F.O. LICHTS
World Ethanol and Biofuels Report
Vol. 1 No. 11 February 11, 2003

HIGHLIGHTS

www.agra-net.com

FUEL ETHANOL PRODUCTION IN THE USA AND GERMANY - A COST COMPARISON

By Oliver Henniges and Prof. Dr. Jürgen Zeddies *

Looking back over the past 10 years, the use of bioethanol as an additive to conventional petrol has increased in popularity around the world, not just in Brazil but also in France and in the US. The advantages of bioethanol derived from sugar or starch are well-known among scientists. This is of particular interest to industrialised countries needing to meet the conditions of the Kyoto Protocol which obliges all of them to reduce their greenhouse gas emissions. Furthermore, the industrialised world is expected to spare no efforts to reduce its dependency on oil supplies from states whose political regimes are often unstable. From the agricultural point of view, there are two main factors that make the ethanol production attractive to farmers. On the one hand, industrial scale production of bioethanol creates jobs in rural areas and on the other hand, it provides the potential for alternative land use for energy crop production. In the case of the EU, it might also help to reduce overproduction of agricultural commodities.

From the technological perspective, many scientific studies have been carried out but literature on the economic aspects of bioethanol production such as cost analyses and the potential for further cost benefits are very rare. This article, therefore, aims to compare the costs of ethanol production from different feedstocks in Germany and the US.

Ethanol production in the USA

The US ethanol facility being reviewed is located in South Dakota and has a yearly capacity of 14 mln gallons (0.53 mln hl). For this quantity of alcohol, 5.3 mln bushels (170,000 tonnes) of corn are needed as feedstock. The ethanol plant is situated next to an elevator which stores supplies of corn during the year. The grain is bought at $2.10/bushel, which equates to EUR67 per tonne. Inside the plant, the process starts with the dry-milling of the corn and ends up with the dehydration and subsequent denaturing of the fuel alcohol. The following cost analysis is based on an exchange rate of $1 to the Euro. It is quite important to remember this since the rate has changed significantly in recent months. As far as fixed costs are concerned, the figures in this analysis have been based on financial accounting methodology. The costings pre-

* Oliver Henniges, Institute of Farm Management, University of Hohenheim, Stuttgart/Germany. Contact: henniges@uni-hohenheim.de

Prof. Dr. Drs. h.c. Jürgen Zeddies, Institute of Farm Management, University of Hohenheim, Stuttgart/Germany. Contact: i410b@uni-hohenheim.de

sented all relate to 1 hl of anhydrous ethanol. The anticipated asset depreciation rates are 20 years for buildings and 10 years for plant using an interest rate of 5%.

Table 1: Absolute and relative composition of production costs in the USA

Expenses for	EUR/hl	%
Buildings	0.39	1.0
Machinery/inventory	3.40	8.6
Total investment	**3.79**	**9.6**
Labour	2.83	7.2
Insurance, fees, repairs	0.61	1.6
Raw material	20.93	53.0
Other operating costs	11.31	28.6
Gross production costs = 100 %	39.48	100.0
Sale of by-products	-6.71	-17.0
State and federal subsidies	-7.93	-20.1
Net production costs	24.84	62.9

Table 1 shows that the outlay relating to buildings and construction amounted to 1% of production costs per hl. Adding this to expenditure on machinery and inventory, the total investment outlay represents almost 10% of the overall cost of one hl of ethanol. In absolute terms, total investment amounts to EUR16.5 mln with labour contributing 7.2% to total costs. In addition, the combined charges for insurance, fees and repairs account for 1.6% of gross production costs. However, the greatest percentage is undoubtedly the feedstock corn which at 53% represents more than half of total production costs.

Adding all these cost centres together, gross production costs amount to EUR39.5 per hl (100%). In addition, the value of the resulting co-product from corn ethanol production, Distiller's Dried Grain Solubles (DDGS) needs to be taken into account. The DDGS can be sold to nearby livestock farmers in the undried form as a protein concentrate. Including storage charges for a maximum of three days, such sales reduce gross costs of production by 17%. As the governments in Washington and in each of the states are encouraging ethanol production through subsidies, net production costs of EUR24.84/hl are only about 63% of gross production costs. In the case of the state of South Dakota, each gallon is subsidised to the tune of $0.20. The support system in the US is very well thought out as it indirectly subsidises each gallon blended with 10% ethanol by 5.2 US cents via an excise tax exemption. Thus, the net value of each gallon of pure ethanol is 52 US cents, since only the 10% mixture is subsidised. This is an intelligent incentive programme for encouraging potential blenders to use ethanol.

In 2002, the selling price of ethanol was about $1.20 per gallon (EUR31.5 per hl). Thus, as far as production costs are concerned, it is evident that only state subsidies allow this selling price which in turn permits profits to be made. Without this support, gross production costs would be well in excess of EUR35/hl.

Taking the life of the investment as 10 years and assuming a selling price of EUR31.5/hl, the capitalised value of the investment is EUR27 mln. Comparing this figure with the amount to be invested of EUR16.5 mln, it can be seen that the investment is highly profitable. According to these figures, the Internal Rate of Return (IRR) is about 32%. This figure has to be compared with an assumed discount rate of about 5% on a term deposit or bank account. It is, therefore, not surprising that the pay back period is only 4 years. That means that worthwhile profits are already being made in the fifth year after the initial investment.

Ethanol production in Germany

Bioethanol production in Germany is a newly established industry. Hence, the following calculations for a 0.5 mln and a 2 mln hl plant have to be hypothetical. In the following it should be assumed that for 214 days each year, the feedstock for such facilities is wheat with sugar beet being used for 90 days of the annual production cycle. On this basis, 64% of the ethanol output is made from wheat and 36% from beet. To understand the basic calculations, it is important to remember that 0.264 tonne of wheat or exactly 1 tonne of beets is required to produce 1 hl of ethanol.

As far as the basic materials are concerned, a realistic price has to be assumed, since there is no practical production experience. Furthermore, a great deal of consideration must obviously be given to the price of the beets. After all, the difference is very wide between A Quota beets (EUR58/tonne) with their full sales and price guarantee and the remaining so-called C beets (EUR13/tonne), whose sugar is sold on the world market. Taking into account the gross margins (including labour costs based on standardised rates) for competing crops in the sugar beet growing areas of Northern Germany, a beet price of EUR32.7/t (including 9% VAT) and a wheat price of EUR109/tonne seem to be appropriate for the calculations which follow. The gross margin including 10% set aside per hectare of wheat destined for ethanol production would be around EUR435/ha. This has to be compared with the gross margin for milling wheat of EUR477/ha. Obviously, the gross margin on ethanol beets at EUR605/ha is not as high as A Quota beet production at EUR1155/ha, but quite close to B Quota beets at EUR645/ha. As long as the beets and wheat are grown as non-food crops on set aside land, the gross margin is comparable to that which would be realised if it were fallowed. This would be represented by the area payment of EUR348 per ha less labour and direct costs.

In Table 2, the figures used for production costs are listed in accordance with plant capacity and the feedstock used. As the prototype plant in question has been constructed so as to be able to use both beet and wheat, the averaged investment costs per hl are equal for both production processes. According to one German construction company, there is a golden rule that says: doubling the capacity raises the investment costs by 60%. As a result, the tremendous economies of scale shown in Table 2 can be readily appreciated. A quadrupling of the capac-

Table 2: Absolute and relative composition of production costs in Germany

Capacity	500,000 hl		500,000 hl		2,000,000 hl		2,000,000 hl	
Raw material	wheat fraction		beet fraction		wheat fraction		beet fraction	
	EUR/hl	%	EUR/hl	%	EUR/hl	%	EUR/hl	%
Buildings	1.28	2.1	1.28	1.8	0.82	1.5	0.82	1.4
Machinery/inventory	8.28	13.4	8.28	12.5	5.30	9.6	5.30	8.9
Total Investment	**9.56**	15.5	**9.56**	14.4	**6.12**	11.1	**6.12**	10.3
Labour	4.26	6.9	4.26	6.4	1.40	2.5	1.40	2.3
Insurance, fees, repairs	1.60	2.6	1.60	2.4	1.02	1.9	1.02	1.7
Raw material (incl.transp)	27.75	44.9	35.10	52.8	27.75	50.5	35.10	58.9
Other operating costs	18.68	30.2	15.93	24.9	18.68	34.0	15.93	26.7
Gross prod. costs = 100%	**61.85**	100.0	**66.45**	100.0	**54.96**	100.0	**59.57**	100.0
Sale of by-products (wheat, DDGS, beet pulp)	-6.80	-11.0	-7.20	-10.8	-6.80	-12.4	-7.20	-12.1
Net production costs	**55.05**	89.0	**59.25**	89.2	**48.16**	87.6	**52.37**	87.9
Average costs (64% wheat, 36% beet (EUR per hl)	56.56				49.68			

ity lowers the share of the investment costs by one third. Nevertheless, in absolute terms, these costs are twice those in the US, based on the same production capacity. This might be due to the fact that the German plant needs equipment for both wheat and beet processing. What is clear is that the procedures for granting construction licences in populous areas in Germany are slightly more complicated than in the US Midwest. In turn, this might lead to higher development costs.

In terms of labour costs, the economies of scale are even more impressive. The manpower requirements only rise from 37 to 50 workers (+35%), while the capacity is four times higher and the percentage represented by labour costs decreases from almost 7 to 2.5%.

Since the price of the feedstock is assumed to be constant and independent of capacity, its relative share rises by 6% from the small to the large plant. The big price difference between the specific crops is the result of the enormous transport costs for beets. Since it is estimated that the average distance from the field to the plant is 50 km, the transport costs are about EUR5.1/tonne for both beets and wheat. Given that less wheat is required for each hl of ethanol, the amount attributable to its transport is lower than that for sugar beet.

A look at gross production costs reveals impressive economies of scale. However, apart from capacity, it is obvious that the gross production costs for ethanol derived from beets are about EUR5 higher per hl than wheat-based output.

Using either substrate, 0.08 tonnes of co-products result from each hl of ethanol produced. The market price for DDGS from wheat ethanol is about EUR85 per tonne while the remaining sugar beet pulp is sold as a pelletted feed at a value of EUR90 a tonne. Subtracting the revenues derived from the sale of co-products, net production costs are about EUR7/hl lower than the gross costs and amount to around EUR50/hl in the case of the 2 mln hl plant processing both wheat and beet.

Nevertheless, the net production costs of ethanol from wheat are about EUR4 lower per hl. This means that, to put raw materials on an equal footing, the price for sugar beets has to fall by EUR4 per hl. Hence, the maximum price payable for beets is EUR26 per tonne. If it is higher, wheat would be the sole substrate processed.

Research into French ethanol production showed the same production costs. As the detailed figures have to be kept confidential, it can only be said that, according to a French ethanol expert, a cost reduction of EUR7 per hl should be achievable. These reductions would come from greater economies of scale, higher energy recoveries and technical progress in plant breeding, all of which would result in improved yields.

Since there are no actual production costs available, the ethanol sales price has had to be assumed. Thus, in the following tables, the capital value, IRR and pay back period are shown for various selling prices and capacities.

Table 3 shows that the enterprise is not profitable at an ethanol selling price of EUR55 per hl and at a plant production capacity of 500,000 hl. The negative capital value shows that it would have been better to have put the money invested in the project into a bank account instead. By contrast, the larger facility is more cost-efficient, assuming a selling price of EUR55 /hl.

According to the calculations shown in the above table, the IRR for the smallest plant and the lowest price scenario is less than the 5% which the funds would have earned on deposit in a bank. All the other price/capacity combinations result in returns much higher than 5%. Consequently, the only pay back period for the small plant coupled with the lowest assumed

Table 3: Capital value of the investment in relation to the sales price of ethanol and capacity

Ethanol price (EUR/hl)	Capital value (EUR)	
	500,000 hl	2 mln hl
55	-6,037,098	82,148,893
60	13,267,227	159,366,193
65	32,571,552	236,583,493
70	51,875,877	313,800,793

Table 4: Internal rate of return and pay-back period in relation to the sales price of ethanol and the capacity

Ethanol price (EUR/hl)	Internal rate of return (%)		Pay-back period (years)	
	500,000 hl	2 mln hl	500,000 hl	2 mln hl
55	2	27	15	4
60	11	37	8	3
65	19	48	6	2
70	26	58	4	2

price is longer than the period specified. At an ethanol price of EUR65/hl, the 2 mln hl plant is already amortised within the first 2 years. This sales price might appear a little unrealistic but it should be noted that in Germany the average price for petrol is more than EUR100 per hl given the current tax on mineral oils kicking in two thirds of the cost to the motorist. The success of bioethanol as a fuel substitute, therefore, depends on fiscal policy, in particular the mineral oil tax. However, if the tax on ethanol were very low, there would be a risk of cheap ethanol imports. Consequently, an adequate import duty on ethanol is of equal importance.

Ethanol in Germany - what does that mean?

As already mentioned, the price for the raw material has to be part of the study. By making a detailed analysis of margins, one reaches a maximum economic price of EUR58.5/tonne for the raw material sugar beet. Therefore the costs of processing, transport and blending have already been taken into account. In addition, a total petroleum tax exemption, which would be EUR65.45/hl in 2003, has been assumed. Equally, a realistic 16% VAT rate has also been assumed. Yet, this is a loss-making situation for all processors, so consequently this high price can only be paid for the last tonne of feedstock processed and has to be considered as the marginal cost of the raw material.

Starting from the average production costs of EUR49.68/hl of ethanol (see table 2) and, taking into account VAT, costs for processing, transport and blending, the minimum necessary petroleum tax exemption would be 52% or EUR33.61/hl in 2003. Once again, this produces a loss-making situation for the plant operator. This means, therefore, that there are no circumstances under which a tax exemption of less than EUR34/hl would be sufficient. The German tax exemption would have to be at least 65% in order to provide an incentive for potential investors (given an average petrol price at the pump of EUR105 per hl).

Table 5: Ethanol requirements of Germany based on 2001 data

	Unit	Amount
Transportation fuels	mln tonnes	128.4
of which:		
Petrol fuel	mln tonnes	28.0
Diesel fuel	mln tonnes	28.5
Petrol fuels total	mln GJ	1,204.0
of which:		
5.75 energy-% replaced by biofuels (EU-target 2010)	mln GJ	68.6
equivalent to ethanol	mln hl	32.5

Currently, there is a total petroleum tax exemption in Germany. Thus, from the economic standpoint, this country should be providing an excellent environment for investors. The reason why there has been no investment so far is lack of legal security.

Briefly, the following points remain unresolved:

a) As long as the European Union's import tariff on denatured ethanol is only EUR10.2/hl, the risk of cheap ethanol imports from low cost producing countries such as Brazil is high. However, it is certain in the context of the WTO negotiations that a higher tariff would only be permitted if ethanol production were put in the "green box". (In order to qualify for the "green box", a subsidy must not distort trade, or at most cause minimal distortion. These subsidies have to be government-funded (not by charging consumers higher prices) and must not involve price support).

b) As long as there is no mandatory blending, the oil companies need strong economic incentives to add ethanol to their fuels. So, without the force of law, there is an enormous pressure against ethanol producers.

How does America deal with these problems? Since its costs of production are lower, the overall risk of cheap imports from a low cost producer such as Brazil is not all that high. Moreover, an import tariff of $0.54 per gallon makes them largely prohibitive. Furthermore, the system of direct subsidies by the states benefits local production. The incentive given to oil companies to produce ethanol blends has already been shown.

Potential biofuel consumption and arable area requirement

Table 5 shows the potential German ethanol requirement, based on petrol use in 2001. The European Commission has set a requirement that in 2010 biofuel use should comprise 5.75% of consumption by energy content, which due to lower energy density, is more than 8% by volume. The quantity of 32.5 mln hl calculated for Germany implies that in round terms 16 ethanol plants of 2 mln hl capacity each would be required.

On the basis of a wheat yield of 9 tonnes per ha equating to 3,400 litres of ethanol per hectare and on a beet yield of 60 tonnes per ha (equivalent to 6,000 litres), the area required to produce sufficient quantities of ethanol would be 805,000 ha.

As a result, each of the 16 plants mentioned above would have to process feedstocks from an area of 50,000 ha (12,000 ha of beets, 38,000 ha of wheat). With respect to the employment effects a rather conservative study by the Fraunhofer Institut is quite useful. In a rather global approach it is estimated that for every 1000 tonnes of oil equivalent (toe) replaced by renewable energy, 16 new jobs will be created. For the 32 mln hl of ethanol (=1.5 mln toe) arrived at above the total number of additional jobs would amount to 25,000. It is obvious that this number also comprises up- and downstream markets as the number of jobs created in ethanol production facilities would be no more than 800.

Comparing the full tax exemption for fuel ethanol and the support for wind energy in Germany has shown that the level of support would be the same per kWh. Even though the German petroleum tax is not based on energy content a 100% tax rate for ethanol would be contentious as ethanol's energy content is only 65% that of petrol (by volume). In this context the CO_2 reduction potential of ethanol would need to be discussed. However, this would go beyond the scope of this article.

Further considerations

From an EU perspective, ethanol production could be justified for several reasons. First, in 2001 the EU produced more than 3.7 mln tonnes of C-sugar. This has to be exported to the world market without any subsidies. If the beets were used to produce ethanol profits for farmers and processors would be much greater as the prices that could be fetched would be higher than the world market price for sugar.

Secondly, the EU is paying export refunds on the Community's sugar surplus which represents the difference between European sugar consumption and production quotas. In 2001, these payments amounted to EUR372.7 mln for exporting 0.882 mln tonnes of white sugar which could be used for ethanol production. The savings on subsidies could be used to support ethanol production.

From an economic standpoint, it is incomprehensible that, as the result of compulsory set aside, 10% of the EU's agricultural area is not being cultivated; this represents a waste of a limited production resource. If this area were used to grow raw materials for non-food products such as biofuels, there would be no effect on the markets for agricultural commodities.

Conclusion

As far as European agriculture is concerned, using land for biofuels is definitely more lucrative than leaving it fallow and furthermore it is a reasonable way for the farmer to become an energy producer. Obviously, only experience will show the price which the market will be willing to pay for each feedstock. Furthermore, there is a competition between field and feedstock productivity. The farmer is interested in high gross margins per hectare which is the measure which he uses for his production. Thus, he might prefer to grow sugar beet if the price postulated above were to be offered. On the other hand, the processor wants to use feedstocks with a high level of alcohol yields. So, his preference will be for wheat.

Comparing the make up of total production costs in both countries, it is evident that no element is cheaper in Germany than in the US. This might be partly due to the exchange rate which assumed a strong Euro.

So how can costs be reduced? Since the raw materials are different, it would be like comparing apples and oranges. However, it is clear that the investment costs are lower if only cereals are processed and the equipment for sugar beet processing is not needed. Thus, a dual feedstock plant should only be considered if there is already established beet production with its associated infrastructure and if large economies of scale can be obtained. In any event, there has to be a price at which there is a switchover between beet and wheat. Since it is not realistic to expect that the price for wheat will be higher than EUR100 per tonne, the price for sugar beets has to be about EUR26 per tonne to be competitive.

Another important point is that the enormous transport costs have to be kept as low as possible by constructing the plant in the middle of the supply area. Reviewing recent German transport policy, there is no reason to suppose that transport will be cheaper in the foreseeable future.

It could be shown that the potential for establishing a profitable bioethanol industry in Germany is realistic if adequate tax incentives are given. A look across the ocean at US alcohol policy should help Germany find the best way to promote the use of ethanol. The system of direct product subsidies, import tariffs and incentives for blenders ensures that the target groups benefit from ethanol production.

If the ethanol trade becomes more and more international, all these factors might be discussed in the context of WTO agreements. However, it is a fact that, as long as import duty and mandatory blending are not the drivers of European bioethanol production, potential investors will hesitate to join the club.