

**DISCUSSION DAY ON BIOFUELS
MAISON DE LA CHIMIE, PARIS
13 MAY 2003**

Prospects for Biofuels

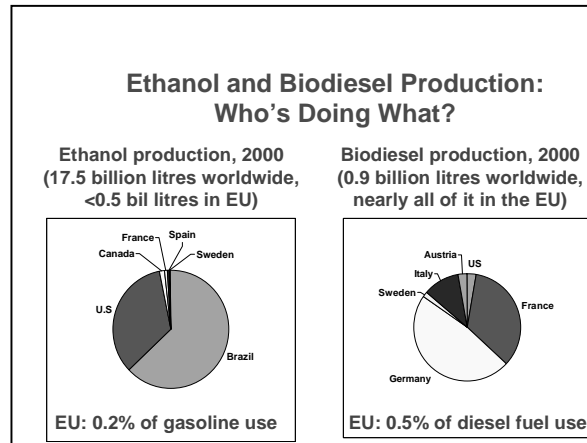
Results to Date from the IEA's Transport Biofuels Project

**Marianne Haug,
Director, Energy Efficiency, Technology and R&D
International Energy Agency**

I am Marianne Haug, Director of the Office of Energy Efficiency, Technology and R&D at the International Energy Agency (IEA). My Office manages – inter alia – a framework for some forty international collaborative R&D and information dissemination programmes in the domain of energy technology. These programmes cover clean, efficient technologies spanning the whole range of energy sectors – fossil fuels, fusion power, renewables and end-use applications in industry, buildings and transport.

Within our transport programme, we undertake our own in-house research, as well as managing the IEA's network for international co-operation. As part of this in-house analysis, one of our current projects is an international review of the current state of liquid biofuels for transport, and their prospects for the future.

What is the current state of biofuel production world-wide?



There are two clear differences worth highlighting here. First, far more fuel ethanol is produced than biodiesel, although the amounts produced differ only slightly from country to country in Europe. Second, while North America and Brazil are the largest producers of ethanol, Europe is the dominant producer of biodiesel. This is partially due to the composition of the vehicle fleets in the two regions: a high proportion of diesel fleets in the EU and a much lower share in the US. Another factor concerns characteristics of the agricultural sectors in each region: incentives in Europe to produce non-food agricultural crops on set-aside land (rapeseed, sunflower) and huge production in the United States of corn for low value use (animal feed).

It is also worth noting that, in 2000, ethanol and biodiesel in the EU accounted for less than 1% of consumption of gasoline and diesel, although production capacities are rising fast. Meeting objectives like the proposed EU target of 5.75% oil displacement by 2010 will require large-scale, rapid investment in conversion facilities, and this represents quite a challenge.

Why use Liquid Biofuels in Transport?

- + **Reductions in oil use**
- + **Reductions in CO₂ emissions**
- + **Reductions in air pollutants and solid wastes**
- + **Improvements in vehicle performance**
- + **Agricultural product market expansion**

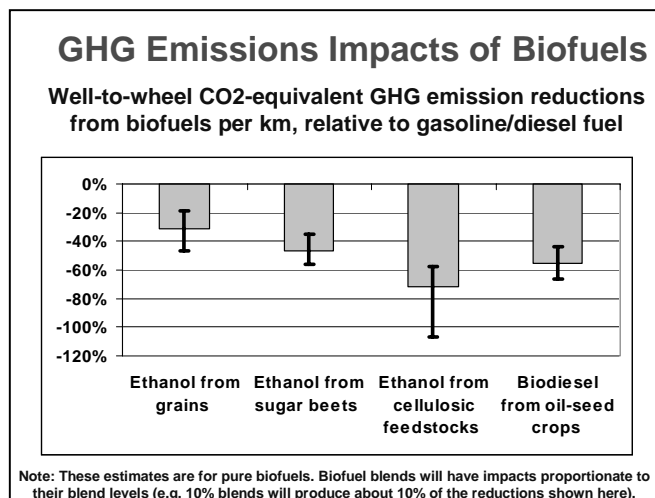
What are the Concerns?

- **Conventional biofuels are expensive**
- **Land requirements are high**
- **Current feedstock and conversion practices (for ethanol) do not maximise potential CO₂ reductions**

So, exactly why are more and more countries becoming interested in biofuels? This list shows why biofuels have become a high priority issue in the US, the EU and in a number of other countries around the world. In some places, the recent impetus for their use has come from concerns about oil dependence and reducing CO₂ emissions. In others, and notably in parts of the US, emerging restrictions on certain other options for octane enhancement and oxygenation – like methyl tertiary-butyl ether (MTBE) – have led to a big increase in demand for biofuels (mainly ethanol).

But we also recognise that current production is very limited, as costs are high and land requirements are large.

Let us now look at some of the benefits and costs in more detail.



First, what about greenhouse-gas (GHG) emissions?

Very little oil is involved in the production of ethanol and biodiesel, except what is used, for example, by tractors on farms where feedstock is grown. So they displace oil on close to a litre-for-litre basis. But that is not the case for CO₂ emissions, since considerable emissions of CO₂ occur during farming, transporting, and processing of raw materials.

The good news from the most recent international studies is that, on a well-to-wheels basis, both ethanol and biodiesel can bring substantial reductions in CO₂ emissions (and CO₂-equivalent GHG emissions) per litre of fuel or per kilometre of vehicle driving.

Even conventional corn and wheat processes can result in a reduction of up to 45% in large, recently built plants. This is much better than the “conventional wisdom” used to suggest. Studies that claim no net CO₂ reduction (or energy gain) for grain-to-ethanol processes are based on old data.

Reductions of up to 70% can be expected from biodiesel, but this does depend somewhat on the source of oil (waste oil, crop type), as well as assumptions regarding fertilizer use and emissions of nitrogen back into the atmosphere during farming.

Sugar crops and cellulosic crops can do even better. Indeed, some estimates point to reductions as high as 100% with cellulosic crops, or even more if co-product credits are taken into account.

From the point of view of CO₂ reductions, then, cellulosic ethanol is our most promising liquid biofuel option. But conversion technologies for cellulose are still in the development stage.

**Biofuels Blendability is a Big Advantage
Over other Alternative Fuels**

- **Ethanol blending to 10% causes no problems for gasoline engines**
 - ◆ Brazil achieves 26% ethanol blending with slight engine modifications (though in a warm climate)
 - ◆ The US manufactures vehicles that can reach 85% with engine modifications costing under \$1000

- **Biodiesel can be blended with diesel from 0-100%**
 - ◆ Only minor problems for high biodiesel blends
 - ◆ Pure biodiesel regularly used in Germany

Second, the compatibility of biofuels with current engine technologies is a frequent concern.

In fact, blending to 10% ethanol by volume appears to cause no problems for conventional vehicles. Moreover, it seems that this percentage could be raised much higher with only slight engine modifications. Brazil, for example, is encountering few fuel compatibility issues in using up to 26% ethanol blends requiring only fairly minor changes in fuel-line components and tuning. And vehicles converted for “flexible-fuel” that can handle up to 85% ethanol appear relatively inexpensive, perhaps US\$500 per vehicle or less.

The problem of fuel vapour pressure with ethanol (high evaporative emissions) mostly occurs over the first 1% ethanol. Above 8% or so, the reading on the Reid Vapour Pressure (RVP) scale actually begins to drop again.

There appear to be no limits to blending biodiesel in conventional diesel vehicles. Pure biodiesel is regularly used in Germany for heavy-duty vehicles.

What are the Downsides? Limited Production Potential

- **Ethanol:**
 - ◆ 5% petrol displacement (8% by volume) appears possible over next 10-20 years without major disruption to ag. markets
 - ◆ Higher levels may require significant crop or land reallocation
 - ◆ Use of cellulosic feedstocks could greatly increase production potential, especially if targeted technical breakthroughs are achieved
 - Development of advanced processes with lower costs for conversion of biomass to ethanol, including development of genetically-modified conversion enzymes (as well as GM crops)
 - "Biorefineries" are also under investigation
- **Biodiesel:**
 - ◆ Attractive in EU to increase non-food agricultural production, especially in set-aside lands
 - ◆ Volumes (chiefly from rapeseed) are still very small compared to diesel use
 - ◆ Above 3-5% diesel displacement may require significant crop or land re-allocation

We have looked at the rather good news about the environmental and engine performance of biofuels. Let us now return to the issue of producing biofuels, and look at the scope for reaching the targets set in the EU and in other countries.

Taking current feedstock, and working with recent crop yield and fuel conversion data for the EU, it appears that 5% of gasoline could be displaced by ethanol (8% ethanol by volume) over the next 10-20 years without major disruptions to domestic crop markets or food supplies. But the picture looks less clear beyond that 5% percentage, since at some point – possibly not much above 5% – it may become difficult to avoid impacts on crop (food) prices as ethanol competes with food for use of sugar and grain crops.

Cellulosic feedstocks could serve to very significantly expand availability of resources for producing ethanol. Since grasses and trees can be grown on pasture land and other marginal land, cellulosic feedstocks open up new possibilities for engaging land in the production of biofuels without threatening natural habitats and biodiversity. This path is being pursued aggressively in North America, but not (so far) in the EU. A large research program is under way in the US to increase the conversion efficiency of biomass-to-ethanol, and to lower the costs. This includes investigation of genetically modified conversion enzymes, as well as exploring the potential for use of high-yield GM crops. "Bio-refineries" are also under development and could produce multiple products, including ethanol, other chemicals, feed grain and co-generated electricity.

As for biodiesel (mainly from rapeseed), volumes are still very small. Getting above 3-5% of diesel fuel displacement may require major increases in biodiesel crop production and significant land reallocation.

Another obstacle to – even low – percentages of transport fuel displacement is the persistently rapid growth in vehicle travel volumes. The IEA forecasts a 20% increase in EU transport fuel use between 2000 and 2010.

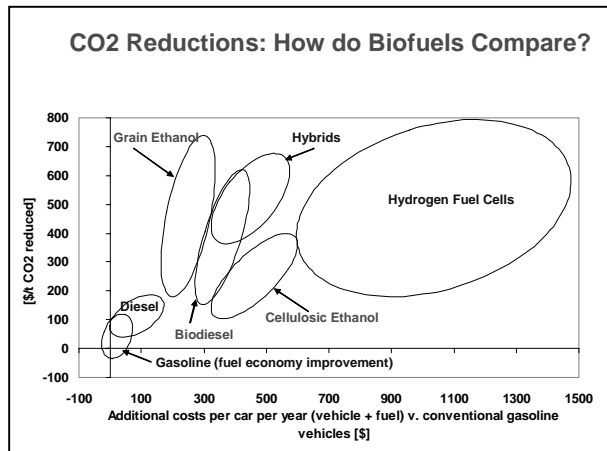
Biofuels costs are high, but falling

- **Both ethanol and biodiesel production costs are 2-3 times higher than gasoline/diesel**
 - ◆ Costs are very sensitive to crop prices, production scale
- **Costs of current processes should continue to decline slowly**
 - ◆ But probably not enough to become competitive with petrol in the foreseeable future (except at very high oil prices)
 - ◆ Biofuels produced outside the EU-15 (e.g. Eastern Europe, developing countries) may be substantially cheaper
- **Cellulosic ethanol conversion technology improvements may eventually bring costs down to competitive levels**
 - ◆ Large scale test facilities, “bio-refinery” concept may bring costs down; US has a large R&D program in this area

The cost of current ethanol and biodiesel production processes is still quite high in comparison with gasoline and diesel; up to three times as much in some cases. While production costs have dropped somewhat over the last ten years, notably as larger conversion plants have been built, prices remain relatively dependent on feedstock prices, which are volatile. We do not think it likely that the production cost of biofuels in the EU-15 will drop near or below the production cost of gasoline or diesel in the next 20 years, unless there are large, sustained increases in world oil prices.

Biofuels can be produced much more cheaply in various regions outside the EU-15 and the US. Brazil, for instance, produces ethanol at about half the cost in the EU, based on current exchange rates. China and India have begun producing fuel ethanol in significant volumes. And Eastern Europe has great potential for producing relatively low-cost biofuels.

In the US, a large research program for developing advanced-technology cellulosic ethanol is targeting cost levels that will eventually become competitive with gasoline. Although progress in the past few years appears to have been slow, recent emphasis on building larger-scale test facilities is encouraging. IEA studies show that most cost reduction is achieved through “real-world” experience and learning-by-doing.



How do biofuels compare with other transport options for reducing CO2 emissions? Despite their apparently high cost compared with gasoline and diesel, they are in fact quite cost-competitive with other options, and they may be cheaper than fuel cells and even hybrids. This is because they do not require changes to vehicles, and those changes represent a substantial share of the cost of hybrid and fuel-cell options. We assume US\$2500-4000 in incremental cost for hybrids, and US\$5000-10,000 in incremental cost for fuel cells, at least up till 2010.

On the other hand, it appears unlikely that conventional biofuels can deliver CO2 reductions at much below \$100/tonne CO2. But if cost reduction targets for cellulosic ethanol can be met, or even if costs can be brought down to the level of current grain ethanol processes, then cellulosic ethanol will be able to offer very cost-competitive CO2 reductions. This is because, compared with gasoline, cellulosic ethanol offers reductions in well-to-wheels CO2 emissions of between 70% and 100%, whereas grain ethanol offers only 20-40% reductions.

It should be noted, however, that these cost estimates do not take account of the value of other benefits of biofuels, such as increased energy security, lower emissions of some air pollutants, and better vehicle performance. Further, in some countries, increased crop production for biofuels may lead to reductions in other agricultural subsidies.

Where are we Heading in Europe?

- **EU- 2005 (2%) and 2010 (5.75%) fuel share targets appear likely to be “indicative” (voluntary)**
 - ◆ But they may still be important if countries have to develop and implement plans to achieve them.
- **Biofuel excise tax reductions (up to 100% of normal rate in proposed directive) may be crucial to achieving market acceptance and reaching targets**
- **The accession countries will create strong new competition in agriculture, but also an important new source of crops that could help some EU-15 countries meet their own targets.**
- **Both the Biofuels directives and the CAP commitments will influence production of crops for biofuels relative to production for other purposes.**

In the EU, a biofuels directive has just been approved. It includes voluntary fuel-displacement targets, as opposed to mandatory targets. But governments will certainly still need to prepare plans for meeting the targets. In order to reach 2% biofuels displacement of gasoline and diesel transport fuel by 2005, and nearly 6% displacement by 2010, governments will have to act very aggressively. This will include creating a climate for increased production or import of feedstocks and encouraging rapid investment in conversion facilities. Perhaps the most important requirement will be to establish conditions that foster market demand of liquid biofuels. A companion directive, allowing a reduction of up to 50% in excise tax for biofuels, will no doubt play a key role in creating those conditions. We estimate that a 50% reduction should bring biofuels prices close to – or even below – the level of conventional fuel prices in most EU countries. But individual countries will of course need to grapple with the revenue impacts of such measures.

The prospect of ten additional European Union countries also raises important questions. Taken together, these countries have greater cropland availability in relation to population size than the EU-15 countries, and their production costs are lower. So they will expand the competition, but will also constitute a potentially important source of biofuels for EU-15 countries which would otherwise have trouble meeting their targets if dependent on domestic production only. The direction taken with the EU Common Agricultural Policy over the next few years on such issues as use of set-aside land will certainly also have an important impact on incentives for farmers to produce biofuels crops.

While the IEA has not conducted detailed analysis on all of these issues, it seems that the conditions are being created within the EU for dramatically increasing the role of biofuels in transport over the coming ten years.

Conclusions and Recommendations

- **Biofuels can play an important part of an overall strategy to improve energy security in, and lower CO2 emissions from, transport**
- **Governments should play a leadership role in developing new technology and fuel options, and introducing new fuels into the market**
 - ◆ Pricing strategies should bring market signals in line with environmental and other social costs and benefits
- **Countries should develop appropriate pricing systems and incentive structures to develop and maintain fuel markets.**

What can we conclude about biofuels? And what does the IEA recommend?

Biofuels will play a role in an overall strategy to improve energy security in the transport sectors of IEA countries and to lower the sectors' CO2 emissions. In the near term, however, reaching even a 5% displacement of gasoline and diesel fuel will be challenging. Over the longer term, it may be difficult to go much above 5% displacement without significant reallocations of crops, crop land or imports, or without developing new types of feedstocks and geographic sources for them.

Governments should play a leadership role in developing technology and fuel options, seeking cost reductions and fostering market introduction of new fuels. They can assist in the drive to expand markets for biofuels through greater research and development efforts, particularly for new feedstocks and conversion technologies for plant matter like cellulose, and by encouraging market adoption of new fuels.

Pricing systems incorporating appropriate incentives are important in supporting fuel market development, so countries should strive to develop these. Incentives can even be an acceptable long-term strategy, so long as revenues are not threatened and those incentives are aligned with societal costs and benefits. For example, ethanol and biodiesel may warrant differential tax treatment on the basis of their energy security and environmental benefits. However, since these benefits can vary significantly depending on how the fuels are produced, it is not a simple task to shape approaches along these lines. Nevertheless, well developed incentive systems will play a major role in encouraging innovation. And innovation is an ongoing requirement if we are to secure continued reductions in well-to-wheels CO2 emissions associated with transportation fuels.