Drivers for an International Biofuels Market

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Abstract

This paper explores geopolitical and economic drivers for an international biofuels market. It is concluded that the biofuels market so far is primarily regionally oriented and policy driven. However, as demand is expected to increase in the years to come and demand and production do not coincide geographically, an international market is soon expected to arise.
How quickly this market will develop is determined by several geopolitical and economic factors. Important geopolitical factors are in particular security of supply and risk abatement considerations, the contents of future emission reduction agreements, and the interaction with in new parties and policies such as those in the agricultural sector. Key economic factors are the prices of primary biomass and petroleum, as well as technological development influencing the price of conversion of biomass to end-use applications. International certification is likely to play a key role in determining whether or not this market will develop in an ecologically sound way.

1. Introduction

Biofuels are presently receiving much attention worldwide. Their use as an energy source for transport, it is claimed, can not only contribute to greenhouse gas emission reduction, but also to supply-security of energy consuming countries. Other advocated benefits of biofuels are local air quality benefits and waste reduction, improved vehicle performance, enhanced rural economic development and, under the right circumstances, protection of ecosystems and soils (IEA, 2004).

Much biofuels research is presently directed at ways to improve conversion technologies, exploring technical and economic biomass potentials and possible environmental impacts. Less is known about geopolitical and economic drivers of this developing biofuels market. This paper examines some of these important drivers and identifies issues for further discussion.

2. Present Policies in the Biofuels Market

The "biofuels market" is a submarket of the overall biomass market. This market consists of a complex interaction of several competing primary sources of biomass, conversion routes and applications (Figure 1). Drivers for the biofuels market are related to the whole production chain from biomass to end-use application. This paper therefore focuses on the route from primary biomass to the main biofuels biodiesel and bioethanol, but will also consider the whole supply chain where appropriate.

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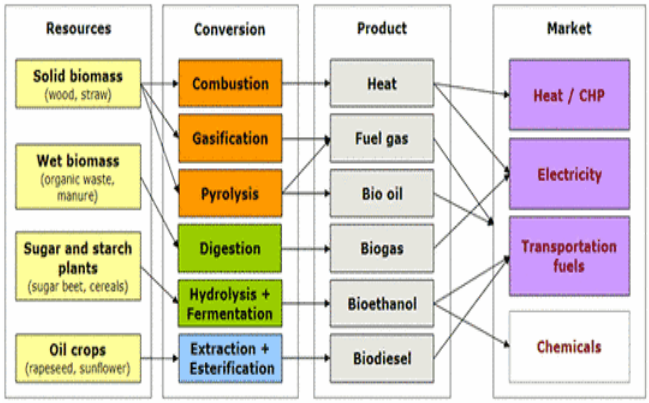
Figure 1: Biomass Application Routes (Source: Eubia, 2005)



Present production rates of biofuels are given in Figures 2 and 3. In 2003, some 30 billion litres of ethanol were produced and about 2 billion litres of biodiesel. Main production regions of ethanol are Brazil and North-America (United States and Canada). Main production regions of biodiesel presently is the European Union. In 2003, share of bioethanol in world motor gasoline use amounted to 2,8% (US/Canada: 2,3%) and of biodiesel to 0,2% (EU: 1,0%).

Figure 2: World Bioethanol Production (Source: F.O. Lichts, 2004)

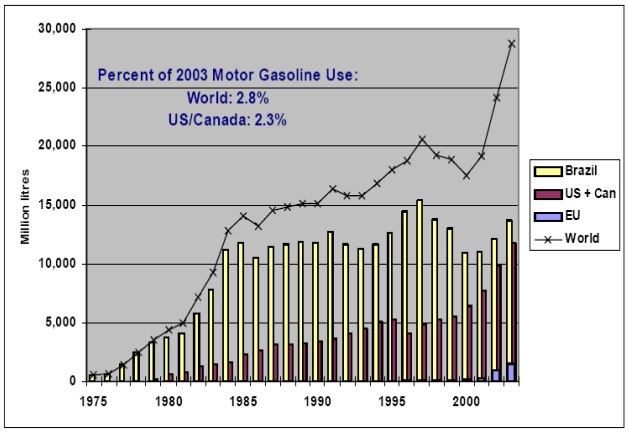
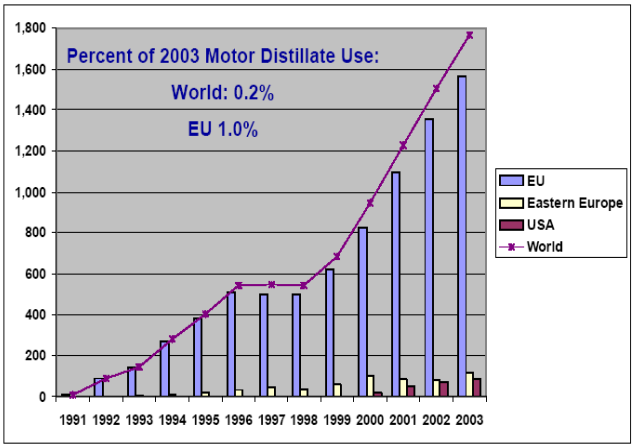


Figure 3: World Biodiesel Production (Source: F.O. Lichts, 2004)



In this section, policies of main regions and nations with a demand for biofuels and/or production potentials for primary biomass will be outlined. Some illustrative export data will be given.

The European Union
Total biofuels production in the European Union in 2003 amounted to 1,8 Mt, of which 82% was biodiesel (Eubia, 2005)[2].
The EU stimulates demand for biofuels with a directive dating from 2003 that sets specific targets to the individual member states. For 2005, a non-binding target has been set for biofuels to contribute 2% to total demand for transportation fuels in member states, in 2010 this contribution would have to be 5,75%. However, most member states did not reach their 2005 target (ENDS, 2005). A new biofuels action plan will therefore be issued in 2006. Germany, France, Sweden and Spain so far are most advanced in their development regarding biofuels. Tax exemptions are their primary instrument used to stimulate biofuels development.
The EU has the largest production of biodiesel worldwide, with 1,4 Mt in 2003. Of this amount, about 50% was produced in Germany and smaller amounts in France and some other countries. Some 80% of EU's biodiesel came from domestically grown rapeseed oil, with imported soybean oil and a marginal quantity of palm oil making up for the rest (PA, 2005).
Spain is the largest bioethanol producer in the EU. Of the total production of 310,000 tonnes of bioethanol in the EU in 2003, 180,000 tonnes were produced in Spain (Eubia, 2005). Other large bioethanol producers are France and Sweden. Bioethanol in Europe is mainly produced from regionally grown starch crops like wheat and sugar beet. Import takes place in particular in Sweden, where quantities of bioethanol from sugarcane are imported from Brazil, India and other tropical countries (Svebio, 2005).

The United States
The United States is the second largest ethanol producer after Brazil, and the second largest biodiesel producer after the EU (PA, 2005). In 2002, 180 million gallons of biodiesel (about 0,5 Mt) were consumed in the United States, and 2 billion gallons of ethanol (~ 6 Mt) (EERE, 2005). The potential of biofuels estimated by the Department of Energy and Department of Agriculture amounts up to 30% replacement of current petroleum consumption for transport fuels by 2030.
The recent energy bill sets new targets and new support mechanisms for biofuels, on top of an existing excise tax credit scheme (PIW, 2005). Particular target is to increase the quantity of ethanol blended with gasoline to around 7,5 billion US gallons per year by 2012 (~ 22 Mt). Some $ 200 million annually are reserved for research and development, loan guarantees for construction of new biorefineries and an extension of the current federal biofuel procurement programme.
Bioethanol in the United States is primarily produced from domestic grain. US biodiesel is produced from domestic soy beans and restaurant cooking grease (EERE, 2005).

Canada
The present annual ethanol production in Canada amounts to about 0,2 Mt per year (Bradley, 2005), that of biodiesel to 0,003 Mt a year (BAC, 2005). A national target has been set to

[2] 1 Mt biofuels roughly equals 1,5 Mt oil equivalent. Total energy consumption in the EU transport sector amounted to around 550 MT oil equivalent in 2002 (source: eia.doe.gov). The contribution of biofuels to the EU transport sector would therefore amount to circa 0,3%. The European Biofuels Association EUBIA claims a contribution of around 1% (source: eubia.org).

produce 1.4 billion litres of ethanol (~ 0,9 Mt) and 500 million litres of renewable diesel (~0,4 Mt) by 2010. Realisation of this target is stimulated by a tax exemption.
Bioethanol in Canada is presently produced by six plants, with a further seven plants to be constructed shortly. Biodiesel developments are in the start-up phase, but are expected to grow rapidly with several plants under construction.
Export is foreseen to develop primarily in wood pellets and, less so, biodiesel. Bioethanol will be primarily produced for the home market (Bradley, 2005).

Japan
In a statement issued in 2002, Japanese Government qualifies present biofuels utilisation in Japan as limited. However, a large potential for biomass in general is foreseen, and Government looks for options to exploit this potential. Part of this development will come from biofuels (Japanese Government, 2002). In 2003, a law was issued that allows for blending of 3% of alcohol with gasoline.
The Japanese Bank for Development Cooperation and Brazil are developing a bilateral program to increase the production of bioethanol and biodiesel in Brazil and its supply to the Japanese market (GCC, 2005). In 2004, Japan imported 149 million litres of bioethanol (0,1 Mt) from Brazil. The world's biggest sugar-ethanol cooperative, Brazil's Copersucar, has signed a deal to sell 15 million litres of ethanol to Japan's independent fuel distributor Kotobuky Nenryo. For the future, a longer term commitment is foreseen (Cardoso, 2005).

China
The search for renewable energy sources in China is triggered by large energy-demand growth rates and an expected very large increase in oil imports. Private vehicle ownership, for instance, has increased six-fold in ten years time, and further growth is expected (IHT, 2005).
Biofuels research in China is stimulated through state-issued five-year plans. The present five-year plan includes laboratory research on biodiesel, ethanol and oil crops, as well as small demonstration plants for some of these applications This search for new biofuels applications is part of China's plan to raise renewable energy use to about 15 percent of total energy supply in 2020, from 7 percent now.
Whereas biodiesel development is still mainly in the research phase, with no large-scale production in practice, bioethanol in China is already produced on a larger scale. The Chinese Government in February 2004 ordered five provinces to include 10 percent ethanol-content in their gasoline. The five account for 16 percent of the nation's passenger vehicles. Government further told another four provinces to promote the use of ethanol-blended gasoline in trials.
New ethanol plants are under construction with a capacity of 1,2 Mt per year. However, demand growth might well outweigh growth in production. Projections show that 22,8 Mt of biofuels will be needed to blend 10% biofuels into all Chinese cars in 2020. Present targets only aim at 11 Mt capacity expansion for 2020 (RNS, 2005).
Almost half of China's ethanol production is presently derived from inland grains, with the rest from cassava and molasses.

South America
Biofuels development in South America so far takes place primarily in Brazil. This country is the main producer of bioethanol worldwide, with a development dating back to 1975. In that year, Brazilian Government started stimulating biofuels with as goals to promote oil- import independency, to stimulate inland sugar production and to create new jobs in the agricultural sector (Cavalho, 1997).
A primary application of bioethanol in Brazil is as a fuel for the inland transport sector. In 2004, 3,5 million cars in Brazil were running on pure ethanol and 1,35 million cars were

adapted as flex fuel vehicles (Coelho, 2005). 2,5 billion liters of ethanol (2 Mt) were exported in the same year. The state oil company Petrobras plans to boost Brazilian ethanol exports to 9.4 billion litres (7,5 Mt) in 2010 (PA, 2005).
Biodiesel development in Brazil started more recently. In 2004, according to Government plans Brazil started to blend 2% biodiesel from soybeans to diesel (Oliveira, 2004). The blend has to contain 5% biodiesel by 2013.

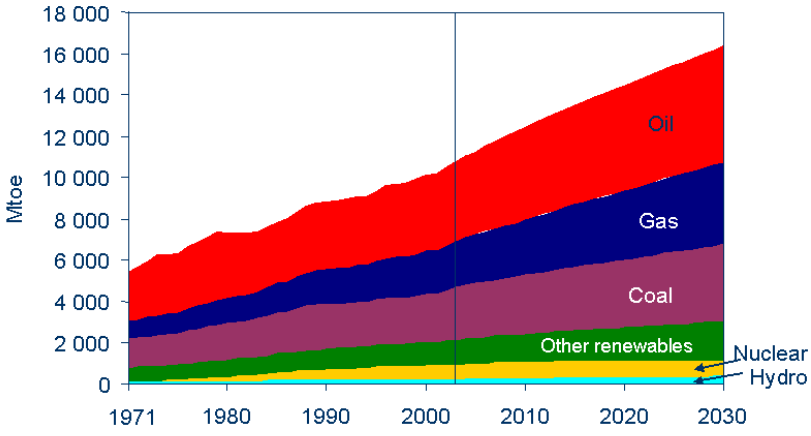
South-East Asia
Apart from China and Japan, there are various countries in Asia that play a role in biofuels development. Thailand is the world's second largest sugar exporter after Brazil. It plans to replace regular gasoline with a mix that includes 10% ethanol in 2007. Goals are a production of 1 to 1.5 billion litres (0,8 –1,2 Mt) a year. Presently a production capacity of 24 ethanol plants in under construction or in planning (PA, 2005).
Malaysia, the world's top producer and exporter of palm oil, is pushing to create a mandatory blending of a certain amount of the oil with retail diesel (PA, 2005). There are plans to build two plants in Rotterdam to convert palm oil into biodiesel (PIW, 2005).
Indonesia, the world's second biggest palm oil producer, plans to double the palm oil area to 10 million hectares over the next 30 years (PA, 2005). The Philippines decided in July 2004 to use a 1% blend of methyl ester made from coconuts in diesel for public transport. The country is exploring the possibilities of promoting bagasse (sugar cane pulp) for biofuel production. Pending legislation would require ethanol use from 2007 (PA, 2005).

Two other regions with high biomass production potentials are Russia and Sub-Sahara Africa (Hoogwijk, 2005). However, substantial biomass- and biofuels policies in these regions so far have not been developed.

3. Future Expectations for Biofuels Development

In most energy scenario's, a substantial growth of the biofuels market is expected in the years to come. According to the IEA (2004), fossil fuels in 2030 still will contribute by far the main part of world energy demand (Figure 4). Nevertheless, biomass is, together with hydro-energy, foreseen to be the largest renewable energy source in 2030. The IEA expects the contribution of sustainable biomass to world primary energy demand to grow from a share of 3,44% in 2002 to 4,15% in 2030. Recent analyses of the IEA even show that a replacement of petroleum fuels by biofuels of up to 6% in the near-term is feasible (IEA, 2005). On the longer term, potentials of up to 130 – 410 EJ/year in 2050, equivalent to 33 to 100% of present energy production, might even be available using only abandoned agricultural lands, low-productive lands and 'rest lands' (Hoogwijk et al., 2005).

Figure 2: World Primary Energy Demand 1971-2030 (Source: IEA, 2005)



The realisation of these technical biomass potentials, and thus the actual contribution of biomass to energy production in 2030 and further, will vary depending on a number of geopolitical and economic drivers. Geopolitical factors which are likely to be very important for biomass development are in particular supply security- and risk abatement considerations, the outcomes of post-Kyoto emission reduction negotiations, the interaction with new parties and policies, and the success of international multilateral certification attempts presently made. Economic factors that are likely to influence biomass development in particular are biomass- and petroleum prices and technological developments made in biomass conversion processes (Table 1). These factors will be discussed here.

Table 1: Geopolitical and Economic Drivers for Biofuels Development

Geopolitical Drivers	Economic Drivers
- Supply Security & Risk Abatement - Post Kyoto Emission Reduction Agreements - Interaction with New Parties and Policies - Multilateral International Certification	- Biomass Prices - Petroleum Prices - Technological Development

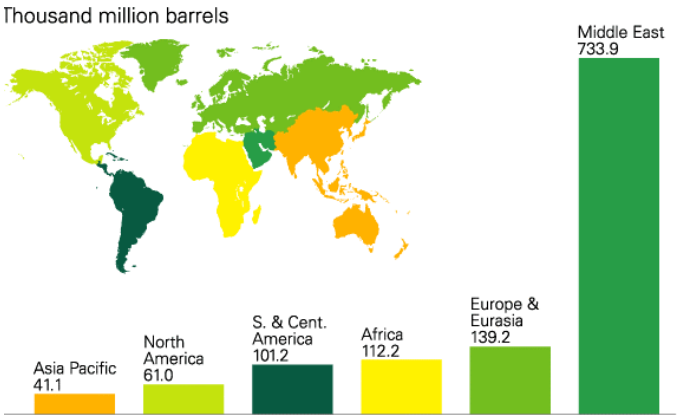
4. Geopolitical Drivers

4.1 Supply Security & Risk Abatement

World oil reserves are concentrated in just a few countries, in particular in the Middle East (Figure 5). With rising demand in industrialized nations and even faster increasing demands in developing countries like China and India, pressure on these reserves increases. This might well be a basis for future conflicts between nations aiming to secure the remaining reserves for themselves.

Diversification of energy sources is one option for risk abatement in this situation (Van der Linde, 2005). This holds in particular for the transportation sector, which is presently for 98% based on petroleum products.

Figure 5: Proved Oil Reserves at the End of 2004 (Source: BP Statistical Review, 2005)



Biofuels development can reduce the dependency of energy consuming countries on fossil fuels for two reasons. First, biofuels development can take place in the energy consuming countries and regions themselves. This is the predominant route in the biofuels market so far.

In this way a new internal market arises in these countries that can be a source of new employment possibilities. Second, because world's largest biomass producers are different countries than the large oil producers. South-America, Russia and the former USSR states, and Sub-Sahara Africa (West-, East- and South Africa) offer particularly large potentials (See Table 2). Of these regions only Russia is also a fossil fuel producer. Hence, new countries will enter the global energy market, which might reduce dependency from the few countries with oil reserves.

Based on existing policies, demand growth can be expected in particular in the European Union, the United States and China. Since these regions hardly coincide with potentially producing regions, with increasing demand also an international market with worldwide trade-flows can be expected to develop.

Table 2: Regional biomass potentials for 2050, based on four different IPCC scenarios (Source: Hoogwijk et al., 2005) *(Present world energy consumption ca. 400 EJ/year, largest potentials per category high-lighted)*

(EJ/year)	Potential at abandoned agricultural land	Potential at low-productive land	Potential at 'rest' land
Canada	9 – 14	2 - 3	2 - 4
USA	18 – 46	0 - 1	0 - 19
Central America	1 – 10	0	0 – 9
South America	1 – 56	1	1 – 32
North-Africa	1 – 2	0	0 – 3
West-Africa	2 – 22	0	0 – 29
East-Africa	1 – 17	0	0 – 24
South-Africa	1 - 26	0	0 – 17
Western Europe	9 - 15	0	0 – 4
Eastern Europe	8 - 9	0	0
Former USSR	47 - 97	1 – 3	2 – 27
Middle East	1 - 2	0	0 – 11
South Asia	3 - 12	0	0 – 13
East Asia	7 - 79	1	1 – 22
South-East Asia	1 - 2	0	0 – 8
Oceania	17 - 32	0	0 – 21
Japan	0	0	0
World	**129 - 409**	**5 – 9**	**6 - 243**

Question:
Will risk abatement strategies of energy consuming countries stimulate a shift to biofuels?

4.2 Post Kyoto Emission Reduction Agreements

International pressure on fossil fuel consumption is also increasing for environmental reasons. Fossil fuels emissions in the energy sector are the main source for global warming. Biofuels cause, dependent on source and circumstances, far lower greenhouse gas emissions. This also, and even more, holds for other routes of biomass application, like electricity or heat production from primary biomass. Technically it is presently analyzed what greenhouse gas reduction potentials various biomass routes - including conversion to biofuels – have, and what the costs are. Studies so far suggest that non-fuel applications of biomass are

ecologically and economically more efficient than use of biomass as fuel for transport (e.g. Kampman, 2005). Also, the greenhouse gas emission reduction from second-generation, woody biomass biofuels appears far higher than that from present generation oil crops. This raises questions as to what is the most efficient route from primary biomass to end-use application, and whether present-, or future biofuels technologies should be preferably stimulated.
Politically, the effects of greenhouse gas emission reduction as a driver for biofuels development are dependent on what greenhouse gas emission reduction agreements will be negotiated after Kyoto. Presently two routes are emerging (Perlot, 2005): one is the Asia-Pacific Partnership on Clean Development and Climate in which the US, China, India, Japan, South-Korea and Australia participate. This route concentrates on voluntary cooperation and technology exchange. No binding emission reduction targets are set. The other route is finding a successor to the present Kyoto protocol that sets binding targets and simultaneously tries to involve those parties presently not involved or without emission reduction obligations.

Questions:

1) Will future international emission reduction agreements include binding targets, and can biofuels contribute significantly to achievement of these targets?
2) Should policy incentives for biofuels concentrate on present or future generations of biofuels?
3) How can the most efficient route from primary biomass to end-use application be stimulated?

4.3 Interaction with New Parties and Policies
The use of biomass as an energy source give rise to new policy interactions in the energy field. In particular a competition between several possible uses of available lands (food crops, forestry or energy crops?) arises. This interaction is complex and can have positive or negative effects which also can be unevenly distributed over (e.g. OECD and non-OECD) countries. Positive can be the use of presently unused lands for bio-energy production and the introduction of new ways for profit in the agricultural and forestry sectors. Negative can for instance be the resulting higher prices for food crops, or economic pressure to turn valuable lands for food production and primary forests into energy-crop producing areas.
Biofuels also introduce a new group of potentially powerful actors to the energy sector: those parties that traditionally are active in the agricultural sector. Farmers organisations and new bio-energy producers can be new investors, and might well replace the existing oil companies as main drivers. However, it is not clear if agricultural interests will be also conducive to development of an international market. So far, biofuels developments have been driven particularly in relation to national agricultural or forestry interests and potentials. Examples are the development of sugar cane in Brazil, of wood residues in Sweden and of rapeseed in Germany and France.

Questions:
1) Will existing oil companies or new parties, in particular in the agricultural sector, be a main driver for biofuels investments?
2) Will agricultural interests drive in particular national developments, or also an international market?
3) How can negative effects on land-use as a result of biofuels production be prevented?

4.4 International Certification

Crucial for the development of the biofuels market is that the production of primary biomass has to be sustainable, and not to result into the degradation of fertile soils or deforestation in producing countries. International certification of biomass can be a solution to these problems. Presently, the IEA is investigating options for such a certification (IEA, 2005). First indicative results suggest that even applying strict sustainability criteria, an economically attractive exploration of significant biomass potentials is possible. Precondition for this would be the realisation of substantial efficiency improvements in existing agriculture (Smeets et al., 2005). Development of an international certification system is only in its beginnings. Certification can also contribute to a guaranteed quality of supply for end-users, as by its nature the specifications of shipments of primary biomass can vary substantially.

Question:
Can an international certification system be introduced and maintained that prevents unsustainable biofuels production?

5. Economic Drivers

Apart from geopolitical drivers, also global economy is a driver for the biofuels market. Some key economic factors influencing future development of the biomass market are biomass prices, oil prices and technological development.

5.1 Biofuels Prices

For biofuels development, the price of primary biomass, its conversion to biofuels and other end-use applications and transport prices to the end-user are important. Crucial for the price of biofuels at the moment are Governmental policies. Tax exemptions form a main driver to make biofuels competitive with fossil fuels. On the other hand, import taxes also presently form a barrier to the development of a more international trade.

Prices for biofuels are furthermore dependent on the type of primary biomass used. Present first generation biofuels are more expensive than their fossil fuel counterparts (Table 3). An exception are applications such as current sugar cane ethanol in Brazil, which is near to market competitiveness with oil (IEA, 2004). Second generation biofuels are foreseen to become substantially cheaper than the first generation, and possibly even cheaper than present fossil petrol and diesel. However, other applications of biomass, in particular co-firing biomass in electric power plants, might well remain cheaper than its conversion into biofuels (Kampman et al., 2003; 2005).

Apart from that, there is also a mismatch between countries where biofuels can be produced at lowest cost and countries where demand for biofuels is rising most rapidly. While production costs of biofuels are much lower in tropical or sub-tropical climates, in particular in developing countries with low land and low labour cost, demand is rising most rapidly in large energy consuming regions as the United States and the European Union (IEA, 2004). However, demand is also foreseen to increase substantially in many developing countries, including the fast developing economies China and India.

Table 3: Prices of 1st Generation Biofuels, Petrol and Diesel in the European Union (Sources: MWV, 2005; Eubia, 2005)

	€c/ l
"Normal" petrol [1])	47
Diesel [1])	52
Biodiesel from Rapeseed	74
Biodiesel from Sunflower	74
Wheatbased Bio-ethanol	59
Beetbased Bio-ethanol	60

[1]) as of 18 October 2005

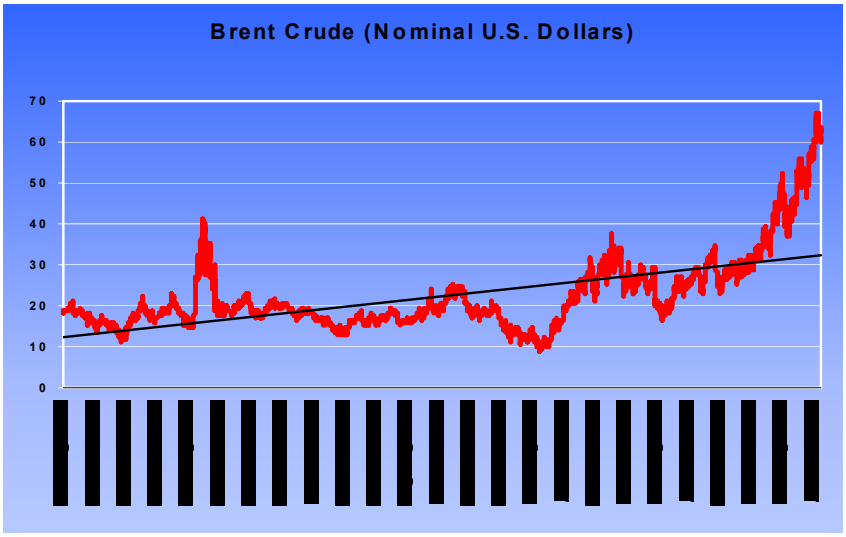
Question:
Will biofuels prices decrease substantially in the coming years?

5.2 Oil prices

Biofuels have to compete with fossil fuels. These are still dominant in world-wide energy demand today, and are likely to remain so in the coming decades. Whether or not biofuels can develop and in what pace depends largely on development of the oil market. Presently oil prices are very high (Figure 6), but if they will remain so depends on many factors. For example, the world oil reserves are concentrated in very few countries. The political stability of these countries to a large extent will determine the availability of future oil supply. Also, future investments in production capacity will influence oil prices as well as energy demand growth. In turn, the latter is influenced by worldwide population- and economic growth.

Question:
Will oil-price developments make biofuels a relatively cheaper energy alternative on the long run?

Figure 6: Oil Price Developments 1987-2005 (Sources: CIEP 2005, IEA 2004)



5.3 Technological Development

Development of second generation biofuels based on woody biomass, Fischer-Tropsch diesel or HTU diesel, might shift the economic balance towards economically competitive

application of biofuels. However, presently all these fuels are still in the research phase, with conversion processes not yet operational in large-scale production facilities (Kampman, 2005). Two basic research lines that are apparent in many countries concentrate on either improving technologies for conversion of cellulose to sugars or on conversion of biomass to transport fuels through gasification and thermochemical routes (IEA, 2004). Research that currently takes place investigates for instance more efficient crop conversion routes, biotechnological applications, agricultural methods, economics, markets, benefits and drawbacks from biofuels. All research developments together might result in substantial cost reductions of biofuels, but the timeframe in which these cost reductions can take place is far from clear.

Question:
How can technological development in biofuels be stimulated most effectively?

6. Conclusions

Based on the analysis in this article, some key characteristics of the biofuels market can be given.

A first key characteristic is that it is in an early stage. Almost all producers, with the exception of Brazil, have only started in recent years with a significant production. Driver for this market until now are mainly Governmental policies. These in turn are motivated by supply security and risk abatement motives, the potential contribution to greenhouse gas emission reduction targets and other potential benefits of biofuels.

Secondly, the present biofuels market is predominantly nationally and regionally oriented. Global trade is developing, but so far relatively limited. This might be explained due to the presently (national) policy driven development of the biofuels market, with tax exemptions varying per country and taxation forming a potential hurdle to imports. National agricultural interests as a driver are another possible explanation. Interaction of energy- and agricultural interests leads to new parties acting as a driver for investments, stimulating in particular the use of domestic agricultural resources.

Thirdly, despite the present regional orientation of the biomass and biofuels market, it shows that main demand and the largest production potentials do not geographically coincide. Whereas the largest demand for biofuels is now concentrated in the industrialized, large energy consuming countries, the largest production potentials can be found in tropical countries in South-America, Sub-Sahara Africa and East-Asia, as well as in countries with a relatively low population density such as Canada and Russia. As demand and supply of biofuels are expected to increase substantially in the years to come, this will be a driving factor for development of an international market, with trade flows between large producers and end-users of biofuels. The share of biofuels in the global energy market, however, in the next decades is likely to remain subordinate to that of fossil fuels.

In addition to market growth, also a technological transition is likely to take place. In this transition, first generation biofuels with relatively low emission reduction potentials and high costs will be replaced by a second generation of biofuels with substantially better performance.

Many uncertainties, however, remain. Some of these have been outlined as questions in this paper. Of the various drivers for the biofuels market identified, in particular the price levels of primary biomass and its end-use applications relative to oil prices might play a crucial role in determining the rate of further biofuels development. How these will develop is very hard to predict. Very important in this respect is also that, depending on geopolitical developments, either a healthy, “sustainable” competition for biomass might arise, or an unsustainable,

degrading competition. What can make the difference here is whether or not it will be possible to agree on, and implement an international certification system for biomass and biofuels.

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