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BIOFUELS FOR TRANSPORT

Alternatives to diesel and petrol can be made from certain agricultural crops, and are currently under trial in many European countries, including the UK. The European Commission foresees that under a favourable tax regime, up to 5% of motor fuels could be provided by agriculture.

This briefing examines the potential of 'biofuels' for transport, and the influence of EC set-aside and fiscal policies.

CURRENT USES OF BIOFUELS

There are two main candidates for liquid biofuels; - a substitute for diesel (rapeseed methyl ester - RME), and one for petrol (bioethanol). They and their sources are described in **Box 1**, together with technical requirements for their use. **RME** or **biodiesel** is produced in commercial quantities only in Italy, France and Austria, but production plants are planned in Germany, Denmark, Belgium, Spain and Czechoslovakia, while Italy's production is expected to double from 50,000 tonnes to ~100,000 tonnes in 1993. The main markets for RME are currently limited to bus and taxi operators in Italy, Switzerland, Austria and Germany; there is also a small UK trial by Reading Transport involving 3 buses.

Trials of **bioethanol** have been carried out in Germany, Italy and Sweden, and a small amount is blended with petrol in France. There is more experience outside Europe. The USA has a major transport biofuels programme using 'gasohol', a blend of 90% petrol and 10% ethanol. Gasohol attracts lower taxes than petrol, as part of a policy to develop different fuel supplies which can meet increasingly stringent air quality standards. Brazil established a 'Pro-alcohol' programme in 1975 to reduce its dependence on oil imports, and is now the world's largest producer and user of pure bioethanol for motor fuel; four million (one-third) of its cars use pure ethanol and the rest use a 20% ethanol blend, produced from sugar cane; the co-products are used for animal feed, in electricity generation, and for fertilisers.

THE ROLE OF SET-ASIDE

Under the EC Common Agricultural Policy (CAP) reform agreement of May 1992, growers with more than 40 (15.5 in England) hectares (ha) of cereals, oilseeds and protein crops must set aside from production 15% of their land. The EC has given a specific undertaking as part of the GATT negotiations that oilseeds will be

❐ WHAT ARE BIOFUELS?

Liquid Biofuels and their Origins. Substitutes for both conventional (mineral) diesel and petrol can be produced from agricultural crops. Alternatives to diesel are usually a group of chemicals called 'esters' produced from edible oils - typically oilseed rape in Europe, soya oil in the USA, and canola oil in Canada. Petrol substitutes tend to be the alcohols, bioethanol and a derivative from ethanol used as a high-octane blending fuel (ETBE - ethyl tertiary-butyl ether).

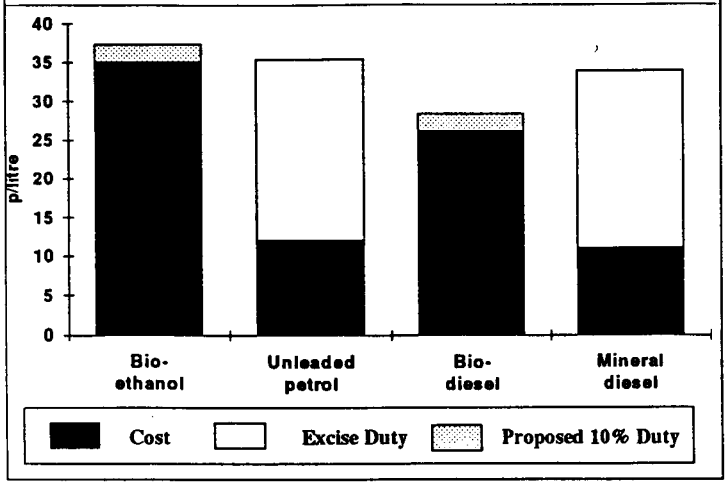
The primary candidate in Europe for a 'biodiesel' is rape methyl ester (RME). This is produced from oilseed rape by crushing, followed by a chemical esterification, separation and cleaning process. One hectare yields 2.2-3.3 tonnes of rape seed which yields 0.7-1.1 tonnes of usable RME. The process also produces glycerine as a byproduct which has many industrial uses.

The main petrol substitute is 'bioethanol'. This is produced from sugar and starch-containing crops by fermentation followed by distillation to recover the ethanol. In the UK, the most promising feedstocks for bioethanol are cereals (mainly wheat) and sugar beet; other possible sources in the EC include sweet sorghum, Jerusalem artichoke, maize, and surplus wine (e.g. there are already 450 million litres of surplus alcohol from the 1991 wine harvest). For wheat, one hectare yields about 6.7 tonnes of grain, which can give ~2 tonnes of bioethanol. Bioethanol could also be produced from the breakdown of lignocellulose (in wood and straw) using enzymes, followed by fermentation, but further research is needed to improve enzyme efficiency.

Technical Considerations. The use of pure or blended biodiesel in existing engines requires only minor engine modifications (if any), but engine performance may be reduced by up to 5%; there may also be problems with lubricants, exhaust catalyst durability, and poor volumetric consumption. Some engines have been specifically developed to run on unrefined plant oils (e.g. the Elsbett engine) without increased fuel consumption, but these are for specialist agricultural use. In the fueling systems (pumps, hoses etc.), RME destroys rubber more easily than mineral diesel oil, so stronger rubber must be used.

Bioethanol blends (e.g. 5 or 10% ethanol) can be used in existing engines without modification, as is common in the USA, to increase the octane rating of the fuel. The bioethanol must be dry however, as even small amounts of water can cause the ethanol and petrol to separate causing the engine to cut out. In the USA, fuel contamination is avoided by 'splash blending' petrol and (dry) ethanol at filling stations. Alternatively bioethanol may be converted to ETBE before blending. To run on pure ethanol, engines require substantial modification to avoid corrosion problems, and can no longer run on conventional petrol. The energy content of 1 litre of ethanol is only two-thirds that of 1 litre of petrol, so that if pure ethanol is used, storage and fuel tanks need to be larger to provide the same range.

Figure 1 COSTS OF BIOFUELS WITH REDUCED DUTY COMPARED WITH PETROLEUM-BASED FUELS AT FULL DUTY



limited to 5 499 000 ha for the 1994 harvest and 5 128 000 ha for 1995 and subsequent harvests, but these restrictions do not apply to crops which are grown for industrial purposes. This and the large acreages involved (~20 million of the total 130 million ha currently farmed in the EC) have led some to evaluate the use of set-aside land for biofuels production. A recent study by the UK's Energy Technology Support Unit (ETSU) suggests that if all the 630 000 ha of the UK's set-aside land in 1992 were used for biodiesel production, 743 000 tonnes (t) of biodiesel could be produced, replacing 643 000t of mineral (conventional) diesel[1]. This is equivalent to 6.4% of the UK's total annual consumption of diesel. However, the potential could in practice be limited to 1-1.5% by the recent US-EC agreement on cattle feeds, aimed at limiting use of biodiesel co-products.

Whether biofuels are commercially attractive depends very much on their tax treatment - as can be seen from **Figure 1**, where the production costs and proposed tax regimes for biofuels are compared to conventional petroleum products. Without major subsidies/tax concessions, biofuels are clearly uneconomic; moreover, the costs in Figure 1 do not include any allowance for the cost of CAP support to farmers.

At present, EC regulations on the harmonisation of duties on mineral oils (COM 92/81/EEC) apply the same tax to diesel substitutes as to diesel itself; under these conditions, it is doubtful if biodiesel production can be economic. Bioethanol is also likely to require subsidy - in the USA there is a Federal subsidy worth about 11p per litre of bioethanol (many States also offer additional subsidies). Moreover, since ethanol can be readily produced by the petrochemical industry, any tax policy to favour biofuels would have to discriminate between synthetic and bioethanol if the latter were to be promoted.

In view of these factors, a draft Directive has been proposed by the EC Commissioner for taxes (COM (92) 36) which would cut the excise duty on biofuels to 10% or less of that charged on unleaded petrol and diesel within Member States. The proposal's justification is on environmental grounds and as a means of increasing energy security and supporting farmers affected by set-aside policy. The EC predict that its tax proposals could lead to biofuels accounting for up to 5% of road fuel use, though at the cost of reduced tax revenues (£500 million p.a. in the UK).

Regardless of the fate of the draft Directive, current EC regulations include a provision allowing Member States to exempt or reduce the rate of duty *"in the field of pilot projects for the technological development of more environmentally-friendly products and in particular in relation to fuels from renewable resources"*. The current trials in Reading do not include any special tax treatment under this exemption, but RME fuel has been made available at normal diesel cost by the Italian RME producer Novamont. At present there is no provision in the UK for biodiesel used in pilot projects to be exempt from excise duty and the future eligibility of such projects has yet to be decided by the Treasury.

CURRENT ISSUES

Environmental Pros and Cons

One of the arguments in support of developing biofuels is that their manufacture and use may have less of an impact on the environment than existing fuels - particularly because they exploit a 'renewable' resource rather than oil reserves. It is claimed that biofuels, because they come from plants which have grown by capturing carbon dioxide (CO_2) from the air, may make less of a contribution to the 'greenhouse effect' (see POST Briefing Note 33) than fossil fuels.

The effect on net CO_2 emissions depends on how much energy is used in cultivating and processing the biofuels, relative to the energy needed to extract oil and refine it into diesel or petrol. The balance will also be affected by the energy costs of pesticides and fertilisers, and the uses to which by-products are put (e.g. whether burnt for usable heat or fed to farm animals). Various assumptions about these factors lead to contradictory results. Thus recent French and German studies concluded that biofuels provide little or no reductions in CO_2 emissions. On the other hand, a study by ETSU concluded that using 1 litre of biodiesel could result in ~1.5 kg of CO_2 less being emitted than if conventional diesel were used. If the ETSU study proved the more accurate, using all the UK set-aside land for biodiesel production would reduce CO_2 emissions from diesel by 3.5% (around 0.2% of total UK CO_2 emissions).

Turning to **regional and local air quality**, the amounts of the various types of air pollutants emitted from conventional fuels and biofuels are shown in **Table 1**,

1. **Mineral diesel has ~ 8% higher calorific value than biodiesel, so it is necessary to burn more of the latter to achieve the same power output.**

Table 1 BIOFUEL EMISSIONS RELATIVE TO CONVENTIONAL FUELS

Pollutant	Bio-Diesel	Blend with Petrol 10% Bio-Ethanol	Blend with Petrol 95% Bio-Ethanol
Sulphur dioxide (SO_2)	almost 100% less	10% less	60-80% less
Nitrogen oxides (NO_x)	up to 20% increase	2% increase	no difference
Particulates	up to 40% less	No significant difference	up to 5% more
Unburnt hydrocarbons (HC)	typically 10-40% reduction	6% increase	up to 15% less
Carbon monoxide (CO)	up to 30% less	4% less	up to 8% more

based on a number of European studies. The Transport Research Laboratory (TRL) is also currently conducting tailpipe emissions tests for the Reading pilot study. Emissions contributing to **'acid rain'** are likely to be lower from biofuels, since the latter contain much less sulphur than conventional fuels; however most SO_2 emissions come from stationary sources, and road transport accounted for only 2% of total UK emissions. Nitrogen oxides may be increased slightly, although the difference depends to some extent on the exact engine settings used in the various tests.

Emissions of **particulates** (mainly soot) can be lower with biodiesel, but this may change with use, as more of the fuel is retained in the engine lubricating oil than with conventional diesel, increasing soot formation. In general, **carbon monoxide** (CO) emissions are lower with biofuels, which was one of the main attractions for the US Gasohol programme. All fuels emit mixtures of **unburnt hydrocarbons**; these include some potential carcinogens, and are also one of the primary contributors to low-level ozone and photochemical smogs. The results of the various tests are inconclusive; both fuels emit various hydrocarbons, and it is not possible to assess whether there are significant differences in risks to human health or in their contribution to smogs and ozone. Bioethanol does generate more aldehydes which contribute to smog formation, but this would not be important where exhaust catalysts are used. RME combustion produces exhaust fumes that many regard as having an unpleasant odour, but this could be rectified by fuel additives.

Local air pollution is also caused by fuel evaporation during filling, storage and use, and losses from bioethanol fuel could be 5%-220% above those for conventional petrol. This is causing some concern in the USA. Measures are also needed to avoid problems caused by bioethanol's solubility in water, since it would dissolve in the layer of water generally found in the bottom of petrol storage tanks, and can also separate out in the vehicle tank.

The wide variations in the results of the emission tests reflect, in part, the differences in the various test cycles employed by laboratories in different countries, and do not necessarily arise from variability in the fuel. There is thus a need for greater comparability of test protocols, and results from in-service trials (such as in Reading), before a clearer picture of the emissions can emerge.

Biofuels are much more readily degraded in the environment than conventional fuels, which can be an advantage where spills would have a significant environmental impact, such as on inland waterways.

Should Biofuels be Encouraged?

The EC believes that up to 5% of EC motor fuel (petrol and diesel) could be obtained from biofuels; this could require between 2-5 times the current area of set-aside to be devoted to crops providing the raw materials for biofuel production. Some studies suggest that there may be greater potential. A Cambridge University study foresees 1-1.5 million ha of land being removed from food production within the UK by the year 2000, rising to 5-5.5 million ha by 2010. If all this land were used for growing oilseed rape for biodiesel under a rotational set-aside agricultural system, then by the year 2000 an estimated 10-15% (1-1.5 million tonnes) of the current UK diesel market could be met by this fuel, growing to 51-56% (5.1-5.6 million tonnes) by 2010.

Although there may be agreement that it is technically possible to divert large areas of land to biofuels production, there is considerable dispute over whether such switches should be encouraged by subsidies through preferential tax treatment relative to petroleum-based products. There are also potential concerns over the wider implications of substantial expansions in the amount of agricultural land used for biofuel crops.

Support from existing biofuels producers and some farming groups for the tax subsidies proposed in the draft Directive, is generally on the grounds that an expanded industry will help the EC's energy security and also help meet targets for reducing carbon dioxide emissions and other air quality targets. An internal source of biofuels could enhance the EC's **energy security**, by reducing EC dependence on imported oil. Oil companies point out however that, even under the EC's own assumptions, EC energy security would be improved only marginally - replacement of 5% of the vehicle fuel market by biofuels would lead to a reduction of 1.5% in oil imports (equivalent to 0.5% of EC primary energy consumption). Neither is it necessary to develop new technologies, since the processes of extracting and refining biofuels are well-established.

On the environmental case, supporters argue that biofuels, particularly biodiesel, can generate less CO_2 over the whole production/use cycle, and that should thus benefit from special tax treatment such as that proposed in the draft Directive. However, the oil and chemicals industries argue that the strength of the environmental case has not yet been demonstrated, and that CO_2 emission targets are better met through technical improvements to vehicles aimed at increasing engine efficiency and reducing fuel consumption; biofuels should thus compete with petroleum products without special treatment, as pure fuels or as octane enhancers.

Given the marginal and unresolved strength of the case for biofuels on environmental grounds, most debate focuses on the cost-effectiveness of biofuels production as a means of supporting the rural economy. Supporters of biofuels point to the large overcapacity in agricultural food production, and see set-aside as potentially leading to further contraction in the rural economy. They see cultivation for biofuels as having positive socio-economic effects by creating employment in rural areas and associated industries, albeit with accompanying pressure on the fossil fuel and allied chemicals industries whose markets would be partially replaced. One study estimates that a 200 000 ha wheat-based bioethanol programme could create 2 680 direct jobs in agriculture and processing, and a further 4 020 indirect jobs, although this does not take account of compensatory effects on the oil and petrochemical industry (some markets for chemicals, primarily synthetic ethanol and glycerine, would be reduced). Many believe that a more cost-effective way of supporting the rural economy and reducing CO_2 emissions would be to use land for energy forestry such as short rotation coppicing.

Moreover, conservation and environmental groups see the overproduction of food as offering an opportunity to reduce the intensity of agriculture and return some of the areas set aside to other conservation and recreational uses (woodland, downland etc.). They see dangers that a widespread switch to biofuel crops would maintain pressures for intensive agriculture with associated detrimental effects on the countryside environment. Concerns have also been raised over whether the increased incidence of asthma and allergies in parts of the country might be caused in part by changing patterns of agriculture, such as the expansion of oilseed rape cultivation. Early research results (e.g. from Aberdeen University) indicate that there is no statistical difference in health between populations living close to extensive areas of oilseed rape cultivation and in other rural areas. However, some environmental groups think it unwise to expand biofuel crop production until the causes of such trends have been established.

2. The environmental costs of electricity production were reviewed in an earlier POST report 'Costing the Environmental Impacts of Electricity Generation'.

Future Prospects

In the UK, most observers believe that biodiesel is more likely to be used than bioethanol in the short-term, principally because there would be less disruption to the energy production and distribution systems, and because its production would best fit present EC farming practices and policies. In the future, biodiesel might also be produced more cheaply by using industrial acid oils and waste oils. There is also widespread agreement that biofuels are suitable for various niche markets where the environmental advantages of their greater biodegradability can be exploited, as in inland waterways and urban use.

Future trends in the UK will be influenced by DTI support for research and development, where at present, out of the DTI's budget of £22 M for renewable and novel sources of energy, the main support has been the production of three detailed ETSU reports on bioethanol (1987, 1990) and biodiesel (1993). The Department of Transport is funding the emissions tests in Reading Transport's biodiesel trial. At the development stage, EC funds are available for demonstration plants, and provide about £13.75 M from 1992 to 1994 (on a 30% funding basis) for 5 biodiesel plants in France, Germany and Italy. The UK is not involved.

The future viability of biofuels could be affected if market prices were to take into account differences in environmental impact; some argue that energy prices should reflect all costs - including environmental costs[2] - and support the introduction of an energy or carbon tax. This would have the advantage of 'rewarding' biofuels to the extent that they do have a reduced environmental impact; however, on the basis of existing information, the likely 'environmental' credit would be only a few pence per litre and insufficient to affect the relative costs of biofuels and petrol/diesel.

The key influence on future UK activity in biofuels in the short term will be the eligibility of demonstration plants and pilot studies for tax subsidies under the current EC Directive on harmonisation of taxes, and this question may be addressed in the March Finance Bill.

FURTHER READING

Additional details and background information are available from POST, 2 Little Smith St., London SW1P 3DL, tel: (071)-222-2688.

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