Chapter 2

Energy Situation in the World

Benchmarking of Biodiesel Fuel Standardization in East Asia Working Group

July 2010

This chapter should be cited as
Benchmarking of Biodiesel Fuel Standardization in East Asia Working Group (2010), 'Energy Situation in the World' in Goto, S., M. Oguma, and N. Chollacoop, *EAS-ERIA Biodiesel Fuel Trade Handbook: 2010,* Jakarta: ERIA, pp.6-15.

2. ENERGY SITUATION IN THE WORLD

2.1 Introduction

With the present situation of increasing energy demand, rising energy prices, and reinforcement of countermeasures for global warming, renewable energy sources have taken the spotlight. Bio-fuels are one form of renewable energy that has become more widespread. Also, bio-fuels have been introduced and expanded as alternative fuel for the transportation sector and as a form of liquid renewable energy that can be blended with petroleum. However, since the source material of bio-fuels is sometimes the same as for food, an increase in grocery prices has drawn attention to the next generation of bio-fuels being non-food sourced. This report will discuss the demand perspective derived from the IEA (International Energy Agency) world energy forecast, basic energy price trends, and bio-fuel trends.

2.2 Increase of Energy Demand

2.2.1 Perspective of World Energy Supply and Demand

According to the IEA World Energy Outlook, the world's primary energy supply has increased by 58% in 25 years, from about 7.2 billion TOE (tonne of oil equivalent) in 1980 to about 11.4 billion TOE in 2005, as shown in Table 1. The OECD (Organization for Economic Cooperation and Development) countries used to be the center of energy demand. However, these OECD countries are lower both in economic and population growth rates than those of non-OECD countries. Further, the OECD countries' economic industrial structure has changed, therefore the increase in demand stays low. In 2005 the non-OECD countries took the lead in demand, accounting for 51% of consumption in 2006. In the future it is expected that energy demand will increase based on economic growth of emerging market countries like China, India, and the Middle East. It is estimated to increase by 48% over 25 years from about 11.43 billion TOE in 2005 to about 17.0 billion TOE in 2030. The share of petroleum demand

Table 1 Perspective of World Energy Demand

Items	Energy Demand (M_{toe})				
	1980	2000	2005	2015	2030
Total primary energy demand	7,223	10,034	11,429	14,121	17,014
Petroleum Oil	3,107	3,649	4,000	4,525	5,109
Transport	1,245	1,936	2,011	2,637	3,171
Petroleum	1,187	1,844	1,895	2,450	2,915
Biofuels	2	10	19	74	118
Other fuels	57	82	96	113	137

(Source: IEA World Energy Outlook 2007, 2008)

in the world's primary energy supply will decrease from 34% to 30%, however in the absolute quantity is estimated to increase by 27.7%, from 4.0 billion TOE in 2005 to about 51 TOE in 2030.

On the other hand, it is expected that exploratory development investment of petroleum and natural gas will be more important for the future energy supply. The world average depletion rate of oil fields following production peak is 6.7 % annually at this point, and it is assumed that the depletion rate of oil fields will accelerate to 8.6% by 2030. In order to continue petroleum production to meet increasing demand in an environment of post-peak oil field production (decreasing yields), it is necessary to obtain additional petroleum by developing new oil fields. In terms of additional worldwide new production capacity, the IEA predicts that from 2007 to 2030 an additional capacity of 64 million bbl/day will be needed. This is equivalent to about six times the current production of Saudi Arabia, the biggest crude oil producing country in the world. A sufficient amount of oil deposits in the world is predicted to exist even after 2030. In order to obtain a rate of oil and gas resource development corresponding to the increase in demand, however, large-scale investment is essential. However, oil reserves are distributed unevenly throughout the world. That is, the OPEC countries account for 75.7% of confirmed oil reserves in the world, while 82% is contained within the OPEC countries and Russia [1]. Natural gas is similar. Three countries, namely Russia, Iran and Qatar hold 55% of the worlds confirmed reserves [2]. At a company level, national oil companies hold 76% of reserves, while the Russian oil companies hold 17% of the reserves. An area of improvement is in major International Oil Companies (IOC), which have access to advanced technology and funds but the amount of accessible reserves they hold is only 7%. In summary, the development of oil and natural gas at a rate to meet the future worldwide demand requires exploratory development investment, especially in a few key resource-rich countries [3]. In the IEA World Energy Outlook, it is predicted that the OPEC countries supply the majority of world petroleum increase in the future, and the OPEC share will increase from 44% in 2007 to 51% in 2030.

On the other hand, the worldwide amount of primary reserves in non-conventional petroleum sources like oil sand and oil shale is estimated to be about 2 trillion barrels, which is very abundant but immediately available. For example, 80% of the approximately 170.0 billion barrels of oil sand minable in Canada, must be obtained from several tens of meters deeper oil sands using vapor methods. Water and natural gas resources are utilized in vapor extraction. Development of these non-conventional petroleum reserves has environmental consequences, such as

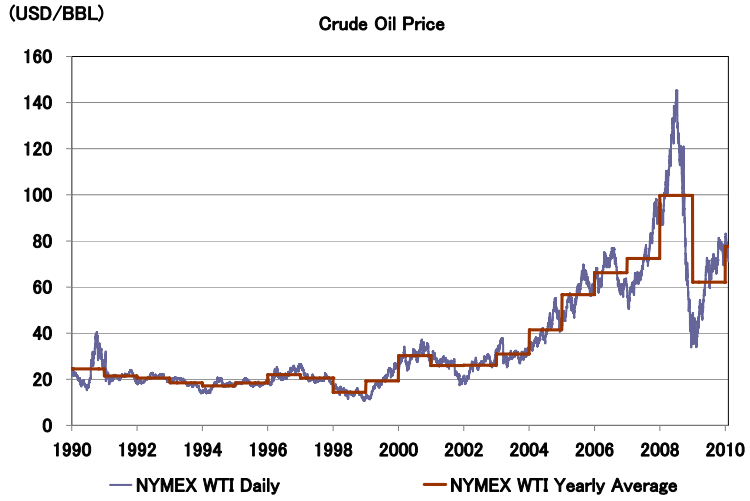
recycling of water resources, and overall CO_2 increase.

2.2.2 Transportation Sector

Energy demand in the transportation sector is estimated to increase 57% from about 2.0 billion TOE in 2005 to about 3.2 billion TOE in 2030. The ratio of petroleum in the transportation sector is estimated to consistently account for more than 90% in 2005 to 92% in 2030. The reason petroleum accounts for a large fraction of energy supply for the transportation sector is that petroleum alternatives are difficult. Petroleum fuels for airplanes, ships and automobiles have several key merits. They have a high energy density, which makes a sufficient cruising distance possible, and liquid fuels are relatively easy to handle. However, more important than that, it is not realistic to change our energy infrastructure like gas stations, storage tanks, engines, or emission characteristics, at any given point in time. Because of this, the current energy infrastructure makes it extremely important that any new alternative petroleum fuel is compatibility with the corresponding conventional petroleum fuel. Liquid alternative fuels that can be blended with petroleum fuels (like bio-fuel) are advantageous in terms of transportation fuel supply resource diversification.

2.3 Trend of International Energy Prices

Figure 4 shows the variation in crude oil prices. In the two oil crises during the 1970's and the gulf crisis of 1990, a disruption of crude oil supply was triggered by the 4th Middle East War, the Iran Revolution, and the Kuwait invasion. As a result, prices increased about 2-4 times. After that, crude oil prices in the 1990's didn't exceed $30/bbl. The WTI crude oil price (an international price index) was stable at around $20/bbl. However, after it went down to $10/bbl in December, 1998, the price started to go up around the Iraq crisis in 2003. Then the price increased as high as $147/bbl in July, 2008. After that the price decreased significantly. Although the price broke $34/bbl in December, 2008, it varied in a range of $40 to $60/bbl until April, 2009, showing a stable price trend.

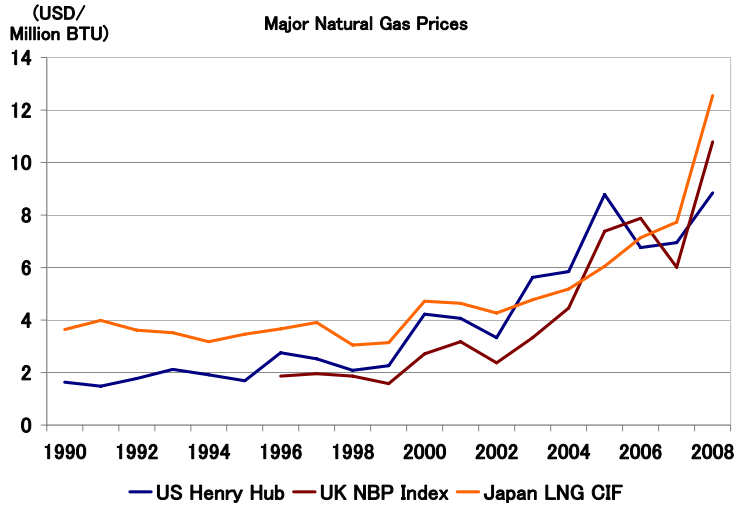


Fluctuating blue line: WTI crude oil price and Flat red line: WTI annual average price
(Source data: US Energy Information Administration)

Figure 4. NYMEX WTI Variation in Crude Oil Price（US dollar/bbl）

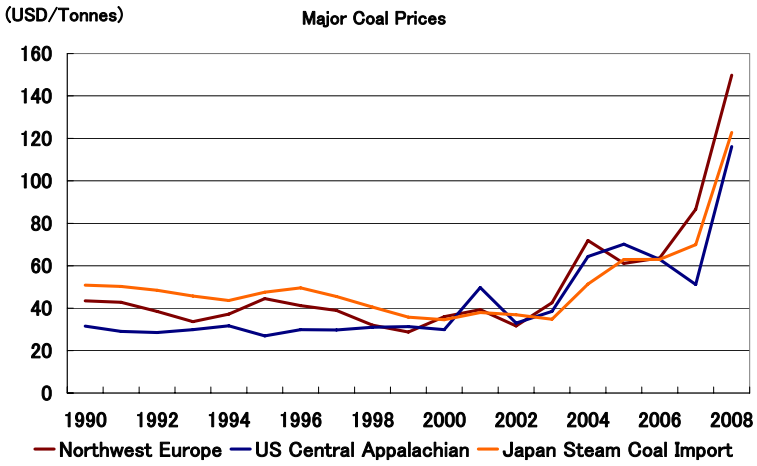
In terms of the hike in crude oil price in the 2000's, the price did not increase rapidly in a short period, as with a physical crude oil supply disruption in past oil crises, but the price increased more gradually. The price hike this time involved various factors: (1) An increase in consumption by the newly wealthy in developing countries, (2) Geopolitical risk and a decrease in stockpiles due to "resource nationalism" in supply countries, (3) The influences of speculative investors, (4) Inflation and influences of dollar depreciation and quotation in dollars, and so forth.

Figure 5(a) shows the variation of natural gas price while Figure 5(b) shows the trends in coal prices. It is expected that the demand for natural gas and coal will increase more than oil in the future. These prices are different from oil prices. Currently, there is no world index, but these prices are increasing in the 2000's similar to oil prices. There are some indirect influences of the oil price due to certain factors. For the price of natural gas, decisions are similar to crude oil buyers' prices in Japan, to heavy oil prices in Europe, and to fuel conversion users like power plants in the US. There is no direct influence of oil price on coal prices. However, there are secondary influences, such as the fuel demand increase for power plants, and higher iron and steel production, and a delay of export infrastructure maintenance due to this demand increase. Regarding coal demand, an increase is expected in China, India and the Middle East owing to their strong economic growth, while for natural gas a steady demand increase is expected in these three countries and regions, along with South America and Africa.



Blue Line: US Henry hub price; Red Line: British NBP price and Orange Line: Japan LNG CIF price
(Source data: BP Statistical Review of World Energy)

(a)



Red Line: Northwestern Europe price; Blue Line: US Appalachia price and Orange Line: Japanese general coal import price
(Source data: BP Statistical Review of World Energy)

(b)

Figure 5. Variation in Annual Average (a) Natural Gas Price (US dollar/million BTU) and (b) Coal Price (US dollar/ton)

After the summer of 2008 the world business situation declined, and crude oil prices decreased remarkably. In order to achieve the necessary petroleum development investments for the future mid-to-long range growth of oil demand, it has been said that prices like we had in the 1990's will not return. From the standpoint of attaining a stable energy supply and diversification supply sources, the importance of alternative fuels is expected to increase.

2.4 Global Environmental Problems

Discussions on environmental problems in energy policy, particularly global warming issues, have been given much attention these days. Scientific temperature observations, begun in the 19th century, have shown that the pace of temperature increase in the latter half of the 20th century has been faster. Currently, the amount of fossil fuel origin carbon dioxide discharge has been increasing, with the corresponding increase in energy demand. Due to this increase, it has been strongly claimed that the artificial greenhouse effect is the main cause. For these global warming problems, the United Nations Framework Convention on Climate Change was issued in 1994, and Kyoto Protocol was issued in February of 2005. The protocol called for efforts to reduce the amount of greenhouse type gas emissions from in advanced countries from 2008 to 2012, ultimately aiming for 1990 levels. For biomass and bio-fuels, CO_2 is absorbed during the growth process of the plants and then the same amount is ideally generated when the fuel is burned. This is considered carbon-neutral when we consider CO_2 exhaust emissions. Thus the importance of biomass and bio-fuels is evident because they not only increase diversification of energy supply sources but also aid in CO_2 reduction.

In addition, the "IPCC Fourth Assessment Report: Climate Change 2007" (Intergovernmental Panel on Climate Change, IPCC) presented by a climate change bureau of the United Nations in 2007, gives a different predicted result. This group predicts a 1.1 to 6.4 ^{o}C higher average temperature at the end of this century. This would mean it is necessary to make more efforts to reduce CO_2 emissions. It is an important task among engineers to control the amount of CO_2 emissions through significant improvements in energy efficiency, and introducing renewable energy sources. After the COP 15 negotiations in Copenhagen in December of 2009, one of the outcome was that "The Copenhagen Accord recognizes the scientific view that an increase in global temperature below 2 degrees is required to stave off the worst effects of climate change." At this point the effort appears to be focused on CO_2 reduction in society. Considering renewable energy forms like bio-fuels, their introduction has been promoted as a core program towards a low carbon social structure.

2.5 Bio-fuels

2.5.1 Introduction and Expansion of Bio-fuels

The history of bio-fuels is fairly old, since they were already investigated as automotive fuels in the latter half of the 19th century. Much later, during the first oil

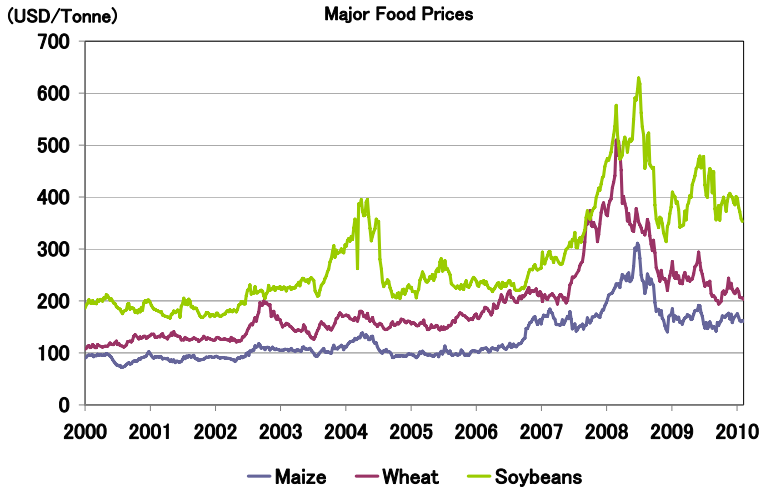
crisis of 1973 bio-fuels were again brought to the limelight. In the US, favorable tax treatment was given to ethanol blended with gasoline, called “gasohol”. In Brazil, at the time of the first oil crisis a national alcohol plan (PROALCOOL) was initiated in 1975. This program aimed to increase Brazil’s energy independence, and started with ethanol gasoline blending. Recently, these two countries account for about 90% of the world’s ethanol production, and Brazil attracts attention as an ethanol exporter. Finally, European countries have also embarked on a CO_2 reduction effort by introduction of bio-diesel fuel, and widespread increase in support for diesel powered passenger cars.

Bio-fuel utilization in Europe and the US has expanded after 1990 with a goal to improve automobile exhaust emission performance, to reduce CO_2 emissions, and to introduce a renewable energy source to offset the finite petroleum resource. Moreover, introduction of domestic sourced bio-fuels is an important outlet for excess supplies of corn and sugar. One should also not ignore the effect of agricultural product promotion on support prices of these agricultural products. However, as the oil price has increased in the past 5 years, the number of countries to introduce bio-fuels and the total production of bio-fuels have both accelerated, as a result competition problems with food gradually comes to the forefront.

2.5.2 Direction of Future Bio-Fuels

The bio-fuel introduction process has so far been forced to use various support measures like tax breaks and tax exemptions, but this has led to expanding levels of bio-fuel usage worldwide. If we assume a continued expansion in production, the price of grains like corn and wheat (which are sources of bio-fuel) has also increased significantly from the latter half of 2007 to the first half of 2008, as shown in Figure 6. Considering the increase in food prices, there are other factors to consider in addition to introduction and expansion of bio-fuel, namely: (1) An increase in grain consumption since developing countries like China and India have become wealthy, (2) A supply limit and a decrease of world storage of wheat due to unfavorable weather in Australia, (3) Influence of speculators, (4) Inflation effects on the US dollar and quotation in US dollars.

However, since the total amount of bio-fuels originating from grains like corn and wheat has expanded, criticism of ‘food vs fuel’ usage has grown rapidly shrill, claiming that the cause of food price increases is the bio-fuel policy, even though bio-fuel is not the only factor for the increase.



Blue Line: corn; Red Line: wheat and Green Line: soybean

(Source data: FAO Homepage)

Figure 6 Variation in Grain Prices

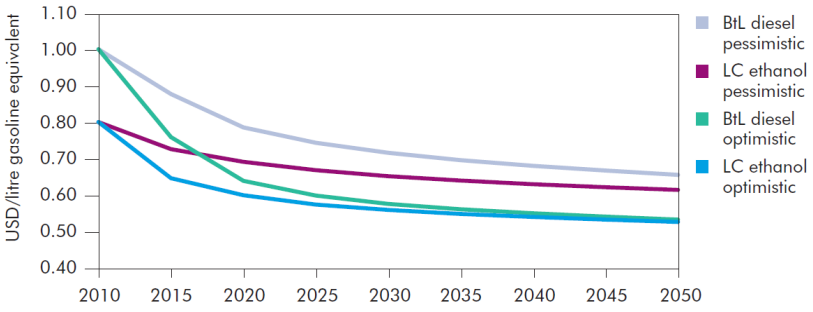
Along with the increased criticism of the competition of food and bio-fuel source material, concerns about their actual ability to reduce a green house gas levels, and problems of deforestation to produce source material, and biological diversity, have been raised in Europe. Discussions on the long-term sustainability of bio-fuels have become more widespread. As a result, a new introduction support plan has been investigated considering the CO_2 reduction effect of various bio-fuel source materials and production methods. However, discussions are continuing on the LCA (life cycle assessment) limitations of various bio-fuels. Developing a standard for the sustainability of bio-fuels in certain parts of countries has a possibility to become a hindering factor for world free trade. Therefore, in addition to harmonization of bio-fuel quality specifications, a harmonization of sustainability standards also becomes necessary.

In this situation, expectations are rising for the second-generation bio-fuels that do not compete with food. In Europe and the US, from the middle of the 2010's, a mandatory quantity of second generation bio-fuels like cellulosic ethanol and BTL (biomass to liquid) will be increased. Commercial introduction of the second-generation biofuels in 2010s is one of the major goals of introducing biofuels especially in developed countries. On the other hand, steady increase with the first generation biofuels is also planned in many countries. As the decline in raw feedstock such as vegetable oil, further introduction of biofuels including mandatory blending is progressing steadily in many Asian countries as a measure to promote and maintain agricultural employment and mitigation of the oil import growth and so forth. With the introduction of cellulosic ethanol, the volume of potential resources will not only

increase but the actual greenhouse gas reduction affect will increase significantly as well. Thus cost reduction research for commercial production has been proceeding.

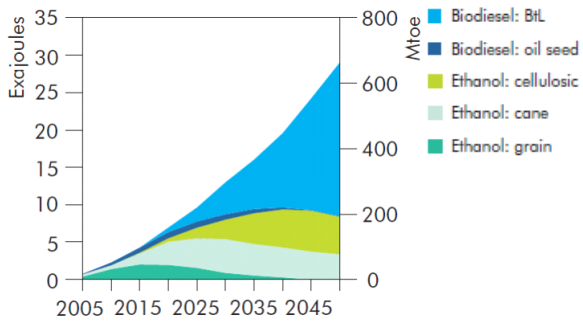
Other than energy crops for second-generation bio-fuels, other sources like micro-algae have been in the spotlight. These organisms do not require cultivated land, and can thrive on land containing high levels of salt, while still yield a large amount per unit area. This can be considered as a third generation bio-fuel ingredient. For algae-sourced bio-fuels, containing about 40% lipids overall, research on biodiesel production has been performed. However, large-scale production, cost reduction, and commercialization need to be advanced to reach current status of second-generation bio-fuels.

A cost analysis has been conducted (shown in Figure 7) on the major second generation bio-fuel sources in the IEA "Energy Technology Perspective 2008," using market-based source material prices, commercialization of plant scales, and a cost reduction trend with increased levels of total production. In an optimistic case, both cellulosic ethanol and BTL will rapidly decrease after 2010, and will reach a final cost around 2030, while in a pessimistic case the cost reduction will be slower, and the final cost will be about 0.15 dollar/L higher, compared to the optimistic case. However, the report describes a scenario that has a lower carbon dioxide exhaust emission levels in 2050, actual introduction of the third generation bio-fuel is assumed, and then an important role is expected towards a future low-carbon world, as shown in Figure 8.



(Source data: IEA "Energy Technology Perspective 2008")

Figure 7 Expected Cost of Second Generation Bio-fuels



(Source data: IEA "Energy Technology Perspective 2008")

Figure 8. Amount of Bio-fuel Introduction in BLUE Scenario