LMC INTERNATIONAL

A Primer on

Global and UK Biofuels

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A Primer on Global and UK Biofuels

This document was prepared for Future Capital Partners in the context of Vireol's proposed investments in two bio-ethanol plants in the UK. It is intended to provide a basic introduction to biofuel processing, production, and policy. It also aims to deal with some of the misconceptions in the media about biofuels. In addition, the status of the UK bioethanol market is appraised and some key risks for the Vireol project identified. Biofuels are renewable transport fuels produced from agricultural crops. Bioethanol is produced from sugar/starch while biodiesel is produced from vegetable oils.

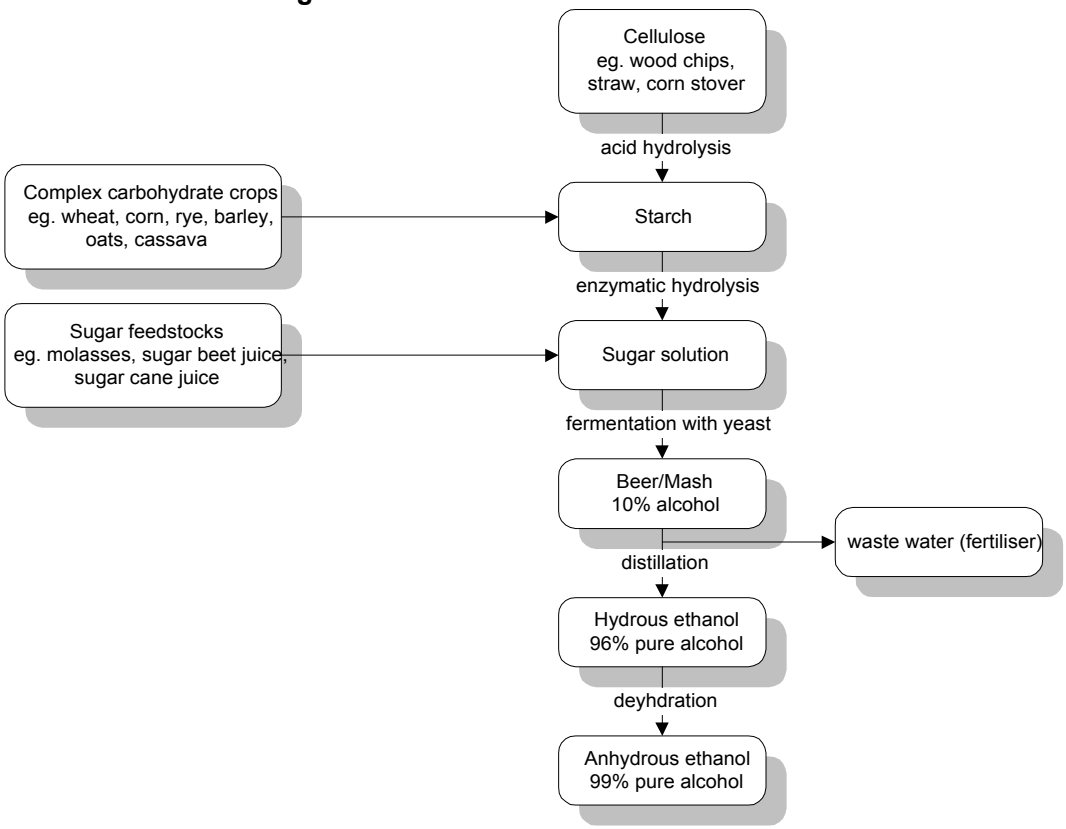
BIOFUEL PROCESSING

Bioethanol

Diagram 1 provides an overview of the production process for bioethanol. Most commercial plants use either grains (wheat or maize), or sugar based raw materials (sugarbeet, sugarcane or molasses). The commercial production of cellulose-based ethanol has so far been hampered by the prohibitively high cost of converting cellulose into starch. When grains are used, a high protein animal feed called distillers dried grains (DDG), is usually produced as a by-product.

Fermentation of the sugar solution with yeast, results in a beer/mash containing 10% ethyl alcohol (C_2H_5OH). This is then distilled to produce a 96% pure solution of hydrous ethanol. Finally molecular sieves are used to remove most of the remaining water resulting in a 99% pure solution of anhydrous ethanol.

Diagram 1: Bioethanol Production Process



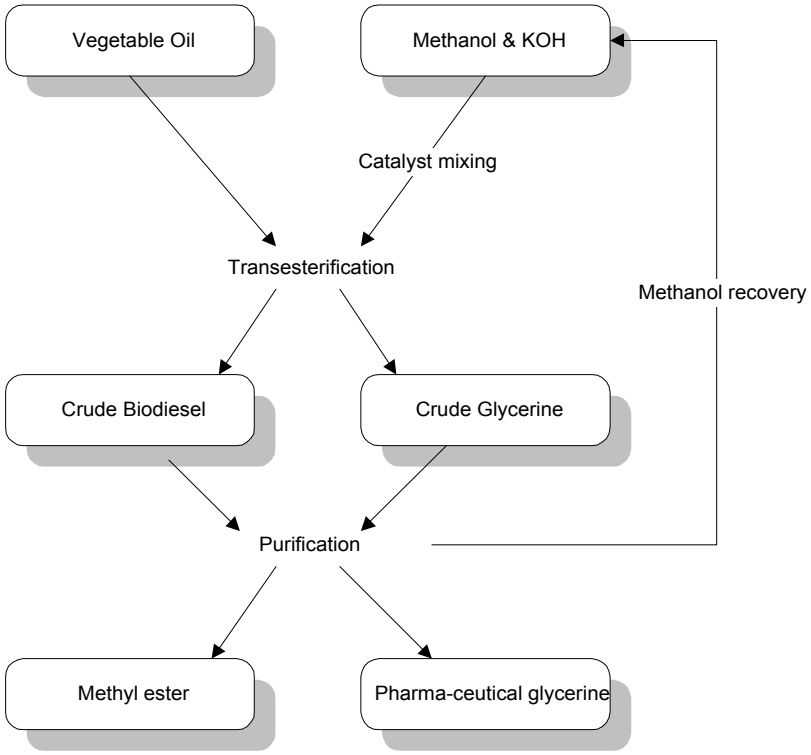
Anhydrous ethanol is used in low levels blends with petrol such as E-5 (an ethanol petrol blend containing 5% ethanol). It is also used to produce Ethyl Tertiary Butyl Ether (ETBE), a petrol additive. Hydrous alcohol is used to produce E-85, which is used to power flex-fuel cars. Anhydrous ethanol contains around 66% of the energy content of petrol and has a correspondingly negative impact on fuel economy. However, the higher octane rating of ethanol means that it offers superior engine performance.

Biodiesel

Diagram 2 presents an overview of the production process for biodiesel. Raw materials that can be used for biodiesel production include: rapeseed, soybean, sunflower, palm oil and jatropha. Waste cooking oils and animal fats can also be used. The production process has three main stages: oil extraction, refining and trans-esterification. The oil extraction phase yields a cake or meal by-product, which can be used as animal feed. Many biodiesel plants do not have their own oil crushing facilities and purchase their oil from either local producers or from abroad. During refining, the oil is treated to reduce the free fatty acid and water content of the crude oil, obtaining a low-grade fatty acid distillate and soapstock as by-products.

Trans-esterfication is an acid catalysed reaction of the oil with methanol whereby the glycerine is separated from the plant oil. The process produces methyl, or alkyl-esters, the chemical name for biodiesel; and glycerine, a valuable by-product that is usually processed further to make soaps and other products.

Diagram 2: Biodiesel Production Process



Biodiesel can be substituted for diesel in both low and high level blends. One advantage of biodiesel over ethanol is that high-level blends such as B-100 (100%

biodiesel) require only a small degree of engine modification. In addition, biodiesel contains around 90% of the energy content of diesel, thus offering greater fuel economy than ethanol based blends.

BIOFUEL PRODUCTION

Biofuel policy is stimulating rapid growth in biofuel production. In 2007, we estimate that global fuel ethanol production reached 49 billion litres, up by almost a quarter on the previous year. The equivalent figure for biodiesel was almost 13 million tonnes (Table 1). Growth in the biodiesel sector was more modest in 2007, owing to the rise in vegetable oil prices and the continuation of cheap biodiesel imports into Europe. The fuel ethanol sector is dominated by the US and Brazil with these two countries alone accounting for almost 90% of global production. In comparison, the biodiesel sector is less concentrated with the two largest players (EU and US) accounting for just over 70% of global output.

Table 1: World Fuel Ethanol and Biodiesel Production, 2007

	Fuel Ethanol Raw Material	Fuel Ethanol (million litres)	Biodiesel Raw Material	Biodiesel (thousand tonnes)
US	Maize	23,856	Soy	3,626
Brazil	Sugarcane/Molasses	19,481	Soy	1,039
EU	Wheat/Sugarbeet/Molasses	2,279	Rape/Imported Oils	5,623
China	Maize	1,790	Soy	350
Canada	Maize/Wheat	818	Canola	550
Others		1,152		1,748
World Total		**49,377**		**12,937**

BIOFUEL POLICIES

Many countries around the world have adopted policies to stimulate demand and supply of biofuels. The most successful policies mandate the use of biofuels in specific blends or quantities and provide tax concessions for refiners to cover the additional cost of producing biofuels relative to fossil fuels. This section outlines the biofuel policies in the major producing countries.

USA

The major driver of policy is to increase energy independence. However, fuel ethanol demand is also underpinned by the Clean Air Act, which mandates the use of reformulated gasoline in certain states. In 2006, the US replaced MTBE with ethanol in reformulated gasoline, boosting demand for ethanol significantly.

At the end of December 2007, the US adopted a new Renewable Fuels Standard (RFS), which mandates the use of biofuels at 36 billion gallons (136 billion litres) by 2022. In addition, the RFS contains a mandate to boost the use of “advanced biofuels” to 21 billion gallons (79 billion litres) in 2022. Advanced biofuels are defined as renewable fuels other than those obtained from corn starch and which offer green house gas savings of at least 50%. This limits production of corn-based ethanol to 15 billion gallons (56 billion litres). The remaining 21 billion gallons is expected to be

produced mainly from cellulose feedstocks such as corn stover, switchgrass, wood chips and other agricultural waste materials. Biodiesel is expected to make only a limited contribution to the fulfilment of the RFS.

Ethanol attracts a lower rate of mineral oil tax with refiners paying 54 cents per gallon (27p per litre) less tax on ethanol than petrol. This allows the refiner to pay up to 54 cents per gallon more than the price of petrol for fuel ethanol. In 2007, high oil prices and an oversupply of ethanol resulted in ethanol trading at large discounts to petrol. This has stimulated the use of ethanol on a discretionary basis and demand is currently running well ahead of volumes mandated under the RFS.

Brazil

Brazil was the first country to promote the large-scale production of fuel ethanol. It has a large established market for the direct blending of ethanol in petrol as well as for high-level blends in flex-fuel cars.

All petrol sold in Brazil must contain a minimum proportion of anhydrous ethanol. The government varies the blend between 20% and 25% depending on market conditions. This creates a guaranteed market for fuel ethanol of around 5.5 billion litres per year. However, with demand for ethanol-blended petrol stagnating, this market is in decline.

By contrast, the market for hydrous fuel ethanol is growing rapidly. Hydrous ethanol is used in alcohol only cars and flex-fuel cars. Flex-fuel cars were introduced in 2003 and today account for 90% of all new cars sold. Consumers use hydrous ethanol in their flex-fuel cars when it is priced at 65% or less of the price of gasoline. The price competitiveness of hydrous ethanol is helped by the fact that a number of the major sugar producing states including Paraná and São Paulo, have lower rates of taxation on ethanol compared to petrol. With the flex-fuel car fleet continuing to grow rapidly, potential ethanol demand is rising quickly. In 2007, sales of hydrous ethanol amounted to around 12 billion litres.

The market for biodiesel is currently very small. From January 2008, Brazil mandated the use of biodiesel in diesel at a 2% blend, boosting demand to 800 million litres.

Europe

Bio-fuels policy in the EU is driven by the desire to reduce greenhouse gas emissions and to increase energy security. In 2007, the European Commission adopted a binding target to replace 10% (by energy) of transport fuels with fossil fuels by 2020. In January 2008, a new directive proposed that all member states adopt the 10% target. The directive on the promotion of the use of energy from renewable sources is expected to enter into law later this year.

Another key part of the directive is that it sets up a system for ensuring that biofuels achieve minimum environmental and sustainability standards. This means that biofuels cannot be grown on land designated as wet land, forest, permanent grassland or any other area with conservation status. In addition, biofuels should reduce greenhouse gas emissions by a minimum of 35%. This requirement is expected to become law as part of the renewable fuels directive later this year.

In earlier legislation, the Commission allowed biofuels to be taxed at a lower level than fossil fuels and a number of states have exempted biofuels entirely from the tax on fossil fuels. However, the trend in policy is to ditch tax incentives (which are costly in terms of foregone tax revenue) in favour of mandatory use. European member states

that are planning or already have put mandates in place include: Austria, the Czech Republic, Finland, Germany, France, UK, Italy, Netherlands and Sweden.

Prior legislation sets an interim target for biofuel use in the EU at 5.75% by 2010. A target of 2% was set for 2005. Thus far, progress at meeting these targets has been slow with biofuels accounting for just 1% of transport fuels in 2005. The Commission expects that biofuel use will also fall short of the 5.75% target reaching 4.2% by 2010.

UK

From April 2008, the UK will implement its Renewable Fuels Transport Obligation (RTFO). The key features of this policy are:

- An obligation to replace 5% of transport fuels (by volume) with biofuels in 2010/11 (April/March). The corresponding values for 2008/09 and 2009/10 are 2.5% and 3.75%. The government intends to raise the obligation to 10% after 2010/11, assuming that the EU fuel quality standard is amended to allow higher blends.

- Refiners who blend biofuels will receive RTF certificates. At the end of the obligation period, companies must show they have acquired an appropriate number of certificates or pay a penalty (buy out) equal to 15p per litre. RTF certificates can be traded.

- Biodiesel and bioethanol are taxed at 20p per litre less than fossil petrol and diesel. The tax concession is likely to be phased out in favour of the buy-out. However, the combination of penalty and buy out is guaranteed to be at least 35p per litre until March 2010, declining to 30p per litre in April 2010.

- From April 2008, refiners will be required to submit reports on both the net greenhouse gas savings and the sustainability of the biofuels that they supply. This will be a prerequisite for obtaining RTF certificates.

- From April 2010, the government intends to reward biofuels under the RTFO according to the amount of carbon that they save. The aim is to make the reward proportional to the quantity of greenhouse gas saved.

- From April 2011, biofuels will only be eligible for RTF certificates if they meet appropriate sustainability standards.

The key to success of the RTFO is the level of the buyout and tax concession, which sets the maximum price that refiners would be willing to pay for ethanol. We estimate that at an oil price of US$100 per barrel, the maximum UK fuel ethanol price would be 149 cents per litre (75p per litre). However, if the world oil price were to fall to US$50 per barrel, the maximum price would be 112 cents per litre (57p per litre). These figures are based on the total level of support being set at 35p per litre.

It is worth noting that the UK obligation is less stringent than the European Commission's target of replacing 5.75% of transport fuels (by energy) in 2010. Given the lower energy content of ethanol, this would imply replacing 8.7% of petrol with ethanol.

MEDIA MISCONCEPTIONS

Recent media reports have raised concerns over the rush to implement biofuel programmes around the world. These fears have centred on deforestation in Indonesia and Brazil, rising oil and grains prices and poor working conditions on some plantations.

The issue of deforestation relates principally to biodiesel. In Indonesia, deforestation has occurred in order to produce palm oil, the main raw material for biodiesel in Asia. In Brazil, the link between deforestation and biofuel production is more tenuous. Growth in soybean and sugarcane production may have displaced other agricultural activities into deforested land. However, a failure to implement land use laws have undoubtedly played a factor and neither soybeans nor sugarcane are grown in areas that were previously rainforest.

Another recently raised objection to biofuels is that they increase food prices. It is certainly true that oil and grains prices are currently trading at record levels. Our view is that the high level of grains prices is due to two successive years of poor crops rather than demand for ethanol. Similarly, vegetable oil prices have increased on the back of soaring food demand from India and China rather than demand for oils for biodiesel.

Recent media reports have also criticised biofuels for their failure to deliver green house gas savings. The European Commission intends to ensure that biofuels make a positive contribution to the reduction of green house gases. In the UK, the RTFO already contains provisions to ensure that only biofuels with proven greenhouse gas savings will be eligible for RTF certificates.

THE FUEL ETHANOL MARKET IN THE UK

In 2007, demand for transport fuels reached 24.0 million litres of petrol and 25.5 million litres of diesel. While demand for diesel is growing by around 5% each year, demand for petrol is declining by around 3%. Taking this into account, replacing 5% of petrol with ethanol will create demand for ethanol equal to 1.1 billion litres in 2010. Further growth in the market will depend on the UK adopting higher blending targets.

At present, there is very little fuel ethanol production in the UK. In 2007, British sugar opened a small 70 million litre plant producing fuel ethanol from sugarbeets. Ensus are currently building a new plant on Teeside, which should be operational by early 2009. The plant will have a capacity of 400 million litres per annum. BP intends to build a 420 million litre plant at Saltend which should be operational in 2010.

The Economics of Production

The profitability of production is driven by the margin between the ethanol price and the wheat price. High wheat prices have resulted in the cancellation of at least one ethanol project and delays to others. By 2010, total fuel ethanol capacity is still likely to be below demand. This suggests that for the foreseeable future, the UK will remain a net importer of ethanol and the price will be driven largely by the cost of importing Brazilian ethanol.

There is a limit however, to the quantity of ethanol that Brazil can export onto the world market. Rapid growth in its own domestic market means that export volumes will not grow substantially in the future. Moreover, as other countries around the world such as Japan move ahead with their fuel ethanol programmes, the world market for ethanol

will grow. This is likely to restrict growth in exports to Europe and its ability to supply the UK market.

While the outlook for ethanol prices is bright, assuming that oil prices remain at high levels, the outlook for wheat prices is less certain. Wheat prices are currently trading at levels where ethanol producers are failing to cover even their cash operating costs. In January, the price of feed wheat in East Anglia stood at £178 per tonne, up by 250% on levels seen at the beginning of 2006. Producers are typically able to offset part of the cost of wheat by selling distillers dried grains (which tends to rise in line with the price of wheat). However, if Vireol choose to burn the DDG instead, these plants would be more exposed than other plants to the price of wheat.

Two successive years of poor harvests have resulted in global wheat stocks being drawn down to very low levels and are responsible for the current high level of wheat prices. High prices are expected to stimulate a supply response from farmers and therefore barring any weather related problems, wheat prices are likely to fall over the next couple of years. However, they may not return to levels prevailing prior to 2006.

The International Grains Council recently forecast that global production of wheat would rise by 6.5% in the 2008/09 season to a record 642 million tonnes. In the EU, production is expected to rise by 5% to 26.3 million tonnes. Even allowing for rising consumption, global supplies are expected to be more than sufficient to meet demand. Nonetheless, global stocks will remain at low levels, with the result that prices will remain relatively high.

The countries of the former Soviet Union such as Russia, Ukraine and Kazahkstan have tremendous potential to boost their future output of wheat. In the region around the Black Sea, the soils are among the world's best and a growing proportion of the region's farms are coming under the control of well-financed groups with access to modern technology. Wheat yields are currently less than one third of those achieved in the highest yielding countries in Western Europe. Over the next five years, we estimate that production in Russia, Ukraine and Kazahkstan could rise by over 13 million tonnes as result of yield increases alone, from its current level of 81 million tonnes.

TECHNOLOGY AND CONSTRUCTION RISKS

Vireol has chosen Vogelbusch as the main engineering provider for its plants. Vogelbusch is an internationally recognised company and has extensive experience of building ethanol plants. While its experience of building wheat-based plants is somewhat limited, it is one of the few companies with expertise in this area. The company's only other wheat based project was the Zeitz distillery in Germany, which suffered start-up delays. However, the problems at Zeitz are unlikely to have been the result of using Vogelbusch technology. Moreover, the Vireol projects have made generous allowance for the start-up of its plants in their financial models.

While burning of the waste by-products will undoubtedly improve the energy efficiency of the plant and the calculated green house gas savings, the economic value of this is likely to be lower than that which could be obtained by drying the stillage to produce distillers dried grains for sale as animal feed. Vireol intend to install drying equipment for the DDG so they have the option of either selling the DDG as animal feed or for burning at a local power station.

Overall, while there is clear demand for fuel ethanol in the UK, the key to the future success of the Vireol projects will be the contractual arrangements with the wheat supplier and the management of the technology risks.

CONCLUSIONS

Demand for ethanol in the EU will grow strongly over the next few years. While some of this demand is likely to be met by ethanol from sugarbeets, the bulk of this demand will be met by ethanol produced from grains and particularly wheat. The growing trend for states to adopt mandates will create guaranteed markets for ethanol.

In the UK, demand for fuel ethanol is likely to outstrip domestic supply over the next few years, with the result that the country will remain a net importer of ethanol. With Brazil's export volumes limited by a need to supply its own domestic market, imports are unlikely to account for more than a small proportion of total demand. The outlook for the ethanol price is constructive so long as oil prices remain at a high level.

It is not clear what will happen to the overall level of support (duty incentive plus penalty) after April 2011. Given the possibility that support could be gradually removed, Vireol needs to do everything it can to get its plants built quickly, in order to benefit from the relatively high level of support that is guaranteed in the early stages of the project.

The biggest uncertainty for the project is the future price of wheat. If expansion plans proceed as expected, prices will decline during the course of the next two seasons. However, it will take at least two years for global stocks to return to normal and any weather related problems during this period will have a disproportionate impact on the wheat price.

The option to be able to sell DDG for animal feed or burn the DDG is very beneficial to the project. However, Vireol needs to ensure that its plant still generates greenhouse gas savings of at least 35%, in line with the Commissions proposals under this option.