Biofuels, sustainability and the petroleum industry






IPIECA

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Acknowledgements

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Executive summary

The benefits for society of biofuels for the transport sector depend on the ways in which biomass is grown and converted to biofuels, i.e. the biofuels system as a whole. Benefits can include improvement of energy security, rural development, and the reduction of GHG emissions.

Biomass is a renewable, but limited resource which, even in optimistic scenarios, considering the current technology, can only be expected to cover a modest fraction of the world's energy needs. If GHG reduction is the prime objective then governmental policy instruments should ensure that biomass is used where it maximizes GHG avoidance, or where it is the best available alternative to replace carbon intensive energy products. This can only be achieved through assessing and comparing the different possible ways to use the available bioresources. These may be different from country to country and region to region; this should be recognized when regional mandates for biofuel utilization are being considered.

Large-scale development of biofuels raises a number of concerns relating to competition with food and pressure on land resources, potentially leading to reduction in food availability, increased food prices and encroachment on sensitive land areas and forests. In some cases, when biofuels production causes clearing of high carbon content land, substantial CO_2 emissions can be produced that may impact the GHG emission benefits of a biofuels system for decades. Many of these effects can only be realistically assessed by considering the performance of specific biofuels systems as well as effects outside a biofuel system's boundaries.

As FAO states, biofuel production involves both opportunities and risks for food security and environment. To effectively manage the impact on food security the establishment of specific public policies regarding the production and consumption of biofuels is needed.

IPIECA members support the development, ultimate adoption and government enforcement of an internationally recognized, transparent and accepted certification scheme, such as that presently under development by the Roundtable on Sustainable Biofuels (RSB). Such a scheme should, at a minimum, include a fair and complete assessment of the GHG footprint of biofuels, an assurance on food competition and availability, and an assessment of the environmental and social issues associated with their production. Only through this process can biofuel systems be properly assessed for their sustainability credentials.

Introduction

Biofuels continue to become an increasingly important feature of the road transport fuel scene. In the USA, Europe and many other parts of the world, governments grant incentives and impose mandates, while research institutes and companies develop new technologies and pathways to convert biomass into substitutes for conventional fossil transport fuels such as gasoline and diesel.

These initiatives all aim to capitalize on the positive effects that biofuels can have on greenhouse gas (GHG) reduction, energy security, and rural development. However, large-scale introduction of certain biofuels can also have unwanted negative environmental and socioeconomic effects, and these effects have recently spurred a worldwide public debate on the sustainability of biofuels, including their effect on food prices.

The object of this short report is to analyse the reasons behind the growth of this new fuel, and describe the challenges and opportunities presented to the petroleum industry by the large-scale production and use of biofuels.

This report shows that all sections of society—policy makers, the petroleum industry and those living on agricultural land—have a role to play in ensuring that biofuels development is effectively regulated, so that the economic and environmental benefits may be realized in a sustainable manner.

Because of the foregoing, IPIECA supports the development of a Global Certification Scheme to ensure that the information on the sustainability of biofuels production is practical, standardized, verified and transparently communicated.

Biofuels for the transport sector

'Biofuel' is a generic term used to designate fuels that are produced from biomass, i.e. crops, wood or residues and waste material from a biomass origin. Although biofuels are generally understood to mean transport fuels and more specifically road fuels intended to substitute for gasoline or diesel, new opportunities for their use, such as railway fuels, are becoming apparent, and others, such as aircraft fuels, are under development. A brief description of current and potential future pathways to various biofuels can be found on pages 4–7.

Transport is about moving people and goods in vehicles with the corollary that space and weight come at a premium. The high energy density of liquid fuels—including biofuels—are therefore a key attribute and, to date, no practicable non-liquid alternative energy source has come close to achieving this energy density.

Another fundamental reality is that there are large established vehicle fleets and fuelling infrastructures and these cannot be changed or replaced overnight (or even within a much longer time-frame). The supply chain is up and running and must continue without even minor disturbances to enable uninterrupted economic activity. Fleet turnover of conventional vehicles—in developing countries in particular—can take an extended period of time and can be extremely costly.

The ideal biofuel for transport will therefore be a liquid with maximal energy density, like its conventional fuel counterpart. It will also be fungible with existing hydrocarbon fuels to enable blending in various proportions without creating major problems within distribution infrastructures or vehicles. This in turn points to liquids with hydrocarbon-like molecules. In addition, these bio-components will have a favourable greenhouse gas balance throughout their life cycle compared to hydrocarbon derived fuels, when assessed on an energy basis. Further, biofuels should not require an overly costly and complex manufacturing infrastructure. Optimizing a fuelling supply chain to meet these requirements narrows the biofuel utilization options considerably.

The above suggests two potential 'modes' for the introduction of biofuels in transport:

Mainstream fuels

If biofuels are to become part of the mainstream they will need to conform to the requirements for transport fuels, and be capable of being used by consumers without requiring any modifications to their vehicles. Fuels containing biofuels are common in many markets now: examples are gasoline containing 5 per cent and 10 per cent ethanol (E5 or E10 respectively) and diesel containing up to 5 per cent biodiesel (B5). These fuels are currently retailed as maingrade fuels in many markets. Newer 'flex fuel' technology vehicles may allow the mainstreaming of higher concentrations of biofuels within the fuel chain, as they are capable of utilizing biofuel-conventional fuel mixtures, in any proportion from 0 to100 per cent.

Niche markets

In this case fuels with particularly attractive properties or benefits can be envisaged even if they cannot be introduced as maingrade fuels. Examples are E85 (gasoline containing up to 85 per cent ethanol), pure biodiesel (B100) and blends of un-hydrogenated vegetable or animal fats (see page 5) as these are not compatible with the entire vehicle fleet and might require specially adapted vehicles. A final example is DME (dimethyl ether), which is a diesel fuel which can be made from biomass sources, with very beneficial emission characteristics (clean burning and low pollutant emissions) but it is gaseous at ambient temperatures and therefore needs a dedicated delivery system like LPG. Examples of niche markets for these fuels are 'captive' bus and industrial transport fleets, or specially adapted passenger vehicles (as in the case of E85).

An overview of current and future biofuels systems

A large range of suitable compounds can, in principle, be produced from biomass. To date, biofuels have mostly been produced from food crops, (many of which are 'non-staple' foods, such as sugarcane, sorghum and palms) by utilizing their oil, sugar or starch content. The use of non-food crops is being developed, although the current use of jatropha and other non-edible crops is very small.

Biocomponents for gasoline

Ethanol is produced by fermentation of sugars from sugarcane and sugar beet, as well as cereals (through hydrolysis of starch), and can be used as a substitute for gasoline in spark ignition engines. Although pure ethanol can be used, for practical reasons it is more often used in mixtures with conventional gasoline. Most existing gasoline engines and fuel systems can

Rape, also known as canola (left), is the favourite biodiesel crop in Europe, whilst soya (right) is the crop of choice in the Americas.

tolerate mixtures of up to at least 5 per cent by volume (v/v) ethanol and, in most cases up to 10 per cent (E10). Additionally, E20 to E25 blends have been used for several years in Brazil. High level mixtures such as 'E85' (up to 85 per cent ethanol) require specially designed vehicles which are normally capable of operating with any mixture of gasoline and ethanol ('Flex Fuel Vehicles').

Ethanol is also used in the form of ETBE (ethyl tert-butyl ether) after reacting with isobutene derived from oil refineries. In practice ETBE replaces MTBE, a similar compound made from methanol. Note, however, that MTBE has been banned by many states in the USA, mainly due to concerns over groundwater contamination.

As with any other fuel, caution is required when reformulating for biofuels, to avoid known issues including sticking valves and interference with exhaust after-treatment systems.

Biocomponents for diesel

Vegetable oils can, in principle, be used in diesel engines. Because of issues related to stability and viscosity, the oil is first reacted with an alcohol to form an ester known as biodiesel. Methanol is normally used, hence the generic name of FAME (Fatty Acid Methyl Ester) as a synonym for biodiesel. Oil from a range of crops can be used although some oils can experience stability issues even after esterification, due to oxidation. The use of anti-oxidant additives can help to solve this problem. Rape (also known as canola) is the favourite biodiesel crop in Europe. Soya is the crop of choice in the Americas. Palm oil, mostly produced in South-East Asia, can only be used in limited quantities in colder climates because of unfavourable cold flow properties. More exotic crops such as jatropha have also been proposed, e.g. in India in relation to use of low-quality land and flexible growing conditions. Tallow oil and used cooking oils can also be turned into biodiesel, however only limited quantities of these materials are usually available for biodiesel production.

Jatropha is one of a range of non-edible crops currently used to produce biofuels, although its use is currently small.

Biodiesel can be used either neat in appropriate vehicles where permitted, or mixed with conventional diesel at low levels in existing vehicles. The use of blends above 5 per cent by volume in modern light-duty diesel engines is currently the subject of intense discussion in Europe as auto manufacturers claim that biodiesel interferes with exhaust after-treatment systems and injector performance, and is related to lubricant dilution. Biodiesel has also been linked to other automotive issues such as valve sticking on standing and poor cold-flow properties. A number of these issues are potentially capable of being addressed through the use of additive packages, however this demonstrates the need to use caution when reformulating to use biofuels.

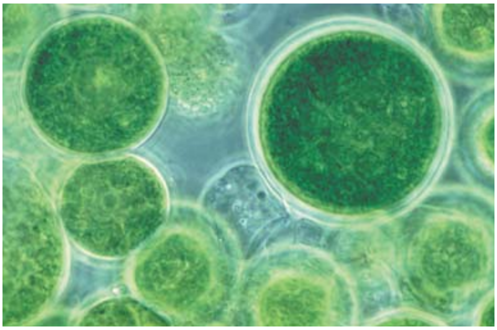
Another way of using vegetable or animal oils and fats is through hydrotreatment whereby these oils are turned into saturated hydrocarbons similar to conventional diesel, albeit of a distinct quality, approaching that of 'BTL' (Biomass-To-Liquids, see below).

Biogas

Biogas is produced by anaerobic fermentation of—mostly waste—biomass. After purification and treatment it consists essentially of methane (similar to natural gas) that can be used in specially adapted vehicles.

Current and advanced biofuels

Ethanol and biodiesel made from food crops are often referred to as 'first generation' or 'current generation' biofuels in contrast to future options ('next generation' or 'advanced' biofuels). Most current biofuels are made from food crops that were not originally developed for energy production. In many cases, during processing, only part of the plant is used to make the fuel, leaving large amounts of



The production of biodiesel from microalgae is at the forefront of research into potential 'advanced' biofuels.

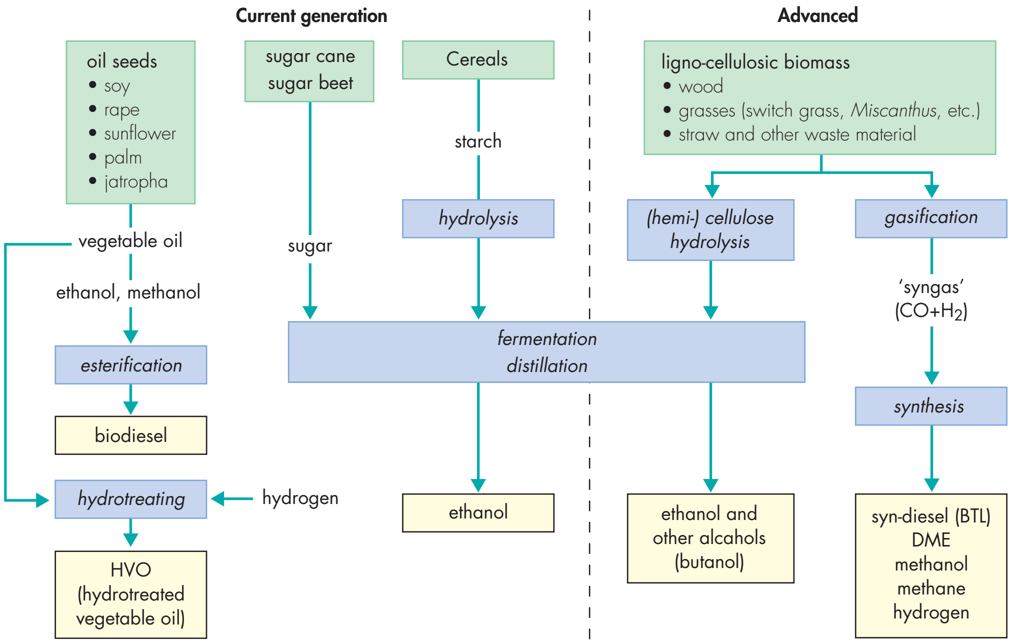
material that may in some cases be used for food, fodder or energy production.

The search for advanced biofuels is therefore driven by a desire to broaden the range of plants—including algae—that can be used and to maximize biofuel production from a given piece of land. Some of the most cutting-edge biofuels research currently ongoing involves the production of biodiesel from microalgae and ethanol production from lignocellulosic residues.

Investigations into the use of advanced biofuels focus on ligno-cellulosic biomass, i.e. wood, a wide range of 'woody' plants such as fast growing grasses as well as waste material such as straw. There are two main routes:

1. The first route turns cellulose and hemi-cellulose into fermentable sugars from which ethanol or other alcohols can be produced.
2. The second route synthesizes molecules after gasification of the biomass into 'syngas'. The process is similar to that applied to natural gas and coal to produce

Figure 1: An overview of the different routes to biofuels production



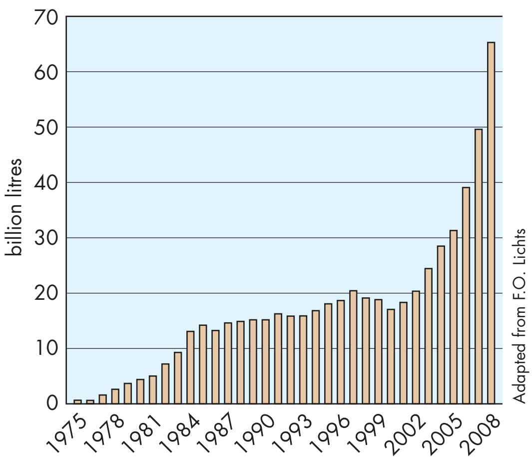
liquid fuels (the Fischer-Tropsch process). A range of compounds can be produced such as methanol, dimethyl ether and synthetic diesel (the latter being known as 'BTL' for 'Biomass-To-Liquids'). It is also possible to produce methane or hydrogen through this route.

Although all these processes require energy, most of that energy can be provided in the form of biomass so that the final fuels will have a very small GHG footprint. Figure 1 provides a schematic overview of the different routes. As is the case for fossil fuels, the energy carried in bio-components stems from their carbon and hydrogen content. In biofuels the carbon originates from recent biomass and therefore from the conversion of atmospheric CO_2 by the original plant. When the fuel is burned the carbon is turned back into CO_2 and the cycle is completed. In theory, no carbon is either added or removed from the atmosphere and one would conclude that biofuels are fully 'carbon neutral'. In practice, however, this is not the case inasmuch as energy is required to grow crops and manufacture biofuels, some of which is from fossil origin. Other greenhouse gases may be emitted at various stages, particularly N_2O, a very potent GHG which is emitted from agricultural fields. The mechanisms by which biofuels can influence greenhouse gas emissions is treated in more detail on pages 14–16.

Current biofuel usage and foreseeable developments

Ethanol derived from crop starch (e.g. from corn) or simple sugars (e.g. from sugar cane) is currently used to substitute for gasoline. Esterified vegetable oils (fatty acid methyl esters (FAME), or biodiesel) or animal tallow are used as substitutes for diesel. As an example of the increasing global use of biofuels, Figure 2 illustrates the historical development of fuel ethanol production worldwide.

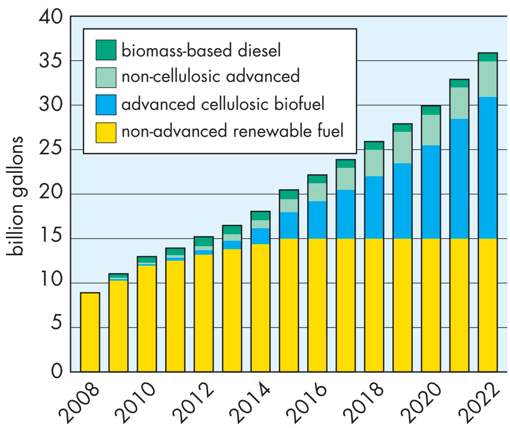
Figure 2: World fuel ethanol production



Ethanol, made from sugar cane, has been used on a large scale in Brazil for many years. Corn ethanol is being introduced at a very fast pace in the USA through an ambitious federal mandate programme accompanied by various subsidies to farmers and producers whereas a smaller mandate has also been put in place for biodiesel (see Figure 3).

In 2007, US refiners and importers were required to use 4.7 billion gallons of biofuels. However, 6.85 billion gallons of ethanol were used as a transportation fuel in 2007, far exceeding the federal mandate. In December of 2007 the US Congress passed the 'Energy Independence and Security Act of 2007' (EISA). The EISA included a significantly increased renewable fuel standard containing four interrelated parts consisting of an overall mandate and set-asides for 'advanced', 'cellulosic' and 'biomass-based' diesel. These mandates incorporate life-cycle GHG reduction requirements. The overall mandate started in

Figure 3: US biofuels mandate— EISA Renewable Fuel Standard (2008–2022)



2008 at 9.0 billion gallons and will grow to 36 billion gallons in 2022. The individual mandates will begin to phase in during 2009.

California's proposed 'Low Carbon Fuel Standard' (LCFS), which aims at reducing the GHG footprint of road fuels, will, in effect, have to be met largely by introduction of biofuels, mostly ethanol in gasoline at a rate that may go beyond the federal mandate.

As a result of legislation passed in 2003 proposing indicative biofuels targets to EU Member States, Europe already uses substantial amounts of biodiesel while ethanol use is growing fast either as such, or in the form of Ethyl tert-Butyl Ether (ETBE). The proposed 'Renewables Directive' seeks a mandatory 10 per cent (energy basis) of biofuels in the road fuel pool by 2020. A separate proposal under the Fuel Quality Directive would imply a considerably larger proportion of biofuels. Another proposed piece of legislation, similar to California's LCFS, would require a 50 to100 per cent greater penetration of biofuels by 2020. (See JRC-EUCAR-CONCAWE case study overleaf). Many other countries are considering, or are already imposing, biofuels legislation, for example in Asia, Africa, Australasia and South America.

The ultimate biomass resources that could be diverted towards energy use and, more specifically, the ultimate quantities of biofuels that could be produced is a subject of conjecture and intense debate. Significant amounts of biomass, in the form of wood, are already used for energy, and the eventual magnitude of the resource depends upon many factors that need to be analysed and understood.

Besides the ethical issue of competing with food, there is also a growing realization that using biomass for energy will, in many countries, put extra pressure on land resources, and thereby on ecosystems, natural habitats, virgin forests etc. This is part of the debate today and the subject of ongoing technical analysis to better understand these effects. Because of this evidence, the European Biofuels Technology Platform has suggested that, in the case of feedstocks, research and development should focus on two items:

Using biomass for energy will place increasing pressure on food and land resources, and is the subject of ongoing analysis.

- Managing competition for land resources (food and fodder vs. bioenergy) and for different biomass applications (transportation fuels, heat, power and industrial raw materials);
- Increasing yield per hectare and developing efficient supply logistics for both dedicated crops and residues.

Various estimates for the proportion of global Total Primary Energy Supply (TPES) that could be provided by biomass without generating undue competition with food production and other uses have been produced; these generally fall in the 5–15 per cent range, although the degree of uncertainty in such estimates is very high. Some regional estimates, based on predictable local practices and policies may appear more credible but food and energy markets are global, and major changes in one region will have an impact on the rest of the world.

The JRC-EUCAR-CONCAWE biofuels partnership

In early 2008, the European Commission set an ambitious target to incorporate significant volumes of bio-components into European road fuels over the next decade and beyond, posing an immediate technical challenge to fuels, vehicles and the supply and distribution infrastructure.

It became obvious that developing workable solutions required both technical knowledge and a multi-stakeholder approach. As a robust European working relationship had already been established between the Joint Research Centre (JRC) of the European Commission, the European Council for Automotive R&D (EUCAR), and the oil industries' European research association (CONCAWE), known as the 'JEC', a new Biofuels Programme was developed in 2008 with the objective of clarifying the opportunities and barriers to achieving the Commission's target of 10 per cent biofuels (on an energy basis) in European road fuels by 2020.

This programme is expected to be of three years duration with three clear steps currently defined:

1. Develop a consensual supply/demand picture of biofuel types and availability, with due consideration of the biofuel challenges and opportunities.
2. Identify possible performance issues for the existing and near-term light-duty vehicle fleet based on this biofuel supply picture.
3. Identify vehicle/fuel options for reducing the impact of biofuels on future light-duty and heavy-duty vehicles and after-treatment systems, in order to ensure that the 2020 targets for biofuels in European road transport are achieved.

As an example, the increased production of corn ethanol is having a significant effect on the agricultural sector in the USA (see Table 1). Corn exports have increased in the past five years due partly to the weakening dollar, bilateral trade agreements and increasing demand around the world. The growth of corn ethanol is expected to have a complex impact on corn supply (Dohlman & Gehlar, 2007).

Table 1: Corn exports from the USA

year	*corn exports (million bushels)*
2003/04	1,900
2004/05	1,818
2005/06	2,134
2006/07	2,125
2007/08	2,450

Source: US Department of Agriculture

Drivers for the development of biofuels

Use of biomass for transport and, more generally, for energy is promoted for a number of reasons, often in combination with each other. Depending on which objectives one focuses on, different actions may be appropriate and the potential benefits may be of a different nature.

National or regional security of energy supply

The largest oil consuming countries are increasingly aware of their growing dependency towards producing countries and seek to develop more diverse and secure supply sources. Biofuels, particularly when grown domestically, but also when imported, can contribute to supply diversity and security. If security of supply is the main objective then actions should target those sectors that import energy. In the USA, this means primarily transport, as most electricity and heat is generated from domestic coal, gas and other sources. In Europe, transport also relies on imported energy, and the heat and power sector is also very much (and increasingly) dependent on imported gas. In such a case, using biomass to generate electricity or produce biogas for heating (e.g. in community 'Combined Heat and Power' (CHP) projects) may also address the energy security issue, albeit a different supply issue than for transport fuels.

Support to agriculture and rural development

In many developed countries agriculture has suffered from over-production and a lack of profitable markets. Developing countries are often looking for suitable cash crops to support rural development, and biofuel production is frequently seen as a way to bring income to farmers either through increased profits or, in cases where biofuels are not cost-competitive with fossil fuels, through government subsidies.

For developing countries, biofuel programmes could be beneficial in supporting rural communities and mitigating the trend of migration into large urban centres. The extent to which biofuel programmes can contribute to rural development is dependent on the characteristics of the industry (scale, modernity, integration) and, ultimately, whether it is able to become financially viable without direct government financial support. As an example, the Brazilian ethanol model is based on modern and mechanized agricultural production, with many small-scale cane producers (but still large by developing country standards), large but not monopolistic mill/distillery complexes that generate electricity for themselves and for sale to the grid, and a nationwide ethanol supply system that is well integrated with urban, social and industrial development. The Brazilian model also benefits from a massive land area, sufficient supply of water, favourable climatic conditions for growing sugar cane, low-cost labour, and an efficient cooperative system with short raw material transport distances. Duplicating these conditions in other countries may be possible, but will be a challenge.

Greenhouse gas emissions reduction

Reducing greenhouse gas emissions in order to mitigate climate change has, in recent years, become the strongest driver for biofuels; the next chapter is dedicated to the reductions in GHGs that can be achieved with biofuels and the considerations that need to be taken into account in order to measure these reductions consistently.

Other potential benefits of biofuels

Biofuels are not generally introduced with the aim of mitigating local pollutant emissions. However, biofuels may, under certain circumstances, have some potential for reduction of vehicle tailpipe emissions. This potential is limited, and it is not a significant driver in Europe and North America where vehicle emission regulations and fuel quality are such that the potential benefits of biofuels in this respect are minor. Ethanol can decrease tailpipe emissions of CO, PM, HC and benzene but can increase tailpipe NO_x and aldehydes, a respiratory irritant, as well as evaporative HC emissions. All emission effects are larger in vehicles without catalytic converters because the overall emissions are higher.

Petrobras: social aspects of biodiesel production

In contrast to the Proalcool Program (the Brazilian Government ethanol programme launched in the mid-1970s), the introduction of biodiesel into the Brazilian fuel market is fairly recent, with the mandatory addition to conventional diesel fuel of 2 per cent biodiesel from January 2008 and 3 per cent biodiesel from July 2008. In parallel, the Federal Government created the 'Social Fuel Seal', which extends tax breaks to biodiesel producers acquiring raw materials from family-run farms.

In Guamaré Municipality, Rio Grande do Norte State, two Petrobras pilot plants have been operating since 2006. One of the plants is based on the conversion of vegetable oils, the end result of a reaction with methanol, and the other plant uses a new technology in which the green fuel is manufactured directly from castor oil seeds using sugar cane alcohol as a reagent. Some 2,500 small farmers and their families grow the castor oil and sunflower crops to supply the pilot plant operations, with a potential annual output of 20.4 million litres. Potentially, the units can generate employment and income for up to 5,200 rural families.

In 2008, three pilot plants were upgraded to full industrial scale facilities (Quixadá Municipality—Ceará State; Candeias Municipality—Bahia State; and Montes Claros Municipality—Minas Gerais State). Each unit has an annual installed capacity of 57 million litres, creating income for 70,000 farmer families that live within 200 kilometres of the plants. Petrobras is encouraging production of oleaginous crops close to biodiesel facilities and has a adopted a partnership approach: as well as forming partnerships with organizations representing small agriculturalists—the local labour unions and land activists—agreements have also been concluded with National and Regional Governments, all key actors in the adoption of incentive-based public policies for new oleaginous crop plantations. Petrobras guarantees purchase from the agricultural cooperatives and supplies selected seeds and technical assistance to farmers that commit to produce grains for delivery to the industrial units. Eighty per cent of biodiesel production costs are made up of raw material inputs, represented by the oleaginous plants. For this reason, remuneration of the farmer has to be considered as critical in guaranteeing the sustainability of the production chain. The major challenge for Petrobras is to meet the need for competitive prices, but at the same time, foster the objective of social inclusion through the creation of rural employment and income.

The potential of biofuels to reduce tailpipe emissions is relatively small, given the increasingly stringent regulations for limiting exhaust emissions.

The growing use of ethanol will increase the emissions of some pollutants and decrease others. All emission effects are magnified in older vehicles that do not have catalytic converters.

Biodiesel, which is essentially (although not entirely) sulphur-free, can help to reduce the sulphur content of the diesel fuel pool and contribute to reducing sulphur and particulate emissions from diesel vehicles. On the other hand, its physical and chemical properties may have a negative impact on after-treatment devices.

With respect to pollutant emissions, it is important to understand that the introduction of biofuels in developing countries where the vehicle fleet is not equipped with catalytic converters may not only fail to yield the expected benefits, they may actually solve one pollutant problem at the expense of another. As an example, the introduction of ethanol into road transport fuels in regions where catalytic converters are not fitted to vehicles may increase the emission of some air pollutants such as aldehydes. However, the introduction of ethanol in these regions may indirectly benefit the environment and human health by replacing lead anti-knock and other fuel additives.

Ethanol production plant, South Dakota, USA

Biofuels and greenhouse gas emissions reduction

Using biomass to generate energy is seen as a way to reduce GHG emissions and this has become, in recent years, the strongest driver for the introduction of biofuels.

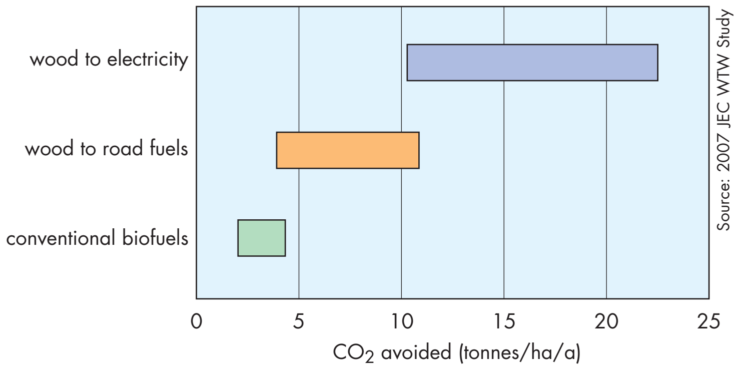
An important consideration is that biomass is a limited resource which, even in optimistic scenarios can only be expected to cover a fraction of the world's energy needs. Land or other resources used to make biofuels cannot be used for other purposes. As illustrated in Figure 4, more GHG can generally be avoided by substituting biomass for fossil fuels in heat and power generation rather than in transport.

If GHG reduction is the prime objective then biomass should be used where it maximizes GHG avoidance. This can only be achieved through assessing and comparing the different possible ways to use available land or biowastes. The answer could include a measure of biofuel production associated with other uses for some of the biomass streams including heat and power and, potentially, chemicals manufacture.

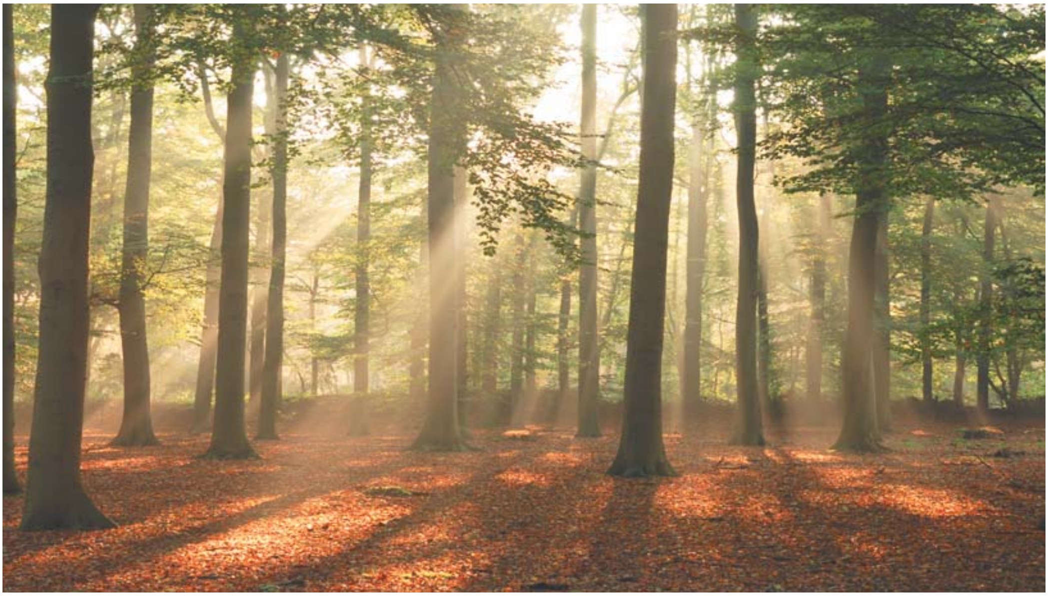
The net GHG avoidance of biofuels can depend on many factors including the type of crop, source of energy, manufacturing processes, etc.

Biofuels can potentially reduce the net GHG produced by transport. The GHG footprint of biofuels can, however, be very different depending on where, how and from what they are produced. The net GHG avoidance of ethanol produced in Europe can, for example, range from virtually 0 per cent to more than 80 per cent compared to fossil gasoline. The main factors affecting this balance are the crop used and the conditions under which it is grown, the origin of the energy used in the biofuel manufacturing process and the fate of by-products.

Figure 4: CO_2 savings from using biomass



More GHG can generally be avoided by substituting biomass for fossil fuels in heat and power generation rather than in transport.



Substantial quantities of CO_2 released through conversion of land to agricultural use may impact the GHG benefits of any crop, hence the need for effective regulation on land conversion.

In addition to the GHG balance pertaining to the ongoing production chain *per se*, converting land from natural or man–made forest or grassland to agricultural use can result in the one-time release of substantial quantities of CO_2 through reduction of both above-ground biomass and of soil carbon content.

There are two types of effects from land-use change. There is a direct effect: GHG gases can be released when converting land to certain agricultural crops (e.g. by releasing GHG gases as methane, N_2O and CO_2 from the soil or when captured carbon gets released as biomass is burnt to clear land). The indirect effects of land-use change are derived by similar mechanisms, but they are more complicated to estimate or manage.

These effects occur through macro-economic forces in the global market for agricultural products. Converting land to biofuels production will impact on the supply/demand balance of the crop previously produced on that land. A decrease in production of a certain crop in one part of the world can lead to increased production of this crop in another part of the world, and hence to land-use change.

Currently, there is no scientific or political consensus on how to best calculate direct or indirect effects associated with land-use change. And without consensus on methods, there can be no agreement on the size of this effect, which is why current estimates vary greatly. However, what has become clear in recent years is that these effects could be significant, depending on the local context, including type of crop change and agricultural practices. This uncertainty in turn emphasizes the need to continually refine these estimates to assess the significance of GHG emissions in the context of land-use change. An additional difficulty in measuring these effects is in setting the time-window for evaluation, as some biofuel feedstocks are being produced on land converted many years ago.

Where GHG reduction is a key driver, the contributions of direct and indirect land-use change can make or break the justification for introducing biofuels. Although we cannot yet be certain of the impact that these effects will have on GHG emissions, we can be certain that direct and indirect effects of land-use change will be the topic of an important scientific and political debate in the coming years, as society strives to ensure the overall sustainability of biofuels.

The effects of land-use change will be an important topic of scientific debate in the coming years.

Biofuels and sustainability

As the large-scale development of a biofuel industry will impact on land and water use, food supply and cost, agriculture and rural development, it is essential to assess the capability of each region to produce biofuel against its particular social, environmental and economic conditions, especially as this may in turn affect biodiversity and lead to increased encroachment on natural forests, grasslands, and protected and environmentally sensitive areas.

Competition with food crops

The effect on food prices of diverting crops, such as corn and palm, to make biofuels is a heavily debated subject. Biofuels expansion plans rely both on growing specific crops and on use of waste biomass. Depending on geographic region, this could lead to a significant portion of the arable land area being used for energy crops rather than for production of food for the growing world population.

Large-scale development of biofuels could have an impact on agricultural commodity markets (e.g. cereals) and potentially increase both price level and volatility. The strength of the demand and purchasing power for fuels to run cars, commerce and industry could create an even stronger pull away from food crops and potentially aggravate global food shortages.

This, however, has also to be considered in the context of public policies regarding rural development and the positive impact of providing farmers with cash crops, particularly in developing countries.

Water usage

Water availability is an increasingly serious concern in many parts of the world and agriculture is the largest user. A 2006 report by the International Water Management Institute (IWMI) estimates that globally, one in three people is already enduring one form or another of water scarcity, and contends that rising demand for irrigation to produce food and biofuels can aggravate scarcity of water. Clearly, the development of biofuel crops needs to take into account the availability and quality of water, e.g. by developing varieties with low water requirements.

The large amounts of biomass needed to completely replace gasoline with biofuel using today's technology would require massive land-use change. In some countries, the complete replacement of gasoline with locally-produced biofuels is not feasible as it would require extensive land areas to grow biomass.

The rising demand for irrigation can place increasing pressure on water availability—an already serious concern in many parts of the world

Land access and rights

Large-scale development of biofuels will increase the global demand for agricultural inputs and, in particular, land. While estimates for global land availability vary, increasing competition for land may encroach and put pressure on individuals' existing use of, and rights and access to, land especially in countries where security of tenure is weak. On the other hand, in most cases the security of tenure is weak due to the low income of such owners and the biofuel crop may foster the regularization of land owning, mainly by providing an extra income to small farmers.

Biodiversity

Large-scale biofuel production, if not carefully managed to avoid biodiversity impacts, has the potential to reduce biodiversity via a number of mechanisms:

- **Encroachment on forests and other natural land areas:** a large demand for biofuel crops could add to the already ongoing pressures stemming from illegal logging and demand for food and firewood, and accelerate reductions in the size and continuity of natural ecosystems including forests, prairie, wetlands and grasslands.
- **Encouraging monoculture:** where it displaces more biodiverse areas, some biofuel crop production at industrial scale is likely to replace the existing natural variation with specific species, optimized for their biomass yield and other characteristics. This means that vegetation would be less varied than in natural ecosystems, unlikely to support a diverse fauna and tend to be less resilient.

Increased agricultural production has the potential to threaten global biological diversity.

- **Risk of invasive species:** certain species that are considered for biofuel production are known as invasive species in many parts of the world. Therefore, information gathering and risk assessments are recommended for the introduction of crops into new areas. (GISP, 2008)
- **Increased use of pesticide, fertilizers and water:** use of additional land to grow biofuels crops will increase current excess pesticide and fertilizer runoffs to receiving land and water bodies. Associated increases in water demand will further tax already-limited freshwater supplies and potentially divert water from aquatic ecosystems.
- **Increased exploitation of natural forests and other habitats:** increased demand for wood, including wood waste, may lead, directly or indirectly, to increased harvesting of existing forests including biologically-important old-growth forest areas and other natural habitats such as prairie, wetlands and grasslands.

Used for biodiesel, the African palm has already become widespread in some biofuels-producing areas.

Dependence on public support schemes

Even in today's world of exceptionally high fossil energy prices, biofuels remain expensive to produce and are generally not competitive without some form of subsidy. Competition with food tends to push up feedstock prices. Public support schemes are generally required, at least initially, diverting financial resources from other sectors of the economy. A thorough cost/benefit analysis is therefore essential before a country or state implements support schemes.

IPIECA believes that it is vital to ensure that the use of biofuels does not lead to undesirable consequences that outweigh the intrinsic benefits.

Global biofuel certification

Differentiating between sustainable and unsustainable biofuel production

Although biofuels carry attractive promises of improved energy security, rural development and GHG emissions reduction, the above discussion also highlights potential negative effects that are dependent on how biofuels are produced. In order to be successful, biofuels need to be sustainable by current social, economic and environmental norms.

Recognizing the emerging international market for biofuels, a biofuel certification scheme that can be applied globally and enforced by governments will be an essential framework to support that market. In general, biofuel providers would certify their biofuel while the fuel suppliers would use certificates from the biofuel providers to demonstrate compliance.

Reduction of GHG emissions is a major driver for biofuels growth. It is therefore essential to be confident that those biofuels that are being encouraged (and often subsidized by governments) do indeed lead to substantial reductions of GHG emissions. This calls for globally agreed, transparent methodologies to assess the 'GHG footprint' of biofuels across their life cycle.

The potentially undesirable environmental and social impacts also need to be addressed. This requires agreement on the high level general principles to be adhered to, following careful consideration of how these principles can be best managed on the macro level (through international agreements) and at a micro level through a sustainability scheme, many of which are under development. One of the initiatives in this respect is the Roundtable on Sustainable Biofuels (RSB—see below) in which IPIECA is participating.

In many if not all cases the issues at hand are not only relevant to biofuels but to the whole agricultural sector and possibly the forestry sector, including, *inter alia*, food production. Indeed their application only to the biofuel sector, which can never represent more than a small proportion of total agriculture, would be wholly ineffectual. One of the challenges is therefore to ensure that the principles and rules are acknowledged and respected by all. In the development of such principles and rules, the aspirations of producing countries in terms of rural development must also be fully taken into account.

These different requirements are included under the generic term of 'sustainability' and several governments, institutions and international bodies are working on certification systems to assess the sustainability of biofuels, as well as verification systems to assure mandates are being met and that auditable management and assurance systems are in place throughout the supply chain.

Developing certification systems will be a long and difficult task, although some aspects can be addressed directly through rules to be followed by producers and the various actors along the chain. A number of the aspirations can only realistically be fulfilled through coordinated national or international efforts. 'Land-use change' is a case in point. Simply ensuring that a consignment of biofuel does not originate from land with high carbon stock will not provide any guarantee against the 'domino' effect whereby such land is used for some other purpose.

IPIECA supports the concept of global biofuel certification

The international oil industry recognizes that if biofuels are to play a material part in the market, they must be produced sustainably: the end-user must also be assured that the biofuels incorporated in fuel blends have been produced sustainably. A corollary of this is the need to introduce schemes to ensure compliance. For such schemes to raise the sustainability standard of biofuel production, they must be widely available and be recognized as being credible indicators of biofuel sustainability—and they must be applied.

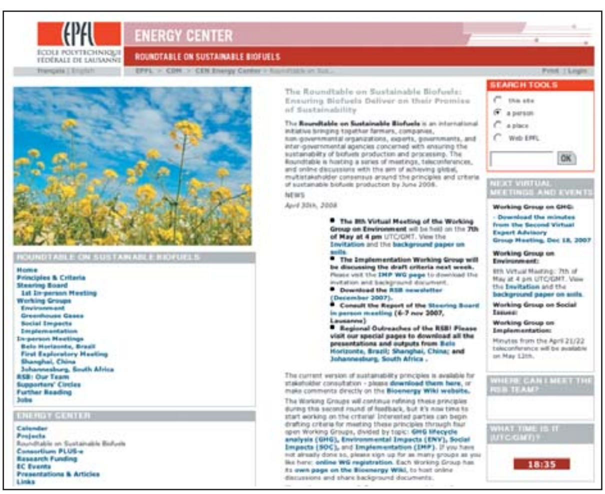
With this aim in mind, a number of members of IPIECA have been working with the Roundtable on Sustainable Biofuels (RSB) alongside participants from universities, NGOs and the United Nations. The RSB was set up in 2007 to establish a global system of standards for biofuel sustainability that would be accepted by all stakeholders.

The RSB is working towards the principle of a global meta-standard, whereby different crop-specific or regional schemes would be validated as meeting specific sustainability criteria. The system will encompass crop schemes such as those developed by the Roundtable for Sustainable Palm Oil, The Roundtable on Responsible Soy and the Better Sugar Initiative—all of which are also important building blocks for the establishment of an international scheme.

The RSB has work streams covering:

- environmental criteria;
- GHG methodology and criteria;
- social criteria; and
- implementation practicalities.

IPIECA members in Europe are also taking part in the CEN (European Committee for Standardization) TC 383 on 'sustainable produced biomass for energy'.



IPIECA is participating in the Roundtable on Sustainable Biofuels—a key initiative to define a 'sustainability scheme' to ensure that the use of biofuels does not lead to undesirable social or environmental consequences.

Taking into account the formal CEN procedure for new standards, publication of the standard could be achieved as early as mid-2011.

Whether certification of sustainability criteria is done at an industry level (Roundtable for Sustainable Palm Oil), a regional level (CEN in Europe) or at a global level (Roundtable on Sustainable Biofuels and the International Organization for Standardization—ISO), defining a mechanism to measure and standardize sustainability is complex. In order for any biofuels sustainability certification mechanism to be implementable and successful, schemes should ensure the following issues are adequately addressed:

1. The indicators used to measure sustainability should be defined in a way that they are measurable, verifiable and relevant.
2. A process and a detailed GHG calculation methodology should be in place for new and existing biofuels production operations.
3. A realistic and practical methodology for accounting of land use to assess the impact of direct or indirect land-use change (including treatment of set-aside and idle lands). Biodiversity of land use and cultivation practices should be considered.
4. All other criteria should be prioritized according to specific relevance to biofuels rather than to agriculture in general.

Summary

The benefits for society of biofuels for the transport sector depend on the ways in which biomass is grown and converted to biofuels, i.e. the biofuels system as a whole. Benefits can include improvement of energy security, rural development, and the reduction of GHG emissions.

Biomass is a renewable, but limited resource which, even in optimistic scenarios, considering the current technology, can only be expected to cover a modest fraction of the world's energy needs. If GHG reduction is the prime objective then governmental policy instruments should ensure that biomass is used where it maximizes GHG avoidance, or where it is the best available alternative to replace carbon intensive energy products. This can only be achieved through assessing and comparing the different possible ways to use the available bioresources. These may be different from country to country and region to region; this should be recognized when regional mandates for biofuel utilization are being considered.

Large-scale development of biofuels raises a number of concerns relating to competition with food and pressure on land resources, potentially leading to reduction in food availability, increased food prices and encroachment on sensitive land areas and forests. In some cases, when biofuels production causes clearing of high carbon content land, substantial CO_2 emissions can be produced that may impact the GHG emission benefits of a biofuels system for decades. Many of these effects can only be realistically assessed by considering the performance of specific biofuels systems as well as effects outside a biofuel system's boundaries.

As FAO states, biofuel production involves both opportunities and risks for food security and environment. To effectively manage the impact on food security the establishment of specific public policies regarding the production and consumption of biofuels is needed.

IPIECA members support the development, ultimate adoption and government enforcement of an internationally recognized, transparent, and accepted certification scheme, such as that presently under development by the Roundtable on Sustainable Biofuels (RSB). Such a scheme should, at a minimum, include a fair and complete assessment of the GHG footprint of biofuels, an assurance on food competition and availability, and an assessment of the environmental and social issues associated with their production. Only through this process can biofuel systems be properly assessed for their sustainability credentials.

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IPIECA

IPIECA is the single global association representing both the upstream and downstream oil and gas industry on key environmental and social issues, including: oil spill response; global climate change; fuels and products; health; biodiversity; social responsibility; and sustainability reporting.

Founded in 1974 following the establishment of the United Nations Environment Programme (UNEP), IPIECA provides a principal channel of communication with the United Nations. IPIECA Members are drawn from private and state-owned companies as well as national, regional and international associations. Membership covers Africa, Latin America, Asia, Europe, the Middle East and North America.

Through a Strategic Issues Assessment Forum, IPIECA also helps its members identify emerging global issues and evaluates their potential impact on the oil industry. IPIECA's programme takes full account of international developments in these issues, serving as a forum for discussion and cooperation, involving industry and international organizations.

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