. & Rathbauer, J. (1999) Vegetable Oil Methyl Esters with a High Iodine Number. *Fourth Biomass Conference of the Americas.* Oakland, CA.

Sagisaka, M. (2010) "Sustainability Assessment of Biomass Energy Utilisation in Selected East Asian Countries." *ERIA Research Project Report 2009.* Jakarta: Economic Research Institute for ASEAN and East Asia.

Shi, X. (2010) "Carbon Footprint Labeling Activities in the East Asia Summit Region: Spillover Effects to Less Developed Countries." *ERIA Discussion Paper.* Jakarta: Economic Research Institute for ASEAN and East Asia.

Tripartite Task Force (2007) *White paper on Internationally Compatible Biofuel Standards*. Tripartite Task Force (Brazil, EU, and US).

UNCTAD (2009) *The Biofuels Market: Current Sitution and Alternative Scenarios.* Geneva and New York: United Nations Conference on Trade and Development.

WWF (2007) *Rain Forest for Biodiesel? Ecological Effects of using Palm Oil as a Source of Energy*. Frankfurt/Main: WWF Germany.

ERIA Discussion Paper Series

No.	Author(s)	Title	Year
2011-03	Xunpeng SHI, Shinichi GOTO	Harmonizing Biodiesel Fuel Standards in East Asia: Current Status, Challenges and the Way Forward	May 2011
2011-02	Hikari ISHIDO	Liberalization of Trade in Services under ASEAN+n : A Mapping Exercise	May 2011
2011-01	Kuo-I CHANG, Kazunobu HAYAKAWA Toshiyuki MATSUURA	Location Choice of Multinational Enterprises in China: Comparison between Japan and Taiwan	Mar 2011
2010-11	Charles HARVIE, Dionisius NARJOKO, Sothea OUM	Firm Characteristic Determinants of SME Participation in Production Networks	Oct 2010
2010-10	Mitsuyo ANDO	Machinary Trade in East Asia, and the Global Financial Crisis	Oct 2010
2010-09	Fukunari KIMURA Ayako OBASHI	International Production Networks in Machinery Industries: Structure and Its Evolution	Sep 2010
2010-08	Tomohiro MACHIKITA, Shoichi MIYAHARA, Masatsugu TSUJI, and Yasushi UEKI	Detecting Effective Knowledge Sources in Product Innovation: Evidence from Local Firms and MNCs/JVs in Southeast Asia	Aug 2010
2010-07	Tomohiro MACHIKITA, Masatsugu TSUJI, and Yasushi UEKI	How ICTs Raise Manufacturing Performance: Firm-level Evidence in Southeast Asia	Aug 2010
2010-06	Xunpeng SHI	Carbon Footprint Labeling Activities in the East Asia Summit Region: Spillover Effects to Less Developed Countries	July 2010
2010-05	Kazunobu HAYAKAWA, Fukunari KIMURA, and Tomohiro MACHIKITA	Firm-level Analysis of Globalization: A Survey of the Eight Literatures	Mar 2010
2010-04	Tomohiro MACHIKITA and Yasushi UEKI	The Impacts of Face-to-face and Frequent Interactions on Innovation: Upstream-Downstream Relations	Feb 2010
2010-03	Tomohiro MACHIKITA and Yasushi UEKI	Innovation in Linked and Non-linked Firms: Effects of Variety of Linkages in East Asia	Feb 2010

2010-02	Tomohiro MACHIKITA and Yasushi UEKI	Search-theoretic Approach to Securing New Suppliers: Impacts of Geographic Proximity for Importer and Non-importer	Feb 2010
2010-01	Tomohiro MACHIKITA and Yasushi UEKI	Spatial Architecture of the Production Networks in Southeast Asia: Empirical Evidence from Firm-level Data	Feb 2010
2009-23	Dionisius NARJOKO	Foreign Presence Spillovers and Firms' Export Response: Evidence from the Indonesian Manufacturing	Nov 2009
2009-22	Kazunobu HAYAKAWA, Daisuke HIRATSUKA, Kohei SHIINO, and Seiya SUKEGAWA	Who Uses Free Trade Agreements?	Nov 2009
2009-21	Ayako OBASHI	Resiliency of Production Networks in Asia: Evidence from the Asian Crisis	Oct 2009
2009-20	Mitsuyo ANDO and Fukunari KIMURA	Fragmentation in East Asia: Further Evidence	Oct 2009
2009-19	Xunpeng SHI	The Prospects for Coal: Global Experience and Implications for Energy Policy	Sept 2009
2009-18	Sothea OUM	Income Distribution and Poverty in a CGE Framework: A Proposed Methodology	Jun 2009
2009-17	Erlinda M. MEDALLA and Jenny BALBOA	ASEAN Rules of Origin: Lessons and Recommendations for the Best Practice	Jun 2009
2009-16	Masami ISHIDA	Special Economic Zones and Economic Corridors	Jun 2009
2009-15	Toshihiro KUDO	Border Area Development in the GMS: Turning the Periphery into the Center of Growth	May 2009
2009-14	Claire HOLLWEG and Marn-Heong WONG	Measuring Regulatory Restrictions in Logistics Services	Apr 2009
2009-13	Loreli C. De DIOS	Business View on Trade Facilitation	Apr 2009
2009-12	Patricia SOURDIN and Richard POMFRET	Monitoring Trade Costs in Southeast Asia	Apr 2009
2009-11	Philippa DEE and Huong DINH	Barriers to Trade in Health and Financial Services in ASEAN	Apr 2009

2009-10	Sayuri SHIRAI	The Impact of the US Subprime Mortgage Crisis on the World and East Asia: Through Analyses of Cross-border Capital Movements	Apr 2009
2009-09	Mitsuyo ANDO and Akie IRIYAMA	International Production Networks and Export/Import Responsiveness to Exchange Rates: The Case of Japanese Manufacturing Firms	Mar 2009
2009-08	Archanun KOHPAIBOON	Vertical and Horizontal FDI Technology Spillovers: Evidence from Thai Manufacturing	Mar 2009
2009-07	Kazunobu HAYAKAWA, Fukunari KIMURA, and Toshiyuki MATSUURA	Gains from Fragmentation at the Firm Level: Evidence from Japanese Multinationals in East Asia	Mar 2009
2009-06	Dionisius A. NARJOKO	Plant Entry in a More Liberalised Industrialisation Process: An Experience of Indonesian Manufacturing during the 1990s	Mar 2009
2009-05	Kazunobu HAYAKAWA, Fukunari KIMURA, and Tomohiro MACHIKITA	Firm-level Analysis of Globalization: A Survey	Mar 2009
2009-04	Chin Hee HAHN and Chang-Gyun PARK	Learning-by-exporting in Korean Manufacturing: A Plant-level Analysis	Mar 2009
2009-03	Ayako OBASHI	Stability of Production Networks in East Asia: Duration and Survival of Trade	Mar 2009
2009-02	Fukunari KIMURA	The Spatial Structure of Production/Distribution Networks and Its Implication for Technology Transfers and Spillovers	Mar 2009
2009-01	Fukunari KIMURA and Ayako OBASHI	International Production Networks: Comparison between China and ASEAN	Jan 2009
2008-03	Kazunobu HAYAKAWA and Fukunari KIMURA	The Effect of Exchange Rate Volatility on International Trade in East Asia	Dec 2008
2008-02	Satoru KUMAGAI, Toshitaka GOKAN, Ikumo ISONO, and Souknilanh KEOLA	Predicting Long-Term Effects of Infrastructure Development Projects in Continental South East Asia: IDE Geographical Simulation Model	Dec 2008
2008-01	Kazunobu HAYAKAWA, Fukunari KIMURA, and Tomohiro MACHIKITA	Firm-level Analysis of Globalization: A Survey	Dec 2008