Biofuels for Transport

Price 30p

Introduction

Many European drivers will have used bio-fuel. Self interest is driving up bio-fuel use in America. In the late 1970s Brazil embarked on a programme to power its vehicles exclusively on bio-fuels. Bio-fuel is in widespread use, proven but expensive, but encouraging progress is being made.

What are bio-fuels?

All organic matter contains carbon and hydrogen which potentially can be converted to carbon dioxide and water, releasing energy. Fossil fuel, after all, starts life as compressed plant material. Bio-fuels, whether they be landfill gas, sawdust or timber, can be burnt to provide heating or generate electricity but this note concerns their use in transport. Bio-ethanol and bio-diesel are the most important though others such as methanol and butanol are of interest.

Bio-ethanol

Any vegetable starch can be converted to a sugar then fermented and distilled to produce ethyl alcohol or ethanol (chemical formula C_2H_5OH) for use in 'petrol' engines. Many years ago synthetic alcohol used to be sold in the UK under the Cleveland Discoll label. Hydrous ethanol (which means it contains some water) can be used neat in modified engines. Up to 25% of anhydrous ethanol can be added to ordinary petrol engines without modification.

A Jatropha bush. The seeds (top)can yield 2 tonnes of fuel/year. Bush grows on marginal land in hot countries

In America almost 6 billion litres of anhydrous bio-ethanol is used in E10, a 10% ethanol, 90% petrol blend. Indeed the US Clean Air Amendments Act of 1990 makes the use of E10 mandatory when forecast levels of carbon monoxide in the local air are high. Bio-ethanol also boosts low octane levels in US unleaded petrol. Farmers like it because it is a new crop to grow on surplus land. More importantly it reduces US imports of oil currently running at a billion barrels a year causing half the US trade deficit.

Bio-diesel

The market for bio-diesel in the US is currently 20 Ml/year, only 0.3% of that for bio-ethanol, though it is thought it could expand to almost 8 billion litres or 8% of US diesel if the current *triple* cost was subsidised or reduced. Bio-diesel is produced in the majority of EU countries with Germany responsible for over 50% and over 1M tonnes, and France and Italy next. Bio-diesel is cleaner than fossil diesel fuel because it contains less sulphur and, it is claimed, produces fewer particulates. Its use neat is encouraged in sensitive areas such as waterways because it is also biodegradable.

The Proalcool Project

Brazil has been particularly bold. Using bio-ethanol from surplus sugar cane, 60% of its transport fuel (12 billion litres/year) came at one time from bio-fuel. In the Proalcool project which began in 1975 Brazil encouraged the use of 100% hydrous ethanol in cars with converted engines. Unhappily the market was badly organised with supply mismatched to demand. Subsidies rose to £600m/year and had to be cut. The more secure blended market grew while the 'neat' one declined, but engine management systems can now detect different fuels and 70% of new cars are now 'flexi-fuelled' and can run on 100% bio- ethanol wherever it is available.

The Proalcool project hit two other problems. Chemical processes create a useful product and also a waste. The stillage or waste from distillation caused pollution and a digestion process had to be introduced. The other problem, *fundamental* to the development of bio-fuels yet often overlooked, is the inefficiency of production in *energy* terms. A great deal of energy was used to produce fertilizers, to grow, harvest and transport the crop, and to actually extract the fuel. *There is no point at all in using fossil fuel to grow crops and only get the same quantity of bio-fuel out.*

Improving the energy yield

A great deal of work has been done, particularly under Dr Nigel Mortimer at Sheffield Hallam University and after, to find ways of increasing the net energy gain as well as improving the economics. It was quickly realised that for any crop the economics depend not only on the quantity of *fuel* produced but the uses made of the *waste* material. Waste from oil seed rape can be used for animal feed though, as the quantities mount, some will need to be incinerated in energy from waste plants. Processing hexane in some crops will produce glycerine which,

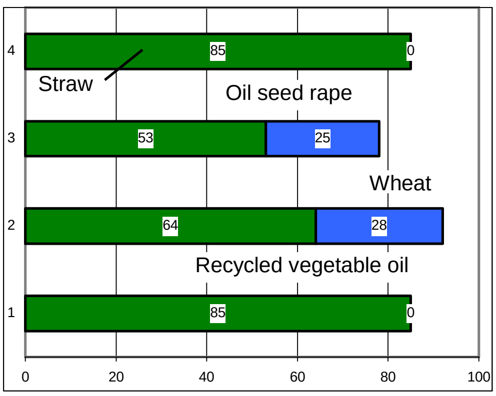

Fig 1. Net greenhouse gas savings %. Blue % gives the energy gained from burning the waste material.

An ALDES Briefing Note

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This note includes ideas and data given by Dr Nigel Mortimer at an ALDES fringe meeting at the 2005 Spring Conference. It should be factually accurate but any opinions expressed are those of the author. Notes on possible errors or any comments should be sent to the author, Richard Balmer, at 79, Links Drive, Solihull, B91 2DJ, or richard_balmer@blueyonder.co.uk

if not removed from the fuel, will ‘gum up’ engines. Glycerine however has industrial uses. Once again though, when that market is satisfied, the remainder will have to be burnt. Bio-ethanol is produced through fermentation. The CO_2 given off can be used in fizzy drinks, urea fertilizers or even to drive oil into wells.

Fig 1 shows the kind of fossil fuel savings that can now be made. Straw is a waste product anyway, so the only fossil energy used is in transporting and processing. Oil seed rape (OSR) however would have to be grown specifically. However, if the waste was used for animal feed it would save the energy costs of producing that feed. Alternatively the waste could be burnt for heat or electricity and replace fossil fuel directly. The green figure shows the net energy gain for the transport fuel alone. The blue figure is the extra energy gain from the waste. For OSR the net energy gain could be 88% (53% + 25%). Put another way, 100 litres of fuel for lorries could be produced with only 12 litres from fossil sources.

Source	Fuel	Yield GJ/ha
Wheat straw	Bio-ethanol	26
OSR	Bio-diesel	40
Wheat grain	Bio-ethanol	61
Sugar Beet	Bio-ethanol	117

Table 1. Productivity. 1 Giga Joule of energy = 47 litres bio-ethanol and 30 litres bio-diesel

Most crops will be harvested over a short season but processed over a year. This means that some storage costs will be incurred but it also means that some processing could be done when renewable wind energy is available.

Land considerations

There is another major factor which is especially relevant in the heavily populated UK: the area of land required.

Where bio-fuels compete for good quality arable land yields are particularly important. As Table 1 shows, sugar beet gives the highest yields, producing 5500 litres of bio-ethanol/hectare (ha). This is about ½ litre/sq metre so a motorist covering 10,000 miles/year driving a frugal car doing 10 miles/litre would require around 2000 m^2 of land.

In the UK bio-ethanol is being obtained from sugar beet, wheat grain, wheat straw, and wood chips, though sugar cane and maize are more important overseas. Bio-diesel locally comes from recycled vegetable oil, OSR and animal tallow, and from imported palm and jatropha oils. Soya is the main source in the USA. Jatropha is an interesting crop because it can grow on poor quality ‘marginal’ land so does not compete for space with food crops. It also grows in hot, relatively low rainfall climates and can be used to resist desertification. This is important. There are fears palm oil plantations will expand in countries like Malaysia and Indonesia at the cost of cutting down virgin forest and releasing carbon.

Getting bio-fuels to market

Originally an EU directive set ‘indicative’ targets (really, aspirations) that 2% and 5.75% of fuel should be ‘bio’ by Dec 2005 and 2010 respectively. Austria and Germany were well advanced but at the time the UK used less than 0.5%. It is now required to reach 2% before end 2007 and 5.75% by 2011. To grow all the fuel locally would use up all the country’s ‘set aside’ land and a bit more good arable land besides. There is some: CAP subsidies encouraged the over production of cereals which were dumped on world markets causing acute embarrassment in trade and aid negotiations. Bio-fuels would be an ideal alternative. British Sugar is one large company keen to supply the bio-ethanol market and has built a plant at Wissington, Suffolk.

The main difficulty at the moment is that UK producers need more than the present subsidy of 20p/litre (only guaranteed until April 2008) to compete with fossil fuels. Thus most bio-fuel would have to be imported. It is thought the Treasury needs to increase the subsidy to 28p (or offer favourable capital allowances) and extend the date. Altenatively government could bring in a RTO (renewable transport obligation) similar to the RO (renewables obligation) for electricity. It seems the Treasury have at last recognised their responsibility for encouraging renewable energy technologies and are beginning to compare alternatives in terms of £/tonne of CO_2 reduced.

Remaining technical and other problems

Bio-ethanol does not have the same chemical formulation as petrol, nor bio-diesel as diesel. Indeed different crops produce bio-diesel with both higher and lower octane ratings. The route into the market has so far been primarily via blended fuel but manufacturers have been reluctant to extend warranties to fuels blended with more than 5%. They want assurances there will be no loss of performance.

A further drag on progress is the common difficulty of establishing any new supply chain. Farmers will not start growing fuel crops and companies will not build processing works if there is no certainty the market for bio-fuels will develop. This requires both leadership from opinion formers and financial support in the first years. However, whereas new fuels such as hydrogen and compressed natural gas (CNG) have to develop nationwide garage networks (perhaps starting with clusters around large cities) blended fuels should be available from existing forecourts and the same tanks. Some companies are already seeking bio blends to enhance their green image. Tesco’s 2000 distribution lorries are to use a 50% bio-diesel blend.

How much could be produced?

In 2002 the UK used 17,654,000 tonnes of diesel for DERV (Diesel Engined Road Vehicle) fuel. (Other diesel and gas oil is used for heating and off road use, eg farm tractors). 17+ M tonnes is equivalent to about 21,000M litres of diesel. If produced entirely from oil seed rape yielding 1200 litres of bio-diesel/ha/year, it would require almost 17.5M ha or virtually all the UK’s total 18 M ha of agricultural land. The target figure of 5.75% would take 1M ha, which is more manageable, though we must remember another 0.6 M ha or so would be needed for the 5.75% of the 39M tonnes of petrol being used. In 2005 about 0.6 M ha of land were ‘set aside’.

Conclusion

Due to the shortage of arable land in the UK additional fuel will probably have to come from wood chips, that is via coppicing on poor quality land. Given some inspired research and perhaps help from GM technology it is thought a maximum of one third of current demand could be home grown. The main hope for other further fossil fuel savings depends on hydrogen. Neither option will be cheap, but at least with bio-fuels the technology is proven and the first supplies are here.