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**Programme Paper**

# The Potential Contribution of Biofuels to Sustainable Development and a Low-carbon Future

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## Introduction

Biofuels – understood here as liquid fuels made from plants and primarily used for transportation – have fallen in and out of favour with governments, investors and the general public. Their gyrating fortunes are a case study in the unpredictable effects of public policy on energy, commodities and climate change. Biofuels have been heavily promoted by governments because they appear at first sight to offer a way of meeting the growing world demand for energy with fewer of the problems that fossil fuels bring: climate change, volatile prices for crude oil and exposure to the risk of disruption of supply from politically unstable parts of the world. But the efforts to promote biofuels have come up against unforeseen obstacles, including a public backlash, as the supposed advantages of biofuels were undermined by their reported indirect effects, notably rising food prices, displaced peoples and their uncertain contribution to reducing greenhouse gas emissions. The true extent of these effects may well have been overstated – and in any case does not apply evenly across the vast range of different kinds of biofuels – but the effect has been a substantial shift in government attitudes regarding biofuels. The long-term effect is unclear. Notwithstanding many anecdotes about their negative effects, there appears to be a small but significant role that biofuels could play in the development of a less carbon-intensive transportation sector. But the realisation of this idea depends on smart public policy that overcomes the very real problems that have been thrown up by the first generation of biofuels and the effects of imperfect policies that currently drive much biofuel production around the world.

This paper is informed by a roundtable workshop held at Chatham House in April 2008 to discuss practical policy options on biofuels. Section 1 introduces the critical role that liquid fuels play in energy systems and outlines the possible contribution that biofuels, properly managed, could make. Section 2 sketches the major risks and opportunities that are associated with biofuels, focusing on their uneven contribution to greenhouse gas mitigation, their relative cost inefficiency, and their possible environmental and social impacts. Section 3 outlines the main policy approaches that currently drive production of biofuels in the developed world. Section 4 concludes with some recommendations

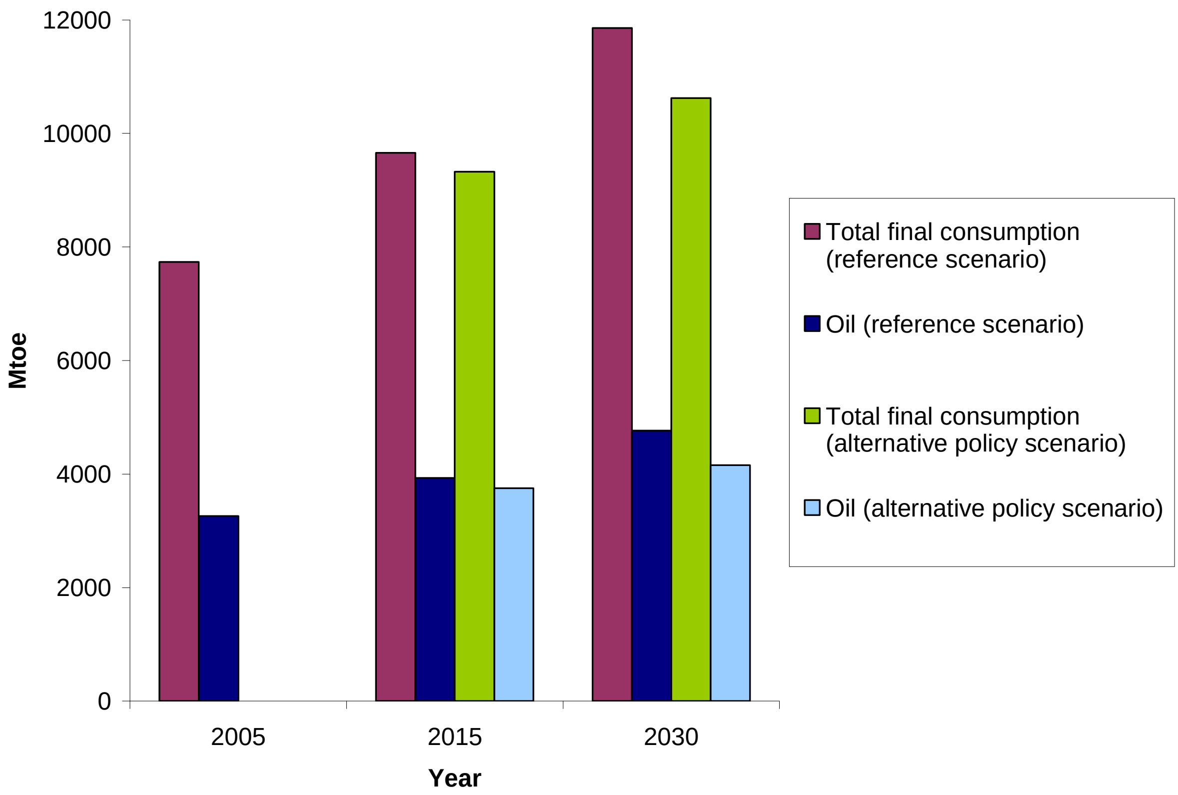
The primary conclusion of this report is that current policy is producing too many of the wrong kinds of biofuels, possibly at the expense of more sustainable kinds. The major policy tools used to promote biofuels do not provide sufficient incentive for biofuel producers and consumers to discriminate between the wide variety of biofuels that are currently available or in development. Moreover, current policies may not be driving the necessary technological developments that could allow biofuels to contribute to a sustainable energy mix at sufficient scale, but instead may be promoting the production and consumption of large volumes of biofuels that have questionable benefits and may have serious negative direct and indirect impacts. At the same time, suggested policy prescriptions are inadequate to overcome the information shortages around biofuels. Initiatives like the Roundtable on Sustainable Biofuels can develop standards to help consumers choose biofuels with the least negative impact on ecosystems and communities, but standards generally only deal with direct impacts from the production of biofuels. The indirect impacts of biofuels, especially on food prices and land use, occur at a scale that is not easily captured by certification schemes. Moreover, there is a danger that the rush to certification could create new barriers to trade, which will be essential to bring the world's low-cost biofuels to market and to allow least developed countries to share in the benefits of biofuels production.

Despite these problems, biofuels do have a role to play in the future energy mix, and there is a risk that the negative stories about certain kinds of biofuels could impede the development of the sector. Section 3 of this report therefore describes some of the practical policy levers that can be applied along each stage of the production chain to promote – without favouring any one technology – the most efficient kinds of biofuels currently available while hastening the development and deployment on sufficient scale of a new generation of biofuels that are least likely to have negative direct and indirect effects.

## Background: liquid fuels and transport

Biofuels are one of the only kinds of liquid fuels currently available that offer a feasible alternative on a significant scale to fossil fuels. This explains much of the interest from policymakers and investors in what is still a developing technology: global demand for oil, driven mainly by the transport sector, is projected to grow for the foreseeable future. The International Energy Agency (IEA) projects that oil will remain an increasingly important part of the global primary energy mix under various scenarios (see Figure 1).

**Figure 1: Total final energy consumption and relative share of oil (in million tonnes of oil equivalent), projected to 2030 under IEA reference and alternative policy scenarios**



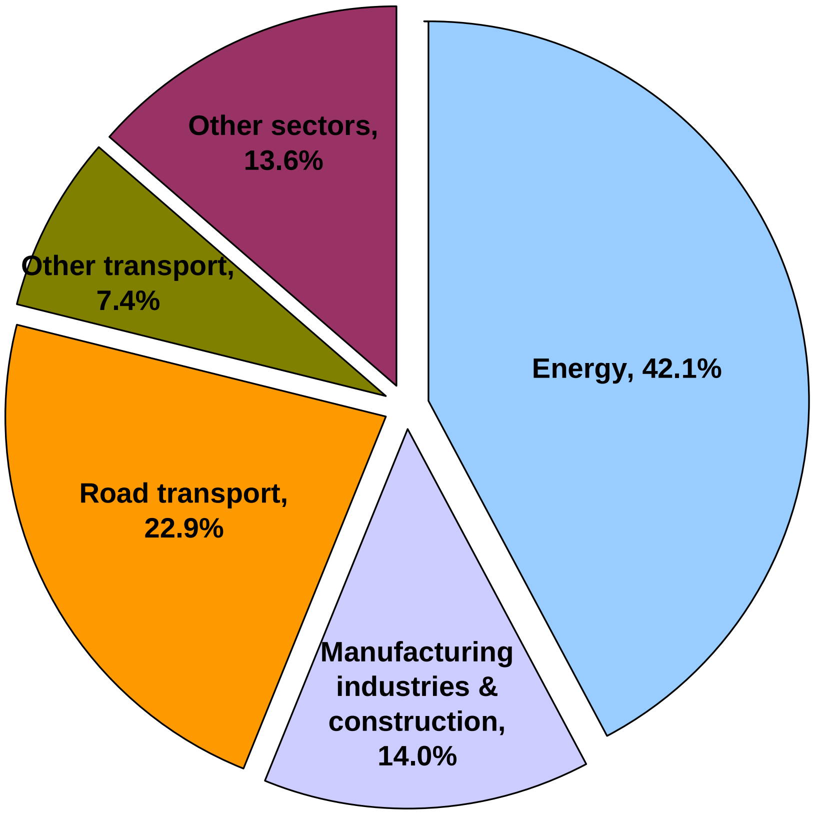

Source: Adapted from IEA (2007)

Transport currently accounts for about 50 percent of total global oil demand and this share is projected to rise.[1] Two challenges arise from this growing

[1] IEA, 'World Economic Outlook', pp. 74-114

dominance. First, the transport sector is a significant and growing contributor to greenhouse gas emissions: a quarter of global greenhouse gas emissions from fuel combustion are caused by the transport sector (this figure is just over 30 percent in the OECD area, of which 22.9 percent is from road transport: see Figure 2). Second, the transport sector is increasingly dependent on imported oil from unstable regions of the world and subject to dramatic price volatility.

**Figure 2: Energy-related greenhouse gas emissions in the OECD area by source**




Source: IEA (2007)

There are many different ways to tackle these problems, most of which involve reducing fossil-fuel demand. The most straightforward and low-cost measure could be to reduce demand for transport through land-use planning, improved public transport and policies to change driver behaviour like fuel taxes and road charging. There are also many opportunities for improving vehicle energy efficiency, ranging from lighter cars and trucks, to improvements in existing motors, to the introduction of new technologies like hybrid and flex-fuel cars. But even with effective demand-side measures, energy demand in the transport sector is set to grow: the IEA projects that demand for oil for transport will rise by 2030 to between 31 percent and 54 percent.[2] This demand will largely be met by liquid fuels because there are only a few technical options available for fuel switching in the transport sector (unlike electricity and home heating, for which there are several technical alternatives to fossil fuel). Liquid fuels hold a number of advantages over alternative transport technologies, not least of which is a century's worth of infrastructure across the globe. Methane and other gases can substitute for liquid fuels in transport but probably only within niche areas like urban bus fleets.[3] Possible alternatives – including electric cars and hybrid electric/liquid fuel cars – are already on the market but claim a limited share, although an increasing number of car companies are investing in the development of advanced hybrid or battery-powered cars. New technologies like hydrogen fuel-cell cars and cars powered by compressed air may have some potential but they are some decades away from mass production.[4]

Biofuels are attractive to policymakers because they seem to address some of transports' problems without forcing expensive technological or societal change. Biofuels can be grown locally (although they often are not), thus reducing dependence on imported energy, and they are – at first sight – carbon neutral, because the carbon dioxide they emit when burnt is offset by the carbon dioxide absorbed when they grow. Biofuels are also an important support for rural development because they offer a potentially large source of income for farmers, which was a major factor in favour of policies to promote biofuels at a time of historically declining prices for agricultural commodities. WWF (among other organisations) maintains that biofuel production, properly managed, could increase investments in agriculture in developing countries and in degraded areas, create decent employment, and have a positive spill-over effect on other agriculture and forestry sectors.[5]

More generally, biofuels are part of a trend of technological evolution that is seeing a proliferation of alternative pathways away from the current dependence on oil for transport. This includes alternative fuels – oil from unconventional and highly emitting sources such as tar sands, as well as natural gas and liquid fuels synthesised from natural gas – and new motor

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[2] IEA, 'World Energy Outlook', p. 592

[3] The Royal Society, 'Sustainable Biofuels: Prospects and Challenges', p. 32

[4] IPPC, 'Transport and its Infrastructure', p. 332

[5] Presentation by J. P. Denruyter, World Wildlife Fund, Chatham House, 15 April 2008. Available at http://www.chathamhouse.org.uk/events/view/-/id/819/

technologies outlined above. Not all of these technologies are new (biofuels and unconventional oil have been produced for decades) and not all of them would contribute to the ultimate necessity of reducing greenhouse gas emissions from the transport sector. Biofuels are likely to have a role in this technological evolution because of their ability to replicate the advantages of current liquid fuels, especially their relatively high energy density per volume compared to gaseous fuels and their greater scope for application in long-haul vehicles. However, many of the current generation of biofuels produced from food crops like maize, corn and wheat have disadvantages that can obviate these benefits, outlined in Section 2 below. Therefore, researchers and policymakers hope to amplify the benefits in "second-generation" biofuels, currently in development, which could theoretically be produced on a mass scale from non-food crops like willow, miscanthus or even the stalks and other waste portions of food crops. The appliance-side barriers to biofuels are also diminishing with the evolution of "flex-fuel" cars that can alternate between conventional petrol and ethanol blend. In Brazil, 90 percent of new cars sold are flex-fuel vehicles.[6] Biofuels can also complement promising new technologies, for instance by providing a low-carbon fuel that can extend the range of a plug-in hybrid car.

Biofuels are likely to play only a contributing role in the move away from fossil fuels for the foreseeable future, due to constraints over the availability of land (since biofuel feedstock production must compete with other land uses), the high cost of biofuels in developed countries compared to fossil fuels and the rate of technological development. To date biofuels have captured only about 1 percent of the global market for liquid fuels, and they are only projected to increase by 2030 to between 3 percent and 6 percent, according to IEA projections (see Table 1). One major exception is Brazil, which substitutes at least 50 percent of petrol sold domestically with ethanol produced from sugar cane.[7] This projection is heavily dependent on policy choices, however. A recent IEA publication projects that under the most extreme scenario, biofuels could supply about 700 million tonnes of oil equivalent by 2050, representing 26 percent of total transport fuel demand, if the appropriate policies were in place.[8]

**Table 1: Projected energy demand in the transport sector**

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[6] Presentation by G. Kutas, Chatham House, 15 April 2008. Available at http://www.chathamhouse.org.uk/events/view/-/id/819/

[7] Duffy, 'Brazil defends biofuel's merits'

[8] IEA, 'Energy Technology Perspectives 2008: Scenarios and Strategies to 2050', pp. 37-46

| | Reference scenario | | | Alternative policy scenario | |
|---|---|---|---|---|---|
| | Millions of tonnes of oil equivalent (share of total) | | | | |
| | 2005 | 2015 | 2030 | 2015 | 2030 |
| Oil | 1895 (94%) | 2296 (93%) | 2919 (92%) | 2171 (92%) | 2481 (89%) |
| Biofuels | 19 (1%) | 57 (2%) | 102 (3%) | 78 (3%) | 164 (6%) |
| Other fuels | 96(5%) | 117 (5%) | 142 (4%) | 120 (5%) | 152(5%) |

Source: IEA (2007)

## Sustainability challenges

Like many developing technologies, biofuels result in some unforeseen consequences that will determine the extent to which they are adopted more widely. The challenges that biofuels face relate to their cost, their general social and environmental impacts, their uncertain contribution to greenhouse gas emissions, and their indirect effects, particularly on land use and commodity prices.

### Cost

Biofuels are currently more expensive to produce in developed countries than petroleum-based fuels. Brazil is the least-cost producer of ethanol and can compete with oil at oil prices of about $30-35 a barrel, whereas ethanol produced in the United States and European Union can compete with oil at prices of about $55 and $80 a barrel, respectively.[9] The largest expense in the production of biofuels is the cost of the feedstock. If waste oils are used as feedstock the cost can be competitive with petrol, but the quantity of available waste oils is miniscule compared to the needs of the transport sector. If crops are used, the feedstock costs are generally far higher than for sugar, starch or cellulosic materials. The prices of key feedstock crops like grain and maize have fallen from their height of May 2008 but they were still higher in September 2008 than in the corresponding period in 2007. The FAO and OECD project that food prices will decline gradually over the next decade, although from a higher level than has been seen over the past few decades, but competition for land and the high cost of fossil fuels (a major input in agricultural production) could maintain an upward pressure on feedstock crop prices.[10] With appropriate policies, the cost of biofuels could fall as production is scaled up and the second-generation technologies move from development to market, although this is not expected for the short term.[11] The co-products of biofuels (like glycerine and animal feed) can also make the production costs for biofuels more attractive.[12] But even if the processing costs are reduced, there are large diseconomies of scale in feedstock production because the cost of transporting bulky feedstock materials to a

[9] IFPRI, 'The World Food Situation', p. 7. The rising cost of crude oil has not improved the viability of biofuels much, since the price of feedstock crops has also risen.

[10] OECD/FAO, 'OECD-FAO Agricultural Outlook 2008-2017', p. 54

[11] IEA, 'World Energy Outlook', p. 405

[12] The Royal Society, 'Sustainable Biofuels: Prospects and Challenges', pp.48-49

central point increases exponentially, and it is difficult to assemble adequate contiguous land to serve single large processing facilities.[13]

Another relevant cost comparison is the relative cost of reducing greenhouse gas emissions from biofuels compared to other approaches. Reducing a tonne of $CO_2$ equivalent using bioethanol from crops grown in the European Union, costs between €209 (from sugar beet) and €317 (from wheat).[14] A recent OECD report estimated even higher abatement costs of $960 to $1,700 per tonne of $CO_2$ equivalent. This means that there is an opportunity cost to devoting resources (e.g. through subsidies) to mitigating greenhouse gases through biofuel production, given that the there are opportunities to reduce emissions in the heavy-industry or power sectors at prices of about €25 per tonne of $CO_2$ equivalent reduced (based on the permit price in the EU Emissions Trading Scheme).[15] There is also an opportunity cost of using biomass for biofuels rather than static applications for combined heat and power, for instance.

## Greenhouse gas emissions

The effectiveness of biofuels in reducing greenhouse gas emissions varies greatly between types of biofuels (and second-generation biofuels are likely to perform better than many of the current generation). Calculated by a life-cycle analysis, including the effects of cultivation, infrastructure, production, transport and operation, ethanol from Brazilian sugarcane performs perhaps best, with a best estimate of a 92 percent reduction below fossil-fuel emissions. This compares with a reduction of just 39 percent from ethanol made from sugar beet (see Figure 3). These estimates may need to be revised downwards, however, when agricultural expansion is included.

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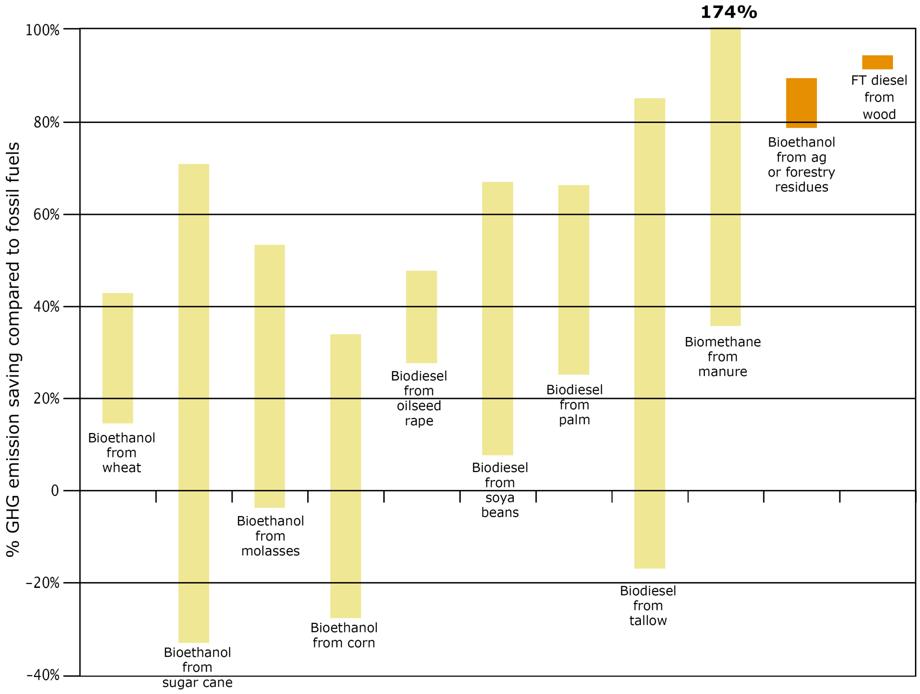
[13] IPCC, 'Transport and its Infrastructure', p. 343

[14] Presentation by L. Ryan, Comhar Sustainable Development Council, Chatham House, 16 April 2008. Available at http://www.chathamhouse.org.uk/events/view/-/id/819/

[15] The permit price under the EU Emissions Trading Scheme was €26.20 on 29 May 2008, although futures prices for December 2008 had dropped to €17.65 by 29 October 2008. Source: www.pointcarbon.com

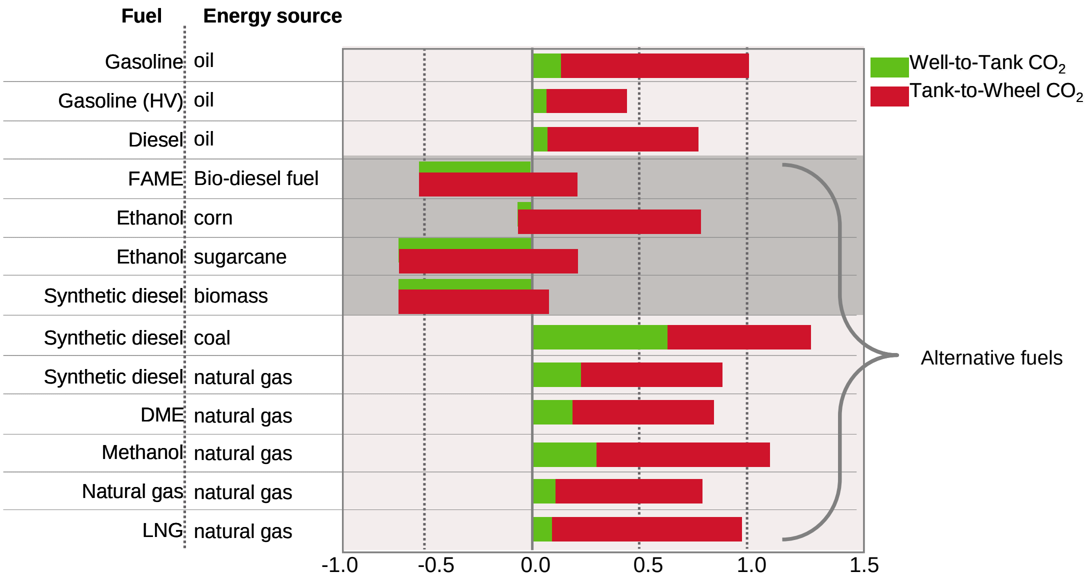
**Figure 3: Estimated greenhouse gas emission savings compared to transport fossil fuels**




Note: current technologies are shown in yellow; advanced technologies in orange Source: Renewable Fuel Agency (2008)

It is also appropriate to compare biofuels' greenhouse gas performance to that of other "alternative fuels", since in the context of high oil prices and relatively inelastic demand for transport (at least in the short term), the alternatives to biofuels may not always be conventional petrol or diesel. Many biofuels have a better $CO_2$ performance than synthetic fuels produced from coal or natural gas (see Figure 4 below), and they compare favourably in terms of $CO_2$ emissions to fuels produced from tar sands and oil shales.

**Figure 4: $CO_2$ emissions from liquid fuels compared (with gasoline indexed as 1.0)**




Source: Stephan Herbst, Toyota[16]

## Indirect effects of biofuel production

Much of the current criticism around biofuels relates to the possible social and environmental effects related to greenhouse gas emissions and global commodity prices as a result of land conversion. These indirect effects of biofuels are difficult to measure and so are difficult to take into account during the decision-making process. In a widely discussed paper published in *Science* in February 2008, Searchinger and colleagues presented evidence that producing corn-based ethanol in the future could increase global greenhouse gas emissions because this production would cause the conversion of forests or grasslands for additional food and animal-feed production (to replace the corn's previous market) and in the process release vast stocks of carbon.[17] As with other indirect effects, the impact depends greatly on the kind of biofuel in question. Biofuels from waste products (e.g. municipal waste, crop waste, and autumn grass harvests from reserve lands) can be valuable, but biofuels that cause land-use change and subsequent emissions can create a carbon "debt" – the amount of time that the emission

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[16] Presentation by Stephan Herbst, Toyota, based on Mizuho Information & Research Institute. Available at http://www.chathamhouse.org.uk/events/view/-/id/819/

[17] Searchinger *et al.*, 'Use of U.S. Croplands for Biofuels Increases Greenhouse Gases Through Emissions from Land-Use Change'

savings of biofuels take to offset the emissions from the initial land-use changes – ranging from four years for ethanol from Brazilian sugar cane to 167 years for ethanol from US corn.[18]

Another possible impact is an increase in food prices as a result of additional demand for food crops used as feedstock in biofuel production. The dramatic rise in food prices – the FAO food price index in May 2008 was 50 percent higher than one year before, although it has fallen since[19] – has many drivers, but biofuels are thought to have played a role; the OECD and FAO consider that biofuel production accounts for more than half of the increase in the demand for grains and vegetable oils between 2005 and 2007.[20] Biofuel production from feedstock crops that are used for food does introduce additional demand for food crops: the production of ethanol from US corn increased corn demand by two-and-a-half times between 2000 and 2007.[21] The UK Renewable Fuels Agency notes that price effects from biofuel production in the short term can be severe, but it estimates that the medium-term impacts, to 2020, are expected to be small – rarely more than 5 percent.[22] Biofuels from non-food crops can also have an effect if they are grown on arable land that could otherwise have been used for food crops. Another driver is the increasing requirement of industrialised regions like the European Union and the United States to import biofuel feedstock (such as sugarcane and palm oil) from more efficient producer countries like Brazil, Indonesia and Malaysia, to meet their own domestic targets for biofuel use. This is driving increased trade, and therefore increased prices, for these crops.

Biofuel production can also have an indirect impact on biodiversity. In general, the production of biofuel feedstock crops can exacerbate problems commonly associated with agriculture, including soil compaction, nutrient leaching, habitat loss and fragmentation and pressures on water use. In Indonesia, the 18 million hectares of forests that have been cleared for palm-oil cultivation have contributed significantly to the threat facing the orang-utan

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[18] Searchinger *et al.,* 'Use of U.S. Croplands for Biofuels Increases Greenhouse Gases Through Emissions from Land-Use Change'

[19] FAO Food Price Index, http://www.fao.org/worldfoodsituation/FoodPricesIndex/en/

[20] OECD/FAO, 'OECD-FAO Agricultural Outlook', p. 44

[21] IFPRI, 'The World Food Situation', p.5

[22] Renewable Fuels Agency, 'The Gallagher Review of the Indirect Effects of Biofuels Production', p. 58

and Sumatran tiger.[23] There is also an additional risk that first-generation feedstock crops and some of the crops being considered for second-generation biofuels could behave like invasive alien species.[24] The European Commission expects that additional biofuels production in the European Union will take place largely on land that has been set aside from production. While this provides an opportunity to develop abandoned agricultural land, set-aside lands may have become refuges for biodiversity, with any conversion reducing the amount of land available for wildlife conservation.[25] Because they compete with food producers for existing agricultural land, biofuels can generate agricultural production on previously uncultivated lands, but such areas may have some biodiversity value from which local communities derive benefit, which would be lost if replaced by monoculture plantations for biofuels.

[23] Presentation by N. McCormick, IUCN, at Chatham House, 15 April 2008, available at http://www.chathamhouse.org.uk/events/view/-/id/819/

[24] Rosenthal, 'New Trend in Biofuels Has New Risks'

[25] EurActive, 'Biofuels: Impact on agriculture 'modest' says Commission'

## Policy approaches for sustainable biofuels

To make a contribution to a sustainable energy future, biofuels will need to compete with fossil fuels on a number of fronts. They will need to offer greenhouse gas savings compared to fossil fuels. They should be produced from sustainably sourced feedstock. They will need to perform as well as current fuels in vehicles and be compatible with engines and operating conditions. They will need to be integrated into the existing fuel infrastructure. They will eventually need to offer an alternative to a wider range of fuel types, e.g. by replacing fuels in jet engines. Most importantly, they will need to meet these criteria while avoiding the problems outlined above, which threaten to negate or even outweigh their advantages.

Biofuels policy must be more discriminating if the most efficient of the many different types of biofuels are to be produced in their most appropriate environment and for their most appropriate markets. For instance, mitigating greenhouse gas emissions is a function of many variables including the kind of feedstock crop, crop yield, effect on land and water use, fertiliser use, emissions during the growth of the plant (especially nitrous oxide), emissions due to the fuel-production process, the use of biomass or non-renewable energy as process energy during the production chain, the use of by-products, and the distribution chain.[26] In practice, however, many policy approaches fail to provide an adequate signal that rewards biofuels according to their respective impacts. The main current approaches are briefly surveyed here.

### Targets and mandates

Targets and mandates are ways to encourage biofuel production by requiring a certain volume or proportion of market penetration for biofuels. The 2003 EU Biofuels Directive set non-binding targets for the substitution of transport fuels by biofuels of 2 percent by 2005 and 5.75 percent by 2010, and the European Commission has proposed a mandatory target of 10 percent use of renewable energy in road transport by 2020.[27] The UK Renewable Transport

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[26] Childs and Bradley, 'Plants at the Pump: Biofuels, Climate Change, and Sustainability', pp. 12-13

[27] European Commission, 'Proposal for a Directive of the European Parliament and of the Council on the Promotion of the Use of Energy From Renewable Sources'. The proposed Directive states that "The binding character of this target is appropriate subject to production being sustainable, second-generation biofuels becoming commercially available and the Fuel Quality Directive being amended accordingly to allow for adequate levels of blending."

Fuel Obligation (RTFO), which came into force on 15 April 2008, requires that 2.5 percent of all the fuel sold on UK forecourts come from renewable sources, rising to 5 percent in 2010/11.[28] The US Renewable Fuel Standard, passed in December 2007, requires that 9 billion gallons of biofuels be mixed into the country's fuel supply in 2008, rising each year to 32 billion gallons by 2022.[29] The limitation of these targets is that they fail to provide sufficient incentives to produce the best kinds of biofuels but rather encourage the production of the largest possible amount of fuel by volume. This is a perverse incentive for crops and farming methods that give the largest final yield of fuel rather than biofuels that deliver the highest carbon saving across their life cycle.

## Subsidies

Subsidies, another common policy approach, effectively make biofuels cheaper than they would otherwise be, although the price comparison between biofuels and fossil fuels is not straightforward because fossil fuels also benefit from many subsidies.[30] Direct or indirect subsidies are provided to biofuels at almost every stage of the production chain. They include:

- Subsidies to the feedstock crop, to its production inputs, such as energy and water, and to value-adding factors like labour, capital and land;
- Subsidies to the production of biofuels themselves, such as production-linked payments and tax credits, tax exemptions and market-price supports like import tariffs;
- Subsidies to the consumption of biofuels or the purchase of biofuel-using equipment.[31]

Subsidies tend to be a wasteful way to promote biofuels. They often fail to distinguish between different biofuels or can be quite technology-specific (as

[28] The obligation applies to road transport fuel companies that supply more than 450,000 litres of fossil fuel to the market. Companies also have the option of paying a "buyout" fee, currently £0.15 per litre, instead of supplying the biofuels.

[29] Childs and Bradley, 'Plants at the Pump: Biofuels, Climate Change, and Sustainability', p. 30

[30] Kutas *et al*.,. 'Biofuels – At What Cost?', p. 51

[31] Presentation by R. Steenblik, OECD, at Chatham House, 15 April 2008, available at http://www.chathamhouse.org.uk/events/view/-/id/819/

for subsidies to specific feedstock crops, like corn). From a political perspective, subsidies (as well as targets and mandates) are difficult to abolish because they create a dependent constituency. Subsidies can cause the diversion of resources that could otherwise be used for more efficient solutions.[32] Although subsidies can sometimes be justified on the grounds of guaranteeing a supply of a new technology and thereby helping its development, there is a large opportunity cost to the subsidy structures in place for biofuels. The Global Subsidies Initiative estimates that EU subsidies to biofuels in 2006 amounted to €3.6 billion through Common Agricultural Policy payments and other measures, and US support at between $5.5 billion and $7.3 billion a year.[33]

## Standards and certification

Standards are a way to compel producers to meet minimum criteria, and certification schemes that ensure biofuels have met a certain standard can increase transparency in the market and provide indicators for producers. Standards and certification can allow policies and measures to differentiate between biofuels based on the methods of their production. One possible drawback is that a proliferation of initiatives risks creating opacity in the markets and impeding trade. Standards could be used as a protectionist measure or be exclusionary for smallholders. An international approach to certification – e.g. through a UN process – could provide a sufficiently broad participatory process that reflects the views and concerns of producers in different regions and avoids a proliferation of approaches. Unfortunately such a process is likely to be complex and time consuming, although it could help avoid standards being seen as protectionist or skewed to the interests of Northern countries. Moreover, certification and standard schemes are not designed to capture the effects of biofuels at an appropriate scale. Nevertheless, a number of criteria do lend themselves well to standards and certification, and these are outlined below.

*Greenhouse gas criteria*

Some approaches evaluate biofuels on their ability to deliver greenhouse gas emission reductions. The proposed EU Renewable Energy Directive requires

[32] Presentation by R. Steenblik, OECD, at Chatham House, 15 April 2008, available at http://www.chathamhouse.org.uk/events/view/-/id/819/

[33] Koplow *et al*., 'Biofuels – At What Cost?', p. 66

that biofuels must produce at least 35 percent fewer greenhouse gases compared to fossil fuels.[34] Biofuels that do not meet the sustainability criteria will not count towards the EU target of a 10 percent share of energy from renewable sources in transport by 2020 or receive financial support.[35] One implication of this approach is that the European Union may find it difficult to meet its 10 percent target for renewable energy in road transport by 2020 without allowing greater imports of more efficient biofuels. A more general criticism of such a minimum threshold approach is that it does not provide any incentive for importers to achieve far above the threshold. But there is great scope for further efficiencies in the production of biofuels depending upon how the feedstock is cultivated, transported and processed; ethanol from wheat can deliver savings of between 7 and 77 percent, depending on how it is produced.[36] For this reason, the UK RTFO links rewards for biofuels to their carbon intensity and requires UK biofuel suppliers to report on the levels of carbon savings, among other sustainability criteria.[37]

*Environmental/biodiversity criteria*

The Renewable Energy Directive, the Fuel Quality Directive, the RTFO and various other measures all include some environmental or biodiversity criteria as part of their sustainability criteria. The Renewable Energy Directive establishes certain biomes within which biofuel production is restricted. These include lands with “recognized high biodiversity value”, “forest undisturbed by significant human” intervention, areas designated for nature protection purposes, unless evidence is provided that the production of the raw material did not interfere with those purposes, and highly biodiverse grassland, i.e. that which is species rich, not fertilised and not degraded.[38] In addition, the proposed EU Renewable Energy Directive would limit biofuels made from raw materials obtained from land with a high carbon stock, defined as wetlands including pristine peat land and continuously forested areas. Such definitions can be problematic, however. There are no details on how these specific requirements were reached, “pristine” is a specific yet vague definition, and

[34] European Commission, ‘Proposal for a Directive of the European Parliament and of the Council on the Promotion of the Use of Energy from Renewable Sources’

[35] IEEP, ‘Biofuels Provisions in the Renewable Energy Directive – A Summary’

[36] Archer, ‘Delivering a Sustainable Market for Biofuels’

[37] European Commission, ‘Biomass Technology Group’

[38] European Commission, ‘Proposal for a Directive of the European Parliament and of the Council on the Promotion of the Use of Energy from Renewable Sources’

the definition of high carbon stock does not cover permanent grasslands or savannahs.[39] Finally, the environmental sustainability criteria under the Renewable Energy Directive do not take into account the impact on soil and water or address the impacts of land use change or displacement.

The RTFO environmental criteria scheme is based on a “meta-standard” approach. Under this approach, existing voluntary agri-environment schemes (for example the Roundtable on Sustainable Palm Oil, and the Forest Stewardship Council) are benchmarked against the RTFO Sustainable Biofuel Meta-Standard. This standard comprises seven principles (including, for example, that biomass production will not destroy or damage large above- or below-ground carbon stocks or lead to soil degradation or air pollution) against which the existing schemes have been assessed.[40] The Roundtable on Sustainable Biofuels, a multi-stakeholder initiative developing standards for sustainable biofuels, takes a similar approach. Both schemes would likely recognise the crop-specific standards developed by the Roundtable on Sustainable Palm Oil, which sets out eight principles by which members should abide. These include a commitment to long term economic and financial viability, appropriate use of best practises by growers, environmental responsibility and conservation of natural resources and biodiversity.[41]

*Social Criteria*

Social issues associated with biofuels generally include one or more of the following: competition with food production, competition with other land uses, land tenure conflicts, consultation and consent, and social impacts of production on the workforce and local communities. The proposed EU Renewable Energy Directive takes no account of social criteria for judging biofuels to be sustainable, on the basis that implementation would be problematic and could be in conflict with international trade rules, although this has not been tested; the European Parliament has expressed interest in adding social criteria. The UK RTFO does contain some reference to social criteria, although these are rather limited compared to those of the Roundtable on Sustainable Palm Oil. The RTFO contains just two principles: biomass production should not adversely affect workers rights and working

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[39] IEEP, ‘Biofuels Provisions in the Renewable Energy Directive – A Summary’

[40] Renewable Fuels Agency, ‘Carbon and Sustainability Reporting within the Renewable Transport Fuel Obligation: Summary’, p. 6

[41] RSPO, ‘Principles and Criteria for Sustainable Palm Oil Production’

relationships, and biomass production should not adversely affect existing land rights and community relations.[42] Several schemes (qualifying standards) meet these social criteria for biofuels, including the Roundtable on Sustainable Palm Oil, Sustainable Agriculture Network/Rainforest Alliance, Basel Criteria and Social Accountability 8000. The Roundtable on Sustainable Palm Oil includes a number of social criteria, including a commitment to transparency, compliance with appropriate laws and regulation and responsible consideration of employees.

*Private-sector certification initiatives*

Voluntary measures can take place in lieu of legislation at national or international levels, including private or voluntary certification systems. Private (voluntary) certification schemes can also set standards higher than those set by law and allow consumer discrimination. The Roundtable on Sustainable Biofuels is a multi-stakeholder initiative to develop standards around greenhouse gas emissions, soil management and other key issues of sustainability. Migros, a major Swiss retailer, has worked with WWF to develop criteria for environmentally sound and socially acceptable soy production,[43] and three large Dutch banks (ABN AMRO, RaboBank and FortisBank) have adopted policies to mitigate environmental and social risks when dealing with palm oil companies.[44] The Better Sugarcane Initiative is developing sustainability criteria around sugar.

*Reporting and enforcement*

Reporting and enforcement will be essential to provide confidence that such criteria – voluntary and mandatory – are being upheld. The RTFO includes sustainability reporting from the outset, and by April 2010 biofuels under the RTFO will be rewarded according to their carbon savings; by 2011 biofuels under the RTFO will be rewarded only if they meet appropriate sustainability standards, subject to compatibility with EU/WTO rules. Reporting under the RTFO is based on existing voluntary standards, e.g. Forest Stewardship Council.

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[42] Low Carbon Vehicle Partnership, 'RTFO Carbon and Sustainability Reporting Requirements'

[43] Riedener, 'Palm Oil from Sustainable Production – a Migros pilot project'

[44] Childs and Bradley, 'Plants at the Pump: Biofuels, Climate Change, and Sustainability' p. 45

## International trade

The production of biofuels offers new opportunities for development through trade, because some developing countries (notably Brazil) have a comparative advantage in producing highly efficient biofuels at lower cost than the developed countries where demand for biofuels is growing fastest in response to mandates and other policies. The indirect effect on food prices notwithstanding, the increase in trade in biofuel feedstock crops can provide a new source of revenue for farmers in developing countries. Trade policy must be reformed to realise these opportunities, however. In the European Union biofuels are variably classed as agricultural products, environmental goods or industrial goods and as such lack their own trade code. This lack of coherence on how to classify biofuels has meant that there is no ready trade forum for discussion of sustainable biofuels. The effect of EU tariffs and non-tariff barriers is to restrict imports of ethanol from major producers like Brazil into the European Union.[45] Tariff barriers are also an obstacle. The United States, for example, applies an extra US$0.54 to each gallon of imported bioethanol on top of the 2.5 percent tariff, bringing the price of Brazilian bioethanol in line with domestically produced US bioethanol.[46]

The removal of trade barriers like tariffs in concert with the establishment of an international certification scheme for biofuels could encourage the trade in sustainable biofuels, but the lack of an internationally agreed definition of a "sustainable" biofuel or any internationally agreed methodology to calculate greenhouse gas emission savings from biofuels complicates the picture. Individual countries are free to adopt sustainability criteria for biofuels produced domestically, but there are limits on such standards/regulations that can be applied to international trade under the rules of the World Trade Organisation. WTO member countries can adopt domestic policies related to trade as long as those policies do not directly or indirectly discriminate between imported and domestically produced "like" products, or between "like" products imported from different countries.[47] Although there are provisions to distinguish between traded goods on the basis of environmental

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[45] Stevens, 'Biofuels and development: Will the EU help or hinder?'

[46] Dufey, 'International trade in biofuels: Good for development? And good for environment?'

[47] Childs and Bradley, 'Plants at the Pump: Biofuels, Climate Change, and Sustainability', pp. 37-38

criteria (such as sustainability standards), these rules are complex and controversial.[48]

## Technological development

Many policies are based on the assumption that first-generation biofuels, with all their limitations, will ultimately be replaced by a second generation of biofuels that deliver the expected benefits without the problems that have risen to recent prominence. The most promising techniques at the conversion and biorefinery stage are thought to be in the development of biofuels from lignocellulose. These second-generation fuels are currently more expensive to produce than biofuels from starch because of the complex process needed to break down cell-wall and woody material to generate sugars for fermentation. But the scope for future development seems to be very large. New technologies that allow biofuels to be produced from almost any kind of crop offer the possibility that biofuels could be produced from trees, grass and other crops that produce large amounts of usable biomass per hectare and that can be grown in areas where bioenergy is less likely to compete with agricultural production for food and feed supplies.[49] About 80 percent of all biomass is in the form of lignin and cellulose, and current world motor fuel energy consumption ($10^{20}$ Joules per year) could be met from just 125 million hectares, or 10 percent of global arable land.[50]

Second-generation biofuel processes are still at the pilot stage, however, and they are unlikely to become competitive before 2020. Even if high subsidies result in the construction of several full-size plants by 2020, the learning will not have an effect until after 2020. Specific R&D and innovation efforts need to be directed across the entire production chain for biofuels, from feedstock crops, conversion and biorefineries, to end use and distribution.[51] At the feedstock stage, R&D and innovation is needed to increase biomass yield per hectare while reducing the needs for production inputs, improving crop quality (higher biofuel yields), and reducing land-use competition through higher productivity and reduced losses from insects and environmental factors (such as drought). At the conversion and biorefinery stage, innovation is also

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[48] House of Commons Environmental Audit Committee, 'Are Biofuels Sustainable?'

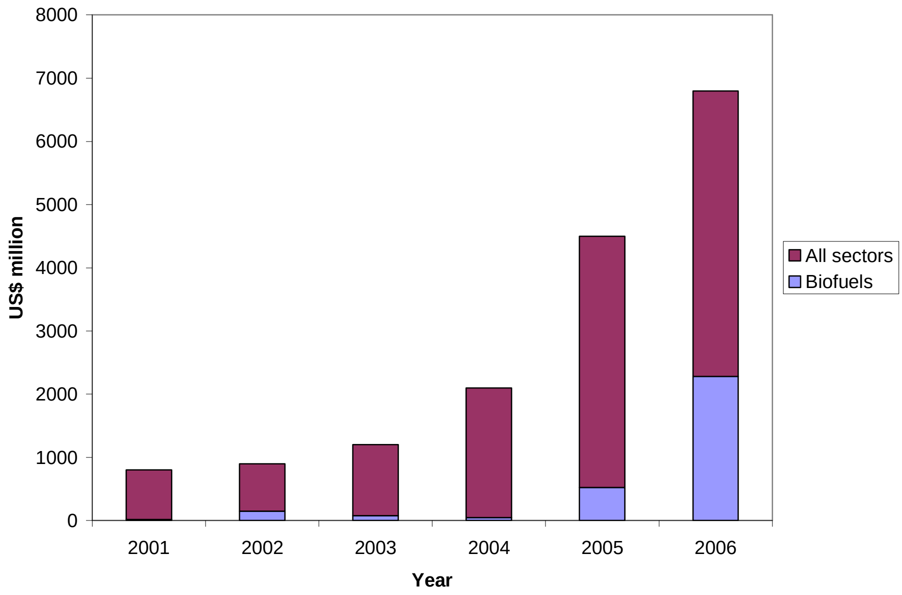
[49] Woods, 'Bioenergy and Agriculture: Promises and Challenges'

[50] Presentation by R. Templer, Imperial College London, at Chatham House, 16 April 2008, available at http://www.chathamhouse.org.uk/events/view/-/id/819/

[51] The Royal Society, 'Sustainable Biofuels: Prospects and Challenges', p. 49

needed to develop sustainable biodiesel, which is currently the only fuel that could reduce exhaust pollution from heavy-goods vehicles and buses. At the end use and distribution stage, innovation strategies should focus on biofuel-relevant engine technologies, such as ensuring that vehicle parts are compatible with ethanol (which is hydrophilic and can corrode parts).

**Figure 4: Worldwide venture capital/ private equity investment in biofuels**




Source: Adapted from UNEP (2007)

Investment in biofuels is particularly risky because they are at the mercy of not one but two commodity cycles: agriculture and oil, in addition to uncertainties related to infrastructure requirements and the sustainability of fuel production processes.[52] A further problem with investing in the biofuel sector is it is largely policy driven and therefore vulnerable to future policy shifts. Investment in biofuels has increased dramatically in recent years (see Figure 4), with over US$2 billion of worldwide venture capital and private equity investment in 2006 in biofuels.[53] But most of this investment went into increasing capacity for existing types of biofuels ($2,031.5m), compared to just $248.6m into next-generation biofuel technology. Total global investment

[52] Childs and Bradley, 'Plants at the Pump: Biofuels, Climate Change, and Sustainability', p. 39

[53] VC/PE investment refers to all equity invested by venture capital and private equity funds into companies developing sustainable energy technologies or providing services to the sector. UNEP, 'Global Trends in Sustainable Energy Investment 2007' , p.23

in biofuel technology in 2006 was $18.2 billion,[54] compared to total investment in "clean" technology of $93 billion. Finally, a major unknown relates to the extent to which technology will be transferred from developed to developing countries, given that many technologies currently being developed are designed for temperate zones. Such levels of investment may not be repeated in the short-to-medium term due to the worsening global economic climate.

[54] UNEP, 'Global Trends in Sustainable Energy Investment 2007', p. 15

## Policy recommendations

As noted in a commentary recently published in *Nature*, the world must quickly embark on a massive transformation of global energy systems through technological change if it is to stabilise atmospheric concentrations of carbon dioxide at acceptable levels.[55] This is because greenhouse gas emissions in China and India are likely to continue increasingly rapidly, driven by development and the move of rural populations to cities and a more energy-intensive lifestyle. The current rates of technological development may not be adequate to effect the necessary transformation of the energy system. Moreover, it may not be enough simply to reduce emissions: the amount of carbon already in the atmosphere or about to be released is already putting the planet at risk. Therefore, technologies that return more carbon to the ground will be required to manage the transition. Crucially, it may be necessary to force technological change, rather than relying on spontaneous technological innovation.

The global transport system must change dramatically if it is to play a role in this transformation. This must entail a reduction in global demand for fossil fuels, primarily through greater efficiency but also through substitution of liquid fuels. Biofuels seem to have the potential to play a small but significant role in the new energy mix, but it will require significant and careful policy changes to manage their wider deployment in a way that has the least possible negative impacts on communities and ecosystems. There is a need for some basic principles to inform all biofuels policies. Greenhouse gas accounting should cover their entire life cycle, including (to the extent possible) their indirect impacts on land use. Policies should reward environmental performance rather than other criteria like volume. Policies should reward economic efficiency and incentivise continuous improvement (dynamic improvement) rather than impose static criteria. Mandates and targets can provide certainty for producers and investors, but they should be set at a low enough level to provide this certainty without creating an artificial demand for biofuels with concomitant, even if unpredictable, knock-on effects. Most importantly, mandates and targets should be directed at the intended social benefit (e.g. reduced greenhouse gas emissions) and technologically neutral to that end, so that they are not diverting scarce funds to the continuation of first-generation biofuels that perform poorly in this respect. Meanwhile, the development of second-generation biofuels must be a

[55] Pielke *et al*., 'Dangerous Assumptions'

prerequisite for the continuation of support policies in the medium term. Research and development is a public and long-term good, so there is a need to devote public money for the development of the next generation of biofuels as part of a suite of transport-sector technology investments. But the focus on R&D should shift from supporting the production and consumption of first generation biofuels to the development of second-generation fuels, which currently only receive a few percent of total R&D support.

Because the indirect effects of biofuels are difficult to capture through standards and certification schemes, a commonly agreed international methodology could provide a framework for resolving these contentious issues. One way to address the indirect impacts of biofuels could be through an international process in the manner of the Intergovernmental Panel on Climate Change, which could define and articulate an international consensus on the contentious issue of land use based on the broadest overview of the scientific data. A UN forum would be appropriate for its universal membership and multi-sectoral approach. The UN Global Bioenergy Partnership is attempting to perform this role, and its work could be expanded. The UN Framework Convention on Climate Change could also contribute by helping to define a methodology for calculating the life-cycle emissions of greenhouse gases of different biofuels. A UN-level process could be time-consuming, and therefore its deliberations should not be an excuse for postponement of many of the measures outlined above, but it would provide a sufficiently inclusive forum to develop a methodology for calculating emissions, allocating their attendant rights (in the context of national emission limits post 2012), and perhaps developing some of the certification criteria.

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