

Biofuels for Transport – Part of a Sustainable Future?

Summary and Conclusions from the IEA Bioenergy ExCo61 Workshop

This publication provides the summary and conclusions from the workshop 'Biofuels for Transport – Part of a Sustainable Future?', held in conjunction with the meeting of the Executive Committee of IEA Bioenergy in Oslo, Norway on 14 May 2008. The workshop was a joint event with Nordic Energy Research.

The purpose of the workshop was to inform the Executive Committee of trends and issues in the rapidly evolving biofuel sustainability debate. The main goal was to stimulate discussion between the Executive Committee and external experts which could subsequently feed into policy-oriented work within IEA Bioenergy.



IEA Bioenergy

INTRODUCTION

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The purpose of the workshop was to inform the Executive Committee about recent results and trends in the rapidly evolving international biofuel sustainability debate. The goal was to stimulate discussion between the Executive Committee and experts working outside the Agreement which could subsequently inform additional policy-oriented work and influence the further development of IEA Bioenergy in the short and longer term.

BACKGROUND

Biomass is already a major contributor to world energy needs, and there is scope for expanding this contribution in both developed and developing countries. Major economies are relying on biofuels as part of their strategies to mitigate climate change and to improve their energy security. Biofuels can also play a role in improving the balance of trade by reducing imports of increasingly expensive fossil fuels. Unlike other renewable energy sources, the production, and use of bioenergy is relatively labour-intensive and so can potentially play a positive role in maintaining and developing the rural economy. The use of agricultural and forestry by-products can provide additional income streams that could help the economics of primary industries.

On the other hand, increasing use of biofuels is likely to have impacts on the way land is used. A whole range of sustainability issues must be carefully considered, including the impacts on social development and the environmental impacts associated with land-use change. The situation is further complicated because significant growth in biomass use is likely to depend on the development of a substantial international trade in both biomass raw material and ready-to-use fuels such as pellets, bioethanol and biodiesel.

Because of these potentially far-reaching consequences, the expansion of the use of biofuels is becoming an increasingly topical and controversial issue. This is exemplified by the 'fuel versus food' debate with biofuels accused of causing food price rises and shortages. There are also fears that biofuels are contributing to pressures for land-use changes and destruction of tropical forest. In addition, recent publications have highlighted uncertainties in the greenhouse gas (GHG) balances associated with the production and use of biofuels.

In this important but extremely complex area there is an urgent need for reliable and authoritative information and analysis which can be used by national and international bodies in formulating policy and programmes. This is very much the remit of the IEA Bioenergy Agreement. The issues referred to above are already being considered in a number of Tasks within the Bioenergy Agreement, particularly:

- Task 29 – Socio-economic Drivers in Implementing Bioenergy Projects
- Task 30 – Short Rotation Crops for Bioenergy Systems
- Task 31 – Biomass Production for Energy from Sustainable Forestry
- Task 38 – Greenhouse Balances of Biomass and Bioenergy Systems
- Task 39 – Commercialising 1st and 2nd Generation Liquid Biofuels from Biomass
- Task 40 – Sustainable International Bioenergy Trade: Securing Supply and Demand

The workshop provided an opportunity to consider some of these complex interactions and to illuminate some of the key issues by considering the following topics.

The Policy Framework: What are the policies in place and how are these likely to develop? Will they ensure that the growth of biofuels for transport follows a sustainable path?

Trade and Producing Country Perspectives: Can a sustainable international trade in biofuels be developed and will this be beneficial to the producing nations?

Sustainability: Can an expanded transport biofuel sector ever be really sustainable, taking into account GHG and other environmental aspects as well as the social implications of land-use change?

Sustainability Assessment and Reporting: What is the state-of-the-art in sustainability assessment and reporting, will these measures ensure a sustainable supply, and what role can the Bioenergy Agreement play in developing and implementing best practice?

The workshop included four sessions, each with three speakers, with time for facilitated discussion and short contributions from other attendees. The main points made by the speakers and during the discussions following each session are summarised below. (The full presentations are available on the IEA Bioenergy website www.ieabioenergy.com.)

SESSION 1 – THE POLICY FRAMEWORK

Biofuel Sustainability in the Renewable Energy Directive: State of Play – Kyriakos Maniatis, European Commission, Belgium

Kyriakos Maniatis provided the European context for the discussion by setting out the aims of the EU's package of measures on energy and climate change. This includes the Renewable Energy Directive, which sets national targets that, in total, will lead to 20% of the EU's total energy demand coming from renewable sources by 2020. This includes a target for 10% biofuels to be used for transport in each country.

The Renewable Energy Directive makes sustainability an essential condition for biofuels use in the EU. Fuels must reach the required sustainability criteria to contribute to the national targets and to qualify for national incentives. Sustainability reporting must be based on the best international science and norms and conform to the principles

of the World Trade Organisation. Currently these criteria apply to all biofuels for use in transport and to liquid biofuels for other energy uses. By 2010 the Commission will report on criteria for other energy uses of biomass. The criteria to be used cover GHG impact; land-use/carbon stock; biodiversity; and environmental requirements for agriculture.

The criteria will be applied to each consignment of biofuel, and must be legally meaningful, quantifiable, and verifiable. They will also be proportionate, placing a limited burden of verification on producers, and based on international trade law.

The criteria for GHG impact will involve a minimum requirement for GHG saving, relative to fossil fuel, of at least 35% (with a waiver until April 2013 for current plants). Biofuel producers can choose to use default values given in the Directive or show actual values that are better. The use of default values is not allowed for land areas in the EU liable to high N₂O emissions from cultivation. The rules for calculation of GHG savings must include all process steps; take end-use efficiency into account; account for land-use change; and allow for carbon capture and storage or replacement.

Allowance can be made for the energy contribution from co-products, except for agricultural crop residues. Criteria will also be applied to land-use change. Removal of raw material from forest undisturbed by significant human activity, highly bio-diverse grassland, and nature protection areas will be prohibited, unless removal is compatible with nature protection. There will be just one European sustainability scheme. Member States must apply the criteria laid down in the Directive and may not lay down conditions which go further.

There are penalties for not fulfilling the criteria. Non-compliant biofuels do not count towards EU targets, nor towards national biofuel obligations and may not benefit

from tax exemptions and similar financial or other support. Member States have primary responsibility for verification and will have to require companies to arrange an adequate standard of independent auditing of the information they submit, and provide evidence that this has been done.

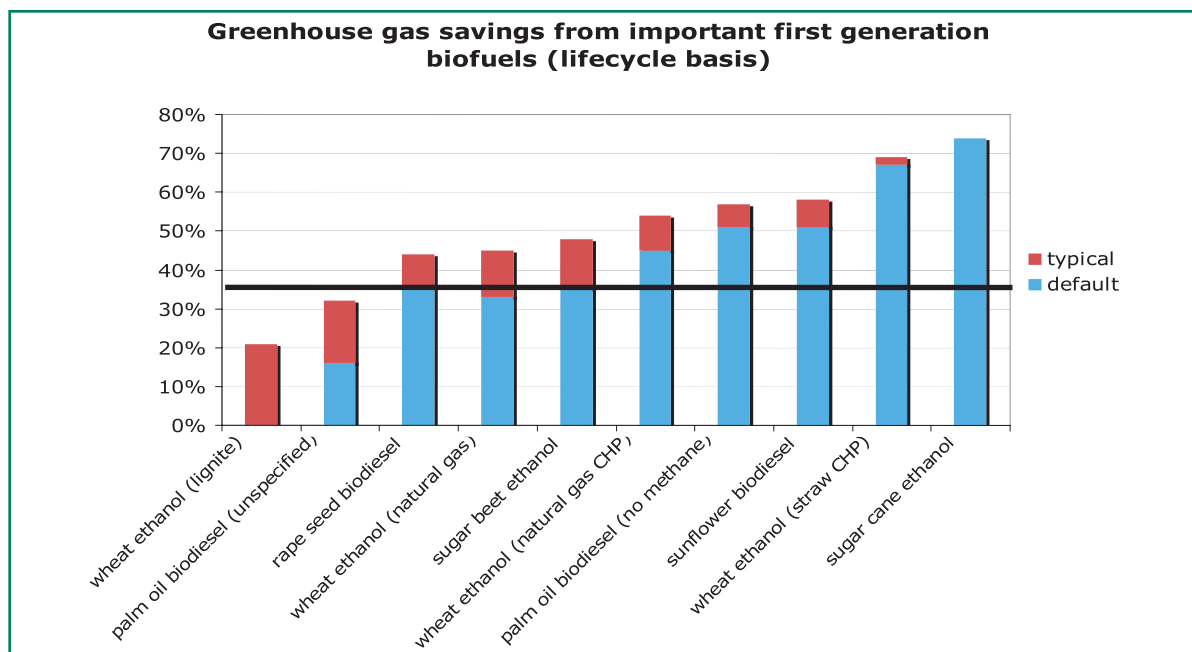
The Commission can approve certification schemes which meet the necessary criteria via bilateral and multilateral agreements between the Community and countries outside the EU and European economic area, or with voluntary national or international schemes. In these cases, all Member States must accept the evidence these schemes provide.

Member States must report every two years on developments in the availability and use of biomass resources for energy purposes; prices and land-use effects of biomass use; and impacts of biofuel production on biodiversity, water resources, water quality, and soil quality.

The Commission must report every two years on the environmental costs and benefits of different biofuels; the impact of increased demand for biofuels on sustainability; the impact of EU biofuel policy on the availability of foodstuffs in developing countries; and the impact of increased demand for biomass on biomass-using sectors.

In addition to the Renewables Directive, the Fuel Quality Directive (which specifies the quality of the fuels to be used in the EU transport market) also has certain provisions for the promotion of biofuels. These include a reduction of the CO₂ level per km driven and a 10% ethanol requirement in petrol. All the relevant institutions (The European Commission, European Council, and Parliament) agree that biofuels should comply with the same sustainability criteria in order to comply with each Directive's requirements. Good progress has been made in reaching agreement about the Directive. However, some major issues are unsettled, for example:

- the definitions of 'undisturbed forest',



PowerPoint slide from presentation by K. Maniatis.

- the reporting requirements for monitoring of the environmental and social impacts of biofuels production in countries outside the EU and European economic area, and
- certain elements of GHG methodology.

There is an ambitious timetable which should lead to agreement under the French Presidency by the end of 2008, adoption in 2009 and entry into force by March 2010.

The US Perspective: Drivers and Sustainability Considerations – James D. McMillan, National Renewable Energy Laboratory, DOE, USA

The USDOE vision is to realise a viable, sustainable biomass industry, producing renewable biofuels, bioproducts and biopower and so enhancing energy security; reducing petroleum dependence; providing environmental benefits, including reduced GHG emissions; and creating widespread economic opportunities.

Ambitious goals have been established. These include development of cost-competitive cellulosic ethanol by 2012, along with the '20 in 10' plan to reduce USA gasoline use by 20% within 10 years (by 2017). 15% of this reduction will come from the production and the use of 35 billion gallon/yr of alternative fuels (AFS), with a further 5% coming from higher vehicle efficiency standards (CAFÉ). The longer term plan ('30 in 30') is to displace 30% of USA gasoline consumption within 30 years, by ramping up biofuels production to 60 billion gallons/year by 2027.

Cellulosic ethanol is the main focus of USDOE's Biomass Program, along with scoping other alternative and renewable fuels in order to help prioritise work on fuels 'beyond' ethanol. The priority is replacement fuels for light-duty and diesel vehicles.

The strategy to achieve the goals has three main elements:

- an accelerated research, development and deployment programme,
- efforts to spur financial sector investment, and
- work to create supportive policies.

Success will depend on the simultaneous development of the supply, conversion, and demand infrastructure for cellulosic ethanol.

Sustainability is already a major thread within the USDOE programme, which focuses on *Renewable* energy (fuels), on the movement away from starch towards cellulose, and on enzymatic pathways which offer potential for more efficient and environmentally benign cellulose degradation. Key issues being addressed are land and water usage, along with a focus on high efficiency and low waste technologies. The programme is striving to integrate conversion platforms and high-efficiency CHP production systems through industrial symbiosis. A specific sustainability plan is being developed which will reduce exposure to future uncertainties and risks and strengthen the ability to meet the long-term goal of enabling the sustainable production of large volumes of biofuels.

The USDOE has announced funding commitments totalling over \$1 billion for biofuels-related projects since 2007. These multi-year investments include:

- \$385 million for commercial-scale biorefineries
- \$200 million for pilot-scale (10%) biorefineries
- \$23 million for more efficient fermentation microbes
- \$34 million for more efficient enzymes
- \$405 million for new bioenergy centres

Industry is sharing the cost of many of these projects, and some include foreign participants and/or technology.

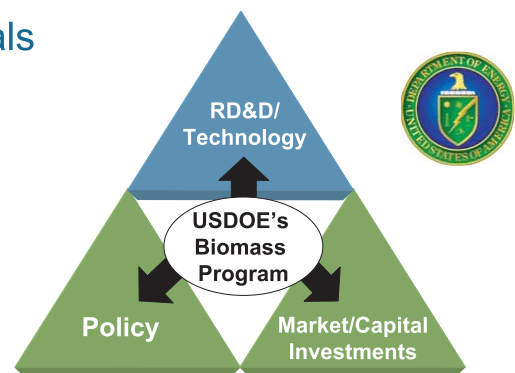
Two new areas of research have recently been launched. \$7 million has been made available to develop cost-effective methods for stabilising biomass fast pyrolysis oil. A further \$4 million is focussed on technology for the conversion of biomass to advanced fuels. The objective is to identify and develop improved approaches to biochemical processing (for pre-treatment, hydrolysis, saccharification, fermentation, etc.) and thermochemical processing (gasification, pyrolysis, synthesis) of biomass in integrated biorefineries.

In the longer term there is likely to be a progression from current production and use of biofuels, where ethanol from either crops or cellulosic raw materials are used as a blending fuel with gasoline, and biodiesel from vegetable oils is blended with diesel fuels. In the future a broader range of products may be produced, including green diesel produced from fats and waste oils in a refinery, higher alcohols (like butanol and higher carbon alcohols), Fischer Tropsch liquids from syngas, pyrolysis liquids and methanol-derived fuels and chemicals.

Leveraged Strategy to Achieve Goals

Three-pronged approach

- Accelerate Research, Development and Deployment (RD&D) program
- Spur financial community investment
- Create supportive policies



PowerPoint slide from presentation by J. McMillan.

Major DOE Biofuels Project Locations

Geographic, Feedstock, and Technology Diversity



May 14, 2008

McMillan IEA ExCo61 US Perspective

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PowerPoint slide from presentation by J. McMillan.

Brazil, EC and US Tripartite Work on Standards – Willie E. May, National Institute of Standards and Technology, Department of Commerce, USA

Willie May provided a summary of the White Paper on Internationally Compatible Biofuels Standards, released in February 2008, and also described the efforts of national metrology institutes to strengthen the measurement infrastructure necessary to support international trade in biofuels.

The work on Internationally Compatible Biofuel Standards is a joint initiative of a tripartite group from Brazil, the EU and USA. They have established two technical groups of experts for biodiesel and bioethanol and have been working to examine the compatibility of the standards for these two biofuels. The task forces have been considering bioethanol and biodiesel, and a combined report and executive summary was made public in February 2008 (www.nist.gov/public_affairs/biofuels_report.pdf). The results were reported to the International Biofuels Forum (IBF), initiated in 2007. The IBF is a government initiative involving Brazil, China, the EU, India, South Africa, and the USA, with the mission of creating an international market for biofuels. The IBF has also established a working group on codes and standards and it is envisaged that the tripartite team of experts will be further supported by experts from the other three countries. The task forces have reviewed existing specifications and classified them into three categories:

- A. those where specifications were already very similar,
- B. those where there were significant differences but where they could be aligned by further work, and

- C. those where there were fundamental differences and where reconciliation would be difficult to achieve because of some link to legislative actions.

They were also asked to describe the extent of work required to harmonise specifications and to prioritise next steps.

For ethanol the conclusion was that many items fell within Category A, with only water content falling under Category C, as shown in Table 1.

Table 1: Classification of Bioethanol Standards

Category A	Category B	Category C
Colour	Ethanol content	Water content
Appearance	Acidity	
Density	Phosphorus content	
Sulphate content	pH	
Sulphur content	Gum/residue evaporation	
Copper content	Chloride content	
Iron content		
Sodium content		
Electrolytic conductivity		

The situation for biodiesel is more complex, as there are many differences in composition and blending properties because oils from different plant sources are used. More work will be required to harmonise standards, as shown in Table 2.

Table 2: Classification of Biodiesel Standards

Category A	Category B	Category C
Sulphated ash	Total glycerol content	Sulphur content
Alkali and alkaline earth metal content	Phosphorus content	Cold climate operability
Free glycerol content	Carbon residue	Cetane number
Copper strip corrosion	Ester content	Oxidation stability
Methanol and ethanol content	Distillation temperature	Mono-, di-, and tri-acylglycerides
Acid number	Flash point	Density
	Total contamination	Kinematic viscosity
	Water content and sediment	Iodine number
		Linoleic acid content
		Polyunsaturated methyl ester

As a result of this work so far, the biofuels industry has access to tools to facilitate international trade and there is a better understanding of the reasons for differences in specifications. This appreciation, along with further alignment of standards where necessary, should enhance prospects for global trade in biofuels. The work will be built on through more work by the established network of specialists and by extending the network to include experts from China, India, and South Africa.

National metrology institutes can play a key role in providing an internationally accepted measurement infrastructure for biofuels, building on existing relationships and established mechanisms for comparing, harmonising, and reporting. A number of recent agreements (such as NIST participation in the EC FP7 BIOREMA contract and agreements between NIST and the EU's JRC Institute for Reference Materials, NIST, and Brazil's INMETRO, and with European national measuring institutes) will help develop these relationships.

SESSION 2 – TRADE AND PRODUCING COUNTRY PERSPECTIVES

Sustainable Ethanol: What is the Context? – Per Carstedt, SEKAB, Sweden

Per Carstedt made clear that a major shift is required to realise a sustainable transport system. The world might double its needs for transport by 2030 and at the same time have to reduce per capita CO₂ emissions. This could mean that each person might have an allowance of only 150 kg CO₂/year, or 60 litres of petrol per year for personal transport purposes.

Sustainable biofuels could play an important role as part of an efficient and clean transport system. For example, this could be achieved by using bioethanol from an advanced process as a biofuel in an efficient hybrid flexi-fuel car.

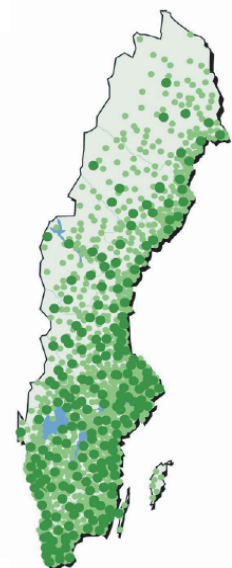
The use of biofuels as part of a low carbon and efficient transport system should provide opportunities for economic development for developing countries. Biofuels can provide renewable transport fuel for use in the producer country, so helping improve its balance of payments position and insulating the economy from changes in oil prices. Renewable fuel could also be exported. This approach could be particularly relevant to parts of Africa. These areas are most affected by rising oil prices while contributing least to climate change. They also have some of the best natural conditions for biofuels production and surplus land, with sufficient water and an available labour force. For example, in Tanzania only 1-2% of available arable land could provide 100% of current fuel needs. Initially, the priority may have to be on exports until local infrastructure for supplying and using the biofuel has been developed.

Unfortunately, biofuels have now become controversial and are receiving some negative press. This leads to the risk that consumers may become alienated and government commitment unnecessarily reduced. This would lead to a loss of the momentum which is needed to meet the challenge

A dynamic development

It took ten years to open the first 100 filling stations with E85.

The last 100 stations opened in the past three months.



PowerPoint slide from presentation by P. Carstedt.

of climate change. It is important to secure supplies of sustainable ethanol and to do this urgently, well before the EU criteria come into force, which may not be until 2010-2012.

SEKAB has been working on an agreement with Brazilian producers to produce ethanol which meets strict sustainability criteria. The main elements of this initiative are:

- a bilateral agreement between Sweden and Brazil to accelerate progress towards sustainable biofuels,
- an agreement between BAFF (BioAlcohol Fuel Foundation) and UNICA to implement a process that will move the entire industry in Brazil towards more sustainable production, and
- a commercial agreement between SEKAB and progressive producers in Brazil. This includes a joint process for developing sustainability criteria along with a commitment to produce and supply sustainable ethanol that is verifiable and traceable, until international procedures are established.

Sustainability criteria will cover six themes including a net reduction of fossil CO₂; mechanical harvesting; labour rights; child labour protection; environmental protection program; and rain forest protection. Verification and traceability will be secured with two audits each year in this new scheme.

Will New Biofuels Provide the Solution? – Dominic Boot, VNPI, the Netherlands

Dominic Boot, representing the oil industry from the Netherlands, suggested that biofuels could not provide a sustainable solution to the problems of oil shortages, security of supply or climate change mitigation. He suggested that concerns we are already approaching 'peak oil' are

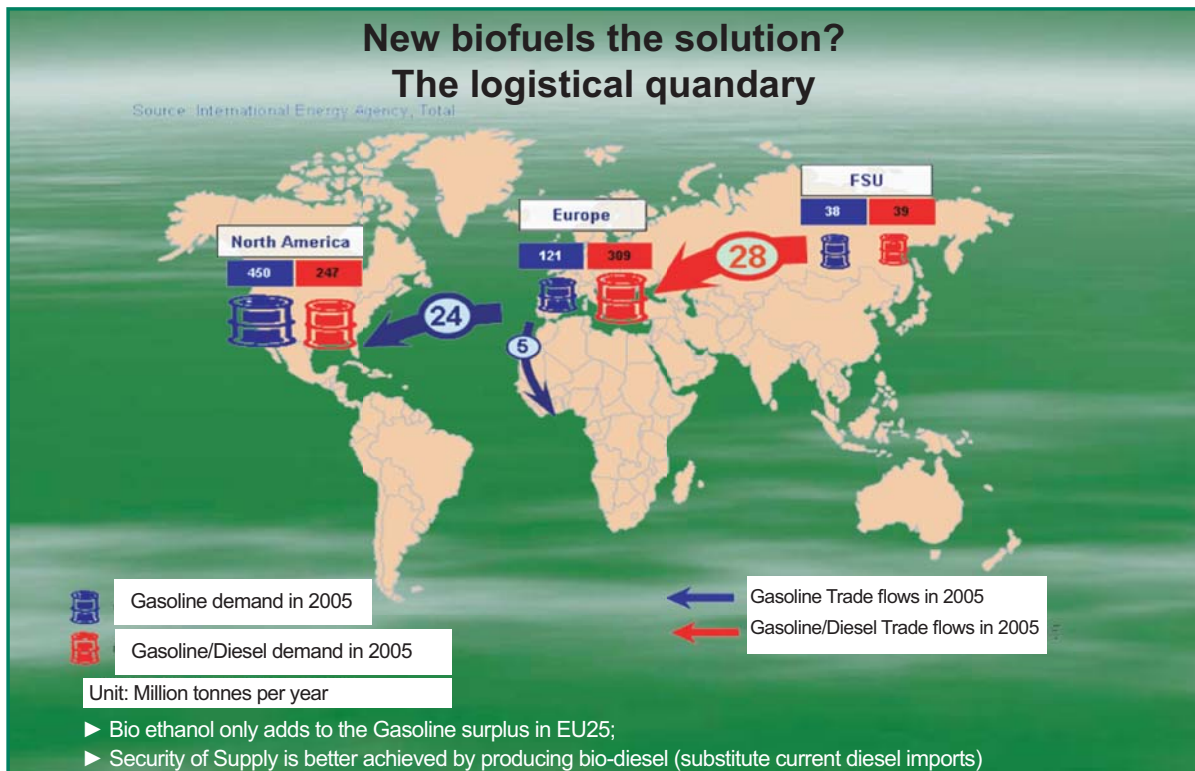
misplaced, since reserves are greater now than in 1965. However we may be at the end of the period of 'cheap oil'. If biofuel use were to rise to more than 4.2% of EU transport fuel consumption, the EU would have to import biofuels and so still be dependent on imports. He also suggested that biofuels are not an effective solution to the climate change issue since energy conservation will be a much more cost-effective way of reducing emissions from the transport sector. He supported Per Carstedt's enthusiasm for efficient electric or hybrid cars. He also argued that using available biomass as a fuel for combustion could be a better way of utilising available resources since this may be as much as five times as efficient.

He recognised that biofuels are now a political and commercial reality which are perceived as good for agricultural employment, and also that there is a conviction that the transport sector has to take its share of the burden of CO₂ reduction.

There are however a number of serious concerns. These include:

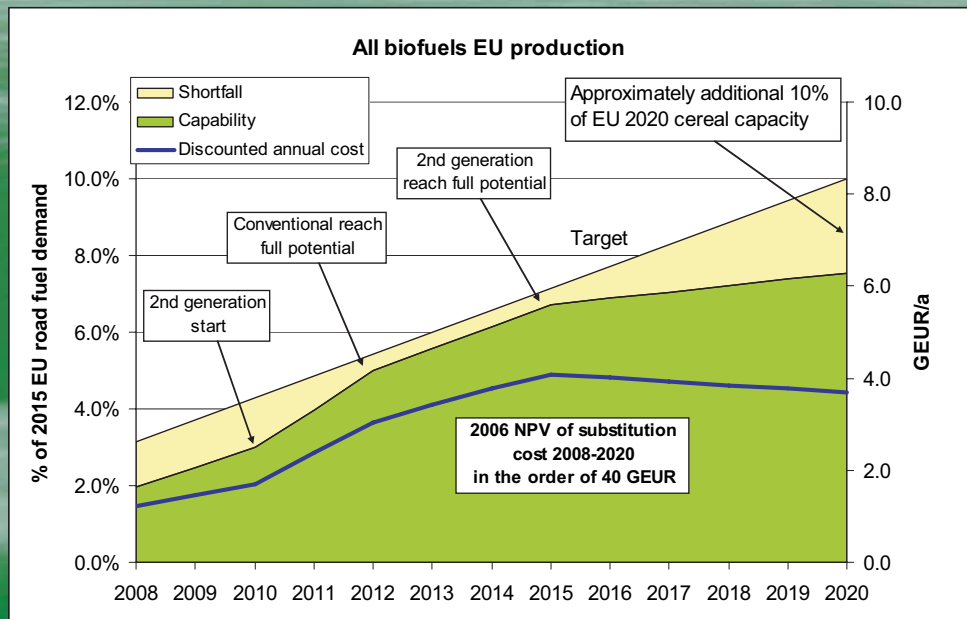
- the morality of using land for fuel production at a time when both food demand and food prices are rising,
- the concern that rapeseed cultivation leads to an increase in acidification of soils,
- the danger that biomass cultivation can lead to deforestation, higher emissions of GHG due to land-use change, and water level reduction, and
- the danger of habitat reduction.

Producing increasing quantities of ethanol in Europe could also exacerbate a logistical problem caused by the current EU gasoline surpluses.



PowerPoint slide from presentation by D. Boot.

“Sense” of Second Generation



Based on WtW

PowerPoint slide from presentation by D. Boot.

Boot questioned the role of 1st generation biofuels. The EU cannot produce enough resources to supply the targeted requirements. There are also problems in making fuels which can meet the precise fuel specifications that modern and future engines will require. He also questioned the role of 1st generation biofuels in creating a platform for 2nd generation fuels.

He felt that there might be some better opportunities associated with next generation technologies. For example, biomass pyrolysis oil could be imported directly into refineries, and biomass gasification may be used to produce biomass-derived liquids which can also be integrated at the refinery.

Some next generation biofuels might therefore make sense if they meet sustainability criteria. The development of these new fuels would also be in line with the Lisbon Accord which encourages innovation. The fuels should lead to better fuel quality and lower vehicle emissions, while also reducing the EU's logistical imbalance. However, questions still remain about the cost effectiveness of these new fuels.

The Brazilian Perspective – Alfred Szwarc, UNICA, Brazil

Alfred Szwarc said UNICA is the representative of bioethanol producers in the Sao Paulo region of Brazil. It represents 100 companies who are responsible for over 60% of sugar production, and 50% of the ethanol produced in Brazil. Their mission is to stimulate the development of a modern and

sustainable industry. Sugar cane production is concentrated in areas of Brazil which have both a wet and dry season and these are located over 2,000 km from the Amazon rain forest region. At present 1% of arable land (3.4 Mha) is used for bioethanol production. By 2020 Brazil aims to produce 65 billion litres of ethanol, with 16 billion litres available for export. This production would also simultaneously generate 15% of Brazil's electricity requirements.

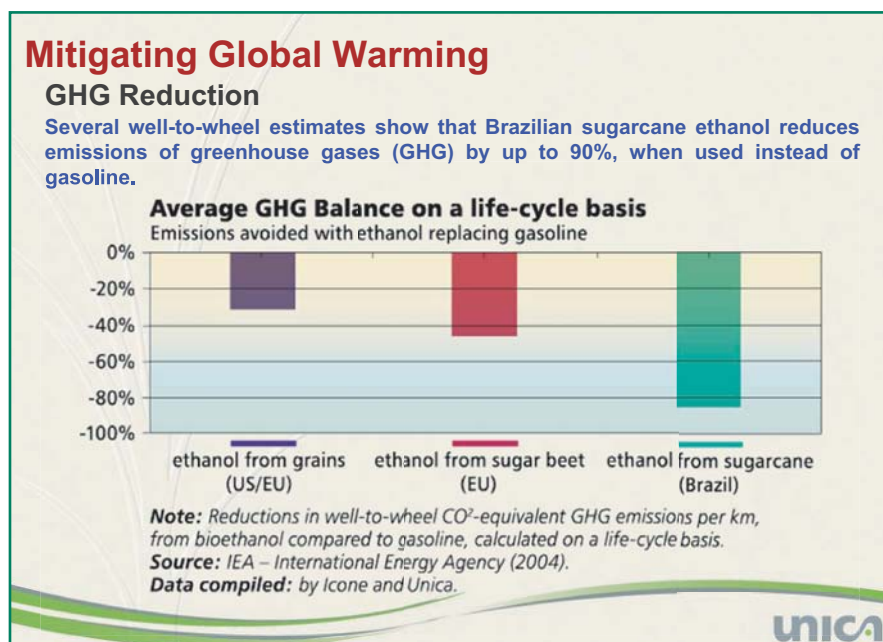
He noted that around 100 countries could supply ethanol based on sugar cane, whilst oil production is concentrated in 20 oil-producing countries.



Source: British Sugar

PowerPoint slide from presentation by A. Szwarc.

UNICA recognises the need to avoid the production of biofuels in sensitive areas where carbon stocks could be reduced. In Brazil sugar cane expansion is mostly taking place in pasture areas where a carbon credit may be generated. They also acknowledge concerns about indirect land-use changes (where displacement of food crops may lead indirectly to land-use changes elsewhere). However he suggested that these concerns do not take account of huge improvements in crop yields that are being achieved, and that they assume that crop displacement leads to land-use change in the most sensitive areas.



PowerPoint slide from presentation by A. Szwarc.

Several well-to-wheel estimates suggest that Brazilian sugarcane ethanol reduces emissions by up to 90% when used instead of gasoline – much better ratios than could be achieved by ethanol from wheat, sugar beet, or corn. The efficiency of land-use associated with sugar cane is also higher than that associated with other crops. Future developments in cellulosic fermentation of residues, which can be combined with conventional fermentation of sugar juices, may increase yields from 7,000 to above 12,500 litres of ethanol per hectare.

Brazil is now implementing agricultural and environmental best practices, and a Green Protocol has been signed between UNICA and the Sao Paulo State Environment Council (June 2007). This is set to ensure that all new sugar cane areas are harvested mechanically, that riverside forests will be protected, and strict measures are put in place to ensure soil and water conservation, and to minimise atmospheric emissions. This has already led to increases in mechanical harvesting and a 60% reduction in in-field cane burning. A further agreement between UNICA and FERAESP (a union movement) will lead to improvements in socio-economic conditions through the gradual elimination of outsourcing of sugar cane cutting, improvements in transport and in working conditions for rural workers and in transparency in the systems for labour evaluation and payment in sugar cane production.

UNICA believes that Brazil can play an important role in the development of a sustainable international trade in ethanol. This is currently being inhibited by markets protected by import tariffs, and by an increasingly complex set of uncoordinated certification procedures (a 'Babel of Certifications'). They believe that a multi-lateral and multi-stakeholder approach to the development of an ethanol certification system should be developed, covering all feedstocks and production processes and

based on the sustainability principles of economic feasibility, environmental acceptability, and social fairness. The system needs to be based on an accepted and agreed methodology, must apply the same criteria to fossil fuels, and take into account energy balances and GHG balances.

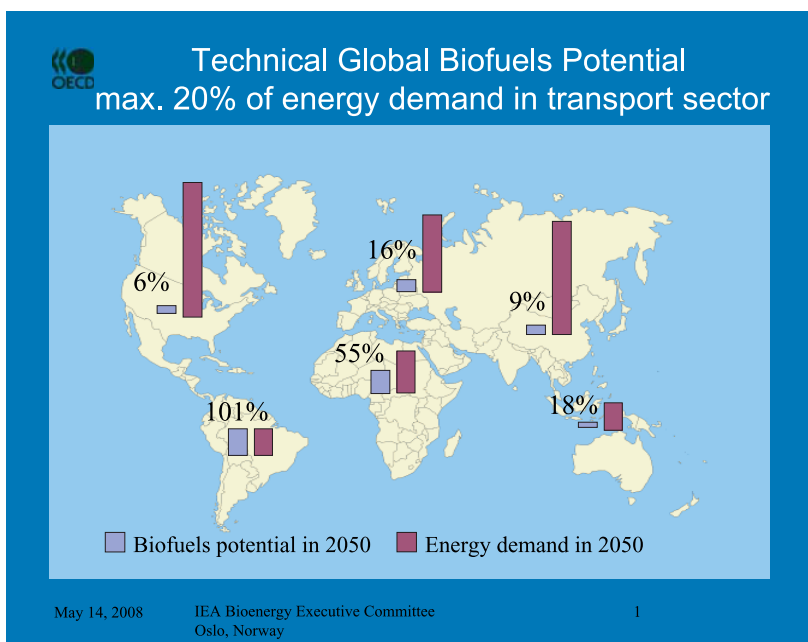
SESSION 3 – SUSTAINABILITY

Biofuels: Is the Cure Worse than the Disease? – Richard Doornbosch, OECD, Paris, France

Richard Doornbosch from the OECD presented an economist's perspective, arguing that biofuels have somewhat limited potential and that current policies were in fact leading to the deployment of solutions that were not likely to be helpful to the climate change issue.

His analysis took into account other land-uses (including the land for forestry, arable use, and pasture needed to support the world's growing population). At a yield of 190 GJ/hectare/year, biofuels production could amount to 14 Exajoules/year by 2050 (equivalent to 8% of transport demand). This estimate is low compared with others. It may still be over optimistic according to Doornbosch by over-estimating the amount of land that could be available and under-estimating the amount of land already in use and the effect of water shortages and of competing demands for the products.

The potential of '2nd generation' technologies was calculated based on the estimated availability of feedstocks which do not require dedicated land, i.e., crop and forest residues, and organic wastes. These feedstocks could be converted to about 24 Exajoules of biofuels per year by 2050 (12% of transport demand). Crops grown on marginal and degraded land have been mentioned as possible additional sources but these



PowerPoint slide from presentation by R. Doornbosch.

were not included in the calculation. Doornbosch also found a geographical mismatch between areas with high resource availability and transport fuel demand.

The economic potential has been estimated by the IEA as between 7% (2030) and 14% (2050) of energy demand in transport. These estimates assume that feedstock prices will decline, that technological breakthroughs occur, and that logistic costs are acceptable.

Referring to recent science articles, Doornbosch stressed that emissions from direct or indirect land-use change might significantly reduce the climate change benefits of increasing levels of biofuels production. Fargione et al., have argued that if allowance is made for the emissions associated with removal of existing vegetation along with losses due to carbon losses from soil because of cultivation, then the 'carbon payback' period for some biofuels can be very extended. Searchinger argued that the expansion of the use of corn for bioethanol in USA requires increased corn cultivation elsewhere to maintain supply to the global food sector. This results in land conversion to cropland around the world, with increased CO₂ emissions as a consequence.

Current policies are expensive, with support of between \$0.66 - \$1.40/litre available in the USA, and between \$0.77 - \$4.98/litre in Europe. This is equivalent to over \$500/tonne of CO₂ avoided in the USA, and between \$340 - \$4,520/tonne in the EU.

Doornbosch argued that the development of certification systems, while useful, were not a panacea, since they cannot properly take indirect land-use factors into account. Implementation would also have to deal with some significant practical issues including the need for international agreement and compliance with WTO rules, and issues associated with enforcement.

He also suggested that current policies, although costly, will lead to limited GHG savings (or even increases once indirect land-use changes are taken into account), could lead to other environmental dis-benefits, increase food insecurity, and do little to improve energy security. There was a need to develop an alternative policy agenda which included:

- phasing out some mandates and support schemes,
- support for the development of 2nd generation technologies,
- introduction of more technology neutral policies (such as carbon taxes and low carbon fuel standards), which stimulated energy efficiency, and
- accelerated certification developments.

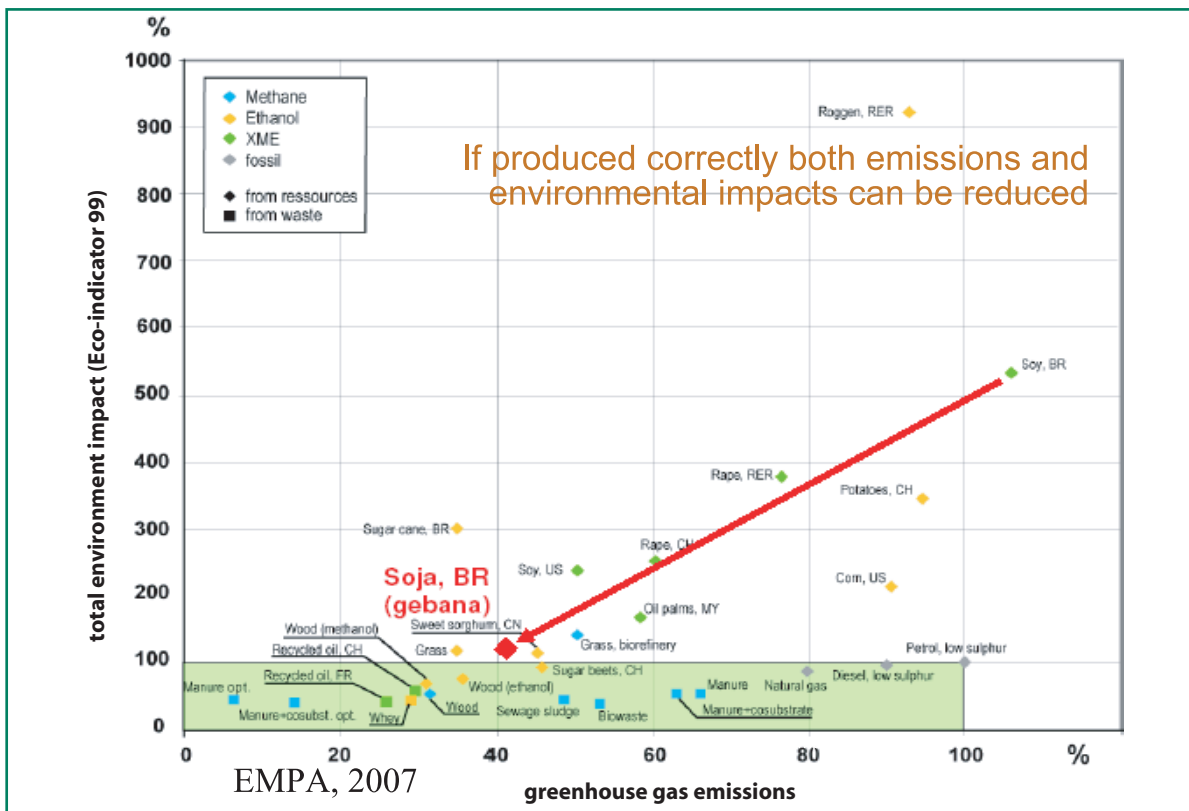
Sustainability of Biofuels: Challenges – Sampsa Kiianna, WWF, Finland

In his presentation Sampsa Kiianna emphasised that the problems and challenges presented by biofuels are serious. These include social issues, displacement effects causing deforestation, and increased food prices. However this does not necessarily rule out biofuels as an option, as long as they can be produced in a way that decreases poverty and does not have a negative effect on biodiversity.

He indicated that WWF's major goal was to avoid dangerous climate change, so that the increase in the earth's temperature was limited to 2°C. This would require GHG cuts of between 50-85% by 2050. WWF believes that key measures to achieve this include improving energy efficiency, stopping deforestation, developing low emission technologies and flexible fuels and storage, displacing coal with natural gas and carbon capture and storage. WWF has also worked for years to promote sustainable commodity production. There is now an opportunity to certify sustainable bioenergy products, and



PowerPoint slide from presentation by S. Kiianna.



PowerPoint slide from presentation by S. Kiianmaa.

WWF together with other partners, is also looking into the possibility of expanding such a system for all kinds of crops.

An evaluation of the environmental impacts of biofuels should be extended to take into account effects other than those related to climate change. In the best cases both GHG emissions and the total environmental impact can be reduced substantially, although some impacts are difficult to detect and quantify. N₂O and indirect land-use change impacts are very significant issues.

N₂O emissions can be limited through better management practice, such as limiting nitrogen use, encouraging conservation agriculture (which involves either no or low till cultivation systems; crop rotation and permanent coverage), and encouraging alternative fertilisers. The impacts of indirect land-use change can best be avoided through the use of idle/degraded land, the use of waste products and by more efficient use of existing agriculture and forestry land. Best practice could be encouraged by introducing a 'risk fee', payable where there is a lack of convincing evidence that these factors have been properly managed.

In industrialised countries, the final aim should be to electrify the transport system. Sustainable biofuels would best be used to extend the range for plug-in hybrid flex-fuel cars, rather than for use in more conventional vehicles. In developing countries, biofuels can be used to reduce dependency on oil and revitalise agriculture.

In the EU, the goal of meeting 10% of transport energy needs by renewables could best be achieved by reducing fuel

consumption by 10%, electrifying transport (providing 1-2%) and introducing 7-8% of biofuels from carefully selected and sourced feedstocks, backed up by a strong certification scheme.

If done well, bioenergy could reduce GHG emissions, increase investments in agriculture in developing countries and in degraded areas, create employment, and have a positive impact on other agriculture and forestry sectors. However this will require significant investment in sustainable agriculture in developing countries. Today, many countries suffer from hunger, often associated with very low levels of agricultural productivity. There are further challenges associated with deforestation, coupled with increasing meat consumption and an increasing population, and exacerbated by an increasing water crisis in various parts of the world.

Resources and Competition between Different Uses – Florian Kraxner, IIASA,

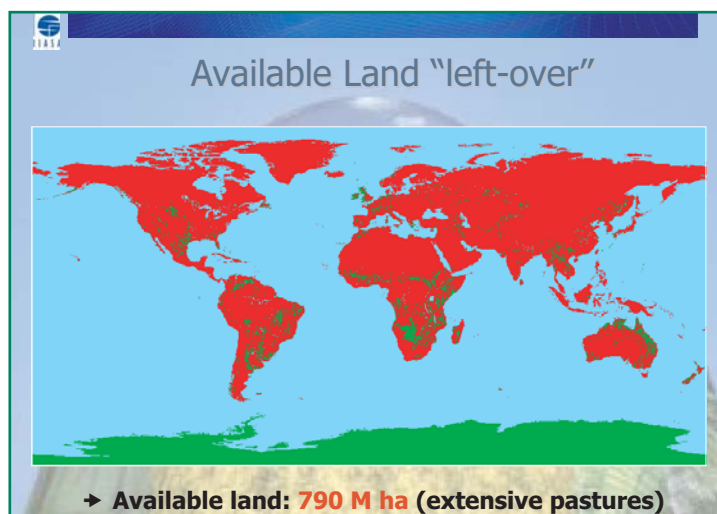
In his presentation Florian Kraxner argued that integrated land-use will be crucial for future sustainable global development. Bioenergy can provide a route to negative emissions for energy use, and without its deployment plans to stabilise CO₂ emissions are not likely to be feasible. However using biofuels will involve some trade-offs between risks. These could include risking some biofuels-induced deforestation in the short-term in order to reduce the risk of large-scale ecosystem breakdown tomorrow, or increasing risks of food shortages in the near future in order to reduce the longer term risks of large-scale famines and social disorder sparked by climate-induced disasters.

He noted the factors affecting the supply of food, fibre, and fuel. These include rising fuel prices and potential food shortages in some regions and rapidly escalating oil prices. A wood shortage is expected in Europe, projected to be as much as 200-300 million m³/year, and this has led to political recognition of the need to enhance wood supply. It will be difficult to meet the sometimes difficult to reconcile goals for security in food, energy, environment and social structure, and an integrated approach to land-use planning and management will be essential.

Several global energy models predict a substantial demand for bioenergy – these are all consistent with a long-term estimate of the order of 100-300 EJ/yr. Models of potential availability suggest that similar volumes of raw material could be available with estimates ranging from 170 to 270 EJ. However these results are very sensitive to assumptions about the prospects for technologies which are not yet established or commercially available.

Competition for land may also be an important factor, as demand for fuel and fibre grows. Population growth and diet changes will drive a substantial increase in demand for land, with cereal demand increasing by 67% by 2030. This will lead to increasing land requirements, although the extent of this is difficult to estimate with certainty as it will depend on the extent to which productivity increases can be achieved and on the impacts of climate change and water shortages on crop yields. In addition the demand for forest fibre is expected to increase significantly, from 1.6 billion m³/yr in 2005 to 2.0 billion m³/yr in 2030. Meeting this demand will require an increase in rapidly growing plantations of around 20-25 Mha. Availability of raw material for liquid fuel production will also face competition from other fuel uses, with conversion efficiencies being higher for heat and combined heat and power generation than for stand-alone liquid fuel production.

The amount of land available for fuel production is not well understood because of deficiencies in information about current land-use and availability, potential changes in productivity and fuel conversion efficiency, and uncertainties about future land demand for fuel and fibre.



PowerPoint slide from presentation by F. Kraxner.

It is clear the proposed stabilisation targets are unlikely to be met without a substantial contribution from bioenergy. This then poses a difficult dilemma. How should we balance the risks of problems caused by increasing biofuels production in the short-term against the larger and potentially more disruptive consequences of future climate change?

SESSION 4 – SUSTAINABILITY ASSESSMENT AND REPORTING

Environmental Issues of Biofuels – Uwe R Fritsche, Oeko-Institut (Institute for Applied Ecology), Germany

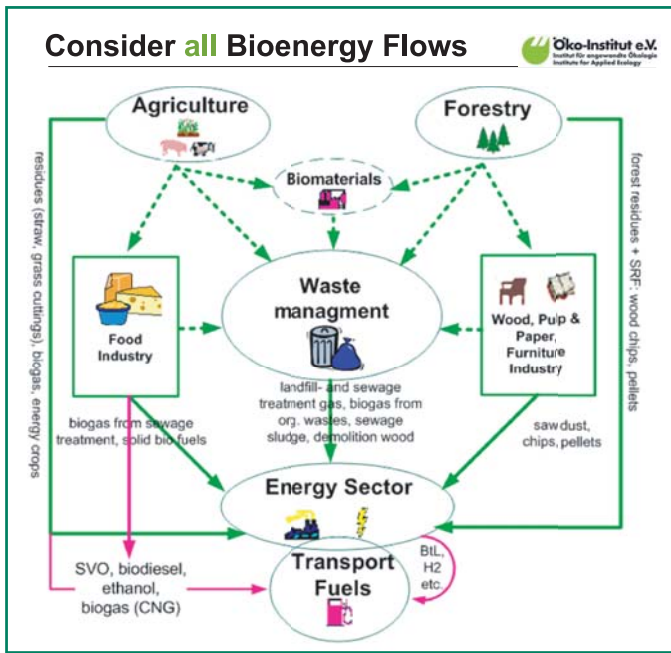
Uwe Fritsche noted that climate models consistently assume that bioenergy can make a substantial contribution to future energy demand, and this represents a substantial challenge. The contribution could best be provided from residues and wastes, followed by crops grown on degraded land, arable land and pasture land, although perversely, policies seem to incentivise these sources in the reverse order.

Bioenergy could have either positive or negative environmental impacts. It could lead to GHG reductions due to fossil fuel substitution, and could lead to improvements in agrobiodiversity by increasing soil carbon levels and reducing erosion. On the other hand it could lead to increases in GHG emissions from increasing levels of cultivation and via direct and indirect land-use changes. It could also lead to a loss of biodiversity from land-use change, water use, the use of agrochemicals and increases in erosion levels. Optimum use of bioenergy should be in the context of all biomass flows, including the use of agricultural products for food with residues cascaded for use in the energy sector.

A study by the European Environmental Agency has indicated that one very significant impact of climate change will be on biodiversity, and species numbers are projected to decrease sharply. Without new agricultural policies the current rapid decrease in the number of species is likely to continue.

Production of bioenergy should focus on the use of degraded and idle land – this should avoid competition with food production and avoid displacement effects. It should also lead to increases in soil carbon levels. On the other hand using this land could have a negative impact on biodiversity if mapping is not carefully carried out. In principle this mapping would be possible using currently available data, and screening criteria could then be applied to avoid areas such as high nature conservation areas. Further information is needed to allow assessment of the impacts of increasing water use from bioenergy farming systems and of the impacts on soil quality.

The significance of the impact of direct land-use change on GHG balances was noted. The serious potential impacts of indirect land-use change



PowerPoint slide from presentation by U. Fritsche.

were also discussed, with energy plantations potentially displacing food and feed crops, which in turn leads to land-use change as these crops move into forest, wetland, or other protected and high value nature areas. Accounting for these effects is difficult. It is important to deal with the whole of the agricultural and forestry sector, not just the bioenergy sector, since all land-use change may have indirect effects. It is difficult to identify what displacement may occur and where it might be. From a policy perspective it is difficult to identify effective instruments which avoid 'spill-over effects'.

It is possible to account for the impact on GHG balances of indirect land-use changes using an 'indirect land-use change factor' or 'risk adder' approach. Table 3 shows indicative values.

Care should be taken with using default values for direct and indirect land-use changes. Values representing real and representative situations should be used where possible. In

practice the impacts can be more positive for biofuels than default values may indicate.

GHG emission balances will become the key issue in biofuels trade, but these must include real values for both direct and indirect land-use change. Methods for verification of GHG effects of direct land-use change need to be harmonised and made more sophisticated. Setting GHG limits for biofuels can reduce the risk of negative biodiversity impacts. Improved mapping of high nature value areas and of degraded lands is needed, along with issues relating to soil and water restrictions. However bioenergy can also provide an opportunity to improve these lands.

So far only a few developing countries use a life-cycle approach to GHG emissions from bioenergy, or take account of biodiversity and social issues. There is a need to actively support these countries to develop sustainability and certification systems. UNEP and GBEP can play an important role here.

Carbon and Sustainability Reporting in the UK – Jessica Chalmers, Low Carbon Vehicle Partnership, United Kingdom

Jessica Chalmers described the work undertaken in the UK to develop sustainability reporting for biofuels. In a situation in which public and political concerns about the sustainability of biofuels have a high profile, the aim is to ensure that unintended negative consequences of biofuels market development are minimised, that claims are based on good evidence, that 'greenwash' is avoided, and that GHG savings are maximised. The solution must involve shared responsibility between fuel suppliers and governments.

The UK introduced the Road Transport Fuel Obligation (RTFO) in April 2008. This requires suppliers of transport fuels to sell a mandated proportion of renewable transport fuel each year. They receive certificates for each quantity of renewable fuel they supply. If they have a shortfall in certificates they must either purchase certificates from

Table 3: Indirect GHG: 'ILUC Factor'

biofuel route, life-cycle	kg CO _{2eq} /GJ with ILUC factor including conversion/by-products, without direct LUC			relative to fossil diesel/gasoline including conversion/by-products		
	max	med	min	max	med	min
Rapeseed to FAME, EU	260	188	117	201%	118%	35%
palmoil to FAME, ID	84	64	45	-3%	-25%	-48%
soyoil to FAME, Brazil	101	76	51	17%	-12%	-41%
sugarcane to ETOH, Brazil	48	42	36	-44%	-52%	-59%
maize to ETOH, USA	129	101	72	50%	17%	-16%
wheat to ETOH, EU	144	110	77	67%	28%	-11%
SRC/SG to Btl, EU	109	75	42	26%	-13%	-51%
SRC/SG to Btl, Brazil, tropical	34	25	17	-61%	-71%	-80%
SRC/SG to Btl, Brazil, savannah	59	42	25	-32%	-51%	-71%

Reporting on the sustainability of biofuel under the RTFO is based on existing voluntary standards

Environmental/social principle	SAN/RA	RSPO	Basel	LEAF	ACCS	EUREP GAP IFA	FSC	SAI	IFOAM	Pro-terra	
Conservation of Carbon	Qualifying standard										
Conservation of Biodiversity											
Soil conservation											
Sustainable water use											
Air quality											
Workers rights											
Land rights											



PowerPoint slide from presentation by J. Chalmers.

another company or else pay a buy-out price of £0.22/litre. The scheme is administered by the independent Renewable Fuels Agency. Suppliers must report on the carbon balance and sustainability of the fuels supplied. From 2010, it is proposed to link the award of certificates to the carbon intensity of the biofuels and from 2011 to issue certificates only to sustainable biofuels.

Suppliers must provide confidential monthly reports on each batch of fuel, covering all fuels produced in or imported into the UK. Companies will publish annual reports on performance, and the RFA will publish comparative performance. Each company will have increasingly stringent targets for performance but will not face penalties if these are not achieved. Company reports will have to be independently verified and audited.

Reporting on the sustainability of biofuels covers a broad range of issues: conservation of carbon, conservation of biodiversity, soils conservation, sustainable water use, air quality, workers rights, and land rights. Reporting is based on existing voluntary standards. Where these standards are fit for purpose, they are designated as Qualifying Standards under the RTFO.

For carbon balance calculations there is a tiered approach using a range of increasingly specific default values and actual data as increasing information becomes available. These can range from fuel defaults (e.g., ethanol) based on conservative values, thorough to actual data where available.

In future the RTFO will move to reward fuels which have the best GHG balance. This should provide enhanced incentives for advanced '2nd generation' fuels, but care will need to be taken in developing the methodologies for doing this to ensure that some fuels are not over-rewarded.

Sustainability assurance is a key issue in trying to ensure that biofuels are as sustainable as possible and to avoid as far as is possible

unintended negative effects of their adoption. However at present the reporting system cannot address all the issues. In particular the methodology does not address the indirect effects of biofuels on land-use change, and the potential GHG consequences. The UK Government has asked the RFA to review these aspects and to report by the end of June 2008. (See www.dft.gov.uk/rfa/)

Nordic Swan Initiative for Biofuels Labelling – Tormod Lien, Nordic Ecolabelling, Norway

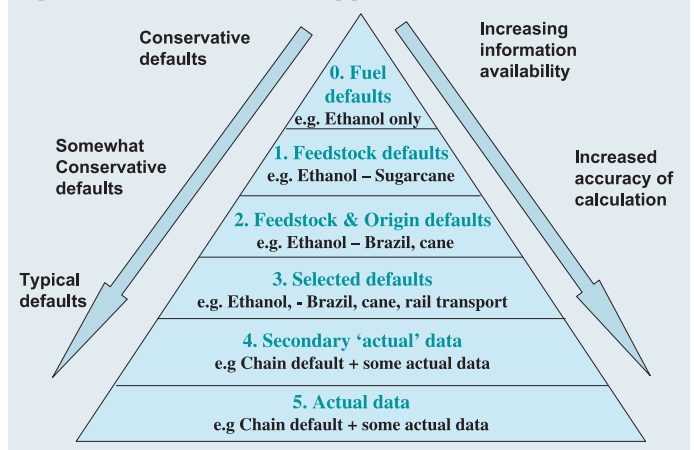
Tormod Lien described the Nordic Swan initiative for biofuels labelling.

This is a voluntary labelling scheme designed to combat myths about biofuels. The scheme is based on simple guidance and aims to provide ethical suppliers with a way of using the environmental performance of their products to provide a competitive marketing edge.

The scheme relies on a straightforward list of criteria which will be continuously improved over coming years. The ecolabelling requirements cover GHG balances, energy consumption, raw material production, health and quality of life issues, and ethics.

The standard for GHG balance is 50g CO₂-equivalents/MJ of fuel, on a well-to-wheel basis. Energy consumption in fuel production should be limited to 1.4 MJ/MJ of fuel. Raw materials used should consist of at least one third renewable material, the sources of the feedstock should be traceable and certified where possible, and a CO₂ balance should be calculated. As far as health is concerned, the production must avoid release of any carcinogenic substances, meet fuel quality standards, and conform to UN and International Labour Organisation conventions.

A tiered approach to defaults provides a practical and flexible approach to carbon calcs



PowerPoint slide from presentation by J. Chalmers.

DISCUSSION AND CONCLUSIONS

Biofuels can clearly play an important role in the future energy mix. Many models that point the way to a world energy mix which can reduce the worst impacts of climate change rely heavily on biofuels. The market for biofuels has been growing strongly, driven by governments who have seen biofuels as an important contributor to their attempts to mitigate climate change and to ensure energy security. However, growing concerns about the sustainability of biofuels are leading to a reappraisal of the potential role of biofuels. It is important that this reappraisal is evidence based, rather than on myth and generalisation. It is clear that some routes to the production of biofuels can be unsustainable, but equally clear that other routes can lead to environmental, economic, and social benefits.

Biomass is much more democratically distributed around the world than oil. Biofuels production could offer significant benefits to developing countries and allow them to insulate themselves from global fossil fuel price fluctuations. In the short-term, their strategy may need to be based on exporting to developed countries, until their infrastructure is fully developed. However, given the sensitivities related to land-use in these countries, special attention will have to be put on sustainable production and the development and application of certification schemes.

The use of biofuels for transport should be an integral part of the development of a sustainable transport policy. Putting their use in the context of evolving transport technology and infrastructure and using biofuels in more efficient vehicles such as hybrids reduces the land-use impacts of increasing biofuels production, and minimises undesirable environmental and social impacts of biofuels production.

While the focus of this workshop was on liquid biofuels, it is important to recognise that the supply of biomass for energy purposes has to be seen in the context of the global supply of food, feed, and fibre, particularly given the complex impacts of indirect land-use change. In this context, ideally any biomass produced for whatever purpose or use should meet certain sustainability criteria, otherwise there will be 'market leakage' of carbon.

It is important that decisions around biofuels are based on the best available methodologies and information. There are now well-developed methodologies and reliable information available covering most of the direct impacts of biofuels production and use. It would be helpful now to develop a harmonised international approach for these assessments, as there are dangers associated with generalisation and the use of default values in calculating GHG balances. The impacts can be significantly influenced by specific local factors and where possible real representative values need to be used.

Certification procedures can play an important role in improving and assuring the sustainability of biofuels, although no system can be developed which can absolutely guarantee the sustainability of biofuels. It is important that producing nations are fully involved in the development of these procedures.

The procedures need to recognise the need to trade off benefits against negative impacts, and the need to optimise biofuels

use in the short-term, given the urgency of the climate change issue. Certification systems can also be used to stimulate the development of next generation technologies, but these must be designed carefully if perverse incentives are to be avoided. Harmonisation of the systems under development is essential to development of an international trade in biofuels, to avoid a plethora of subtly differing systems and standards. These need to be accompanied by an effort to reduce and remove unnecessary tariffs which may inhibit international trade.

There are many areas where there are gaps in the data, information, and methodologies needed to properly consider the sustainability of biofuels. An international effort is required to fill these gaps. Particular issues highlighted during the workshop included:

- methodologies for considering indirect land-use change,
- definitions and information on idle and underused land, and
- methodologies and policies to incentivise sources and processes which optimise GHG savings.

The development and commercialisation of 'next generation' biofuels sources and processes offers the prospect of systems with better overall carbon balances and reduced land-use change impacts. Such systems should be encouraged so that they come into production at the earliest possible opportunity.

A concerted international effort is required if sustainable routes to biofuels are to be established and to play an important role in a sustainable energy future. The way forward should include the following measures:

- international harmonisation of standards and certification methodologies;
- concerted international efforts to identify key uncertainties in methodology and data, and a concerted effort to fill these gaps;
- priority for the development, demonstration and commercialisation of improved technologies;
- identification of 'best practice' examples of sustainable biofuel production and development of 'best practice' guidelines; and
- identification of major international opportunities for sustainable biofuels production, including those in developing countries, accompanied by technology transfer and assistance with investment in the necessary infrastructure.

IMPLICATIONS FOR IEA BIOENERGY

The Bioenergy Agreement is already playing a key role in the development of a sustainable global biofuels industry, with many of the existing Tasks contributing expertise and knowledge to the field. The output from this workshop will have a far-reaching impact on the development of future work in the Tasks and the Executive Committee. It will also influence the work in the national programmes of Member Countries.

IEA Bioenergy will strengthen its efforts to collaborate with other international bodies working in this field as part of a comprehensive communication effort – currently under development. Also, the Agreement should be able to play an important role in the identification of methodological and information gaps. Additionally, it should be able to work to fill these gaps, and to contribute new technology development including 'best practice' guidelines.

REFERENCES

The presentations from the workshop are available at www.ieabioenergy.com

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Adam Brown also convened an editorial group comprised of the rapporteurs, the Vice Chairman, Birger Kerckow, and the Secretary, John Tustin, to prepare and review drafts of the text. John Tustin and Adam Brown facilitated the editorial process and arranged for final design and production.

IEA Bioenergy

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