Biofuels for transport – a dangerous distraction?

Biofuels are being proposed by governments and industry as a means to mitigate carbon emissions from transport. Andrew Boswell questions how mature and sustainable these fuels are – could they be a dangerous distraction in the urgent battle against climate change?

Biologist David Ehrenfeld[1] has recently written of the phenomenon of 'friendly fire' in the context of the climate change/energy debate. Without comprehensive understanding of economic, social and environmental impacts, there are many ways that a new technology can inflict friendly fire on the very goals it is intended to achieve. It may be developed too quickly without complete appreciation of its full lifecycle impact, or it may be developed beyond the capacity of its benefits. The risk of this increases dramatically when the intrinsic benefits of the technology are exaggerated for political or commercial reasons.

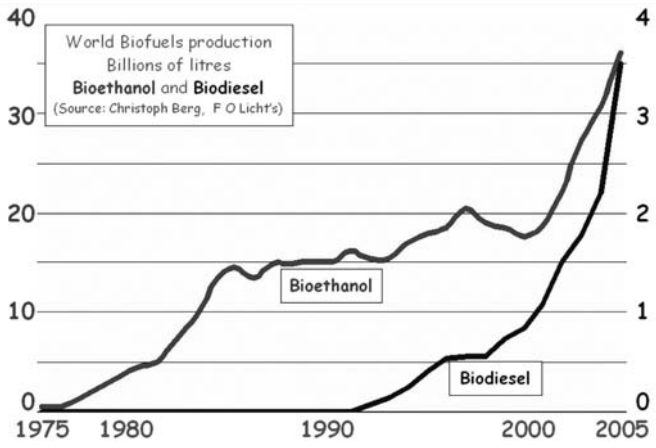
This article argues that biofuels development is already rolling out in this way – and that there is an urgent need for policy-makers to understand this. Rapid action is required to limit the friendly fire happening with biofuels development and ensure that only benign forms of bioenergy are developed. The article highlights how the friendly fire is occurring – and makes some suggestions as to where UK investment in bioenergy can be made.

What are biofuels?

Transport biofuels are in fact part of a complex family of bioenergy technologies[2]:

- Bioethanol – alcohol-based fuel derived by fermentation of sugar or starch crops such as sugar cane and beet, corn, wheat, barley and maize. It can be blended with petrol, e.g. E5 (5% ethanol), E85 (85% ethanol).
- Biodiesel – can be manufactured from virgin or waste vegetable oils, e.g. palm oil or rapeseed, or animal oils. It is generally blended with conventional diesel.
- Biogas – derived from landfill, the anaerobic digestion of waste or other organic material. Biogas can be used for electricity production, and can share similar benefits to biomass as below.

Bioethanol and biodiesel are *first generation biofuels* – the primary focus of this article. Industry and government are increasingly talking of *second generation biofuels*, which include pre-commercial ligno-cellulosic ethanol, and synthetic fuels produced by Fischer-Tropsch processes.



World biofuel production 1975-2005[5]

Non-transport bioenergy is known as biomass: that is, animal/vegetable material (e.g. timber, woodchip, miscanthus, straw, chicken litter and other waste) that can be used as a source of heat and/or power. One of the most efficient ways of using biomass is in combined heat and power (CHP) plants, which minimise waste energy by generating electricity and using the heat by-product to warm buildings, heat water etc.

Exponential growth – the biofuels explosion

The last five years have seen the world's farmers rapidly moving from their traditional products – food, feedstock and fibre – to producing fuel in a huge, fast-growing industry.

Current global bioethanol production is around 12 billion gallons per annum (see Figure 1). This is nearly double that in 2000. The smaller biodiesel industry has more than tripled in the same period. Currently, the bioethanol industries in the US and Brazil are each about one third of this and expanding – Brazil into large export markets, while the US alone could triple its own domestic supply to around 12 billion gallons in 2012[3, 4].

US expansion is being vigorously pursued, driven by very powerful vested interests: the legislators and farmers from the US Corn Belt states; the large corn brokers and traders; car manufacturers who see a huge market in 'green' cars; and the oil companies who will own and run the refineries.

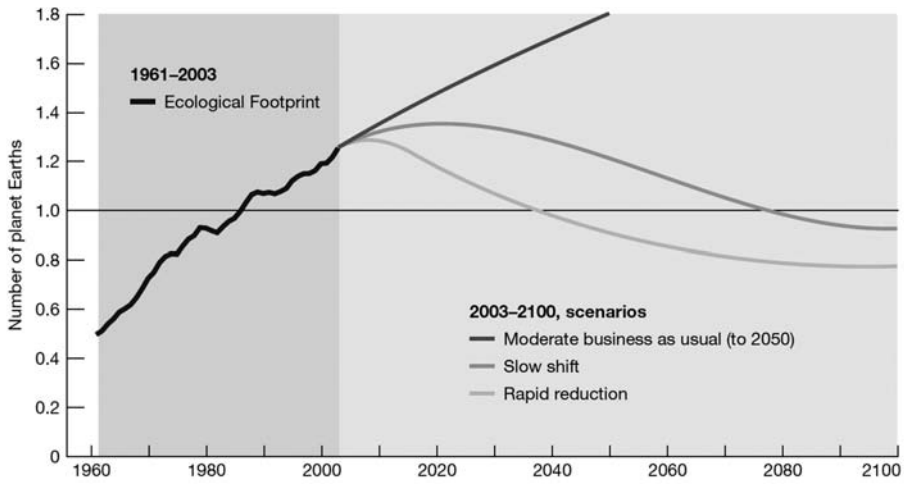
Monoculture industry is reflected by monoculture politics as all sides agree: Bush's State of the Union address in February 2006 set the massive goal of running 30% of America's cars on bioethanol by 2020, and Hilary Clinton[6] recently echoed Bush in calling for US dependence on foreign oil to halve by nearly 8 million barrels a day by the year 2025 by the use of bioethanol.

The effect is global. Brazil and Argentina plan to grow genetically modified (GM) soya for biodiesel, while across Africa states are looking to exploit sugar, maize and sorghum[7]. The European Union has set a target of 5.75% biofuels at the pump by 2010 and 20% biofuels by 2020 – from soya, sunflower and rape seeds. India, China, Malaysia, the Philippines and Indonesia have all announced biorefineries and biofuels strategies.

This adds up to a global-scale step-change, and yet has developed largely without environmental and scientific scrutiny.

Sustainability in the complete lifecycle

The two key arguments used by proponents of biofuels are that they can save fossil fuel-based energy and they can save carbon emissions. Thus they should prove net energy gain and a net saving in CO_2 emissions. Yet whilst the industry growth has surged, no one really knows "how much energy it takes to make the energy"[8] in biofuels, nor their full-lifecycle carbon emission balance. Scientists are clear that it depends on many factors including type of crop, where it is grown, where it is transported to, how it is grown, and how it is processed.



Three scenarios of humanity's ecological footprint 1961-2100
© 2006, WWF – the environmental conservation organisation[13]

The Society of Environmental Journalists has succinctly summarised the four questions needed to clarify the debate[9]:

1. What is the energy content of a gallon of the biofuel?
2. How much energy is required – farm equipment, fertilizers, pest management, transportation, storage – to produce the biomass feedstock (corn etc) for that gallon?
3. What other substances – process chemicals etc – are required and how much energy is required to produce each of these?
4. How much energy is required to manufacture, transport and store a gallon of the biofuel?

(1) must be greater than (2+3+4) for the fuel to have net positive energy. A parallel analysis must be carried out for net greenhouse gas emissions.

The picture emerging is that large-scale biofuels production is an extremely energy intensive, CO_2-emitting and polluting process. Energy inputs for large-scale production include *petroleum-based* herbicides, pesticides and fertilizers, while *fossil-fuelled* tractors and trucks plough the fields, and harvest and transport the crop to the fuel refineries. In the case of the US ethanol industry, refineries are themselves fired by fossil fuels – largely natural gas, but sometimes even coal – in enormous quantities to ferment the crop, and then purify ethanol from the watery fermentation product.

Even research from proponents does not look good – a 2002 US Department of Agriculture report found the energy from corn bioethanol was a mere 8% in excess of the input production energy[10], while a much-hyped recent paper in *Science* magazine[11] found corn bioethanol production was only net-positive when the energy savings from 'co-products' such as cattle feed were included.

However, scientist Tad Patzek[12] hotly contests these findings, asserting that no biofuel has a positive energy balance in a more complete analysis (detailed and complex physics). Patzek also calculates the CO_2 emissions of the complete production cycle and finds them 50% greater from corn-ethanol than gasoline – this becomes 100% higher when the methane emissions from beef cattle fed with the co-product are accounted for. (Bear in mind that the co-product is an unnatural feed for cattle, and the beef industry is already unsustainable).

Wider environmental impacts

This huge step-change in the use of the biosphere comes when we are already living far from sustainably. It is well documented that we are now living off natural 'capital', over-exploiting resources such as soil, water, forest and fisheries. For example, the WWF Living Planet Report[13] shows humanity's ecological footprint (HEF) increasing beyond the capacity of one planet since 1987 (see Figure 2).

Compounding this is climate change, which is set to make losses of ecological capital happen much faster. Take fresh water – a vital agricultural resource for food security. We are seeing falling water tables, rivers running dry and disappearing lakes. Aquifers are being depleted in many countries including the big three grain producers – India, China and the USA[14].

In October, Met Office scientists published key new research predicting that drought threatening the lives of millions will spread across half the Earth by 2100. As water resources become more depleted, a general 'global drying' effect from climate change will reduce supply – a deadly combination.

The expansion of biofuels development requires huge water resources. 1 tonne of corn may produce 450 litres of bioethanol but requires 1,000 tonnes (1,000,000 litres) of water. Sugar cane being rapidly developed for biofuels in Brazil, India and Thailand is even thirstier – in parts of the Indian state of Maharashtra water tables have been lowered by 50 metres by sugar cane production[15].

While WWF urges that the HEF should be rapidly reduced, biofuels development on a massive scale could force it the other way – above the moderate business as usual curve.

Expansion of biofuels use could also speed tropical deforestation. The destruction of tropical rainforests is linked to about one quarter of all greenhouse gas emissions from human activities. The conversion of rainforests into palm oil plantations (or soya plantations in the Amazon) is also one of the main threats to many thousands of species of animals and plants, including the orang-utan.

As mentioned earlier, the EU has brought in legislation to increase the proportion of biofuels at the pump to 20% by 2020. As soon as it was passed, both Malaysia and Indonesia declared their intention to become major providers of biodiesel made from palm oil, and to expand oil palm plantations into virgin rainforests. This is now subject to a major campaign calling for an EU-wide ban on imports of biofuels from these regions.

So there is huge concern about the wider environmental impacts of biofuels. *New Scientist's* Fred Pearce summarised this eloquently when he warned this summer that first generation biofuels "will trash rainforests, suck water reserves dry, kill off species and, worst of all, barely slow down global warming"[15].

Food security in the hands of speculators

A combination of low corn prices, high oil prices and a government subsidy of 51¢ per gallon fuelled the unprecedented ethanol market growth in the US. It was not going to be long before market pressures led to direct competition between food and fuel producers for crops. This happened in April and May this year with a 20% rise in corn prices, and the *Financial Times*[16] reported that US farmers were diverting more of their harvests towards producing fuel rather than food or feedstock for animals. Then, in June 2006, the Malaysian government put a hold on further bio-refineries due to concern about palm oil in the food supply being displaced[17].

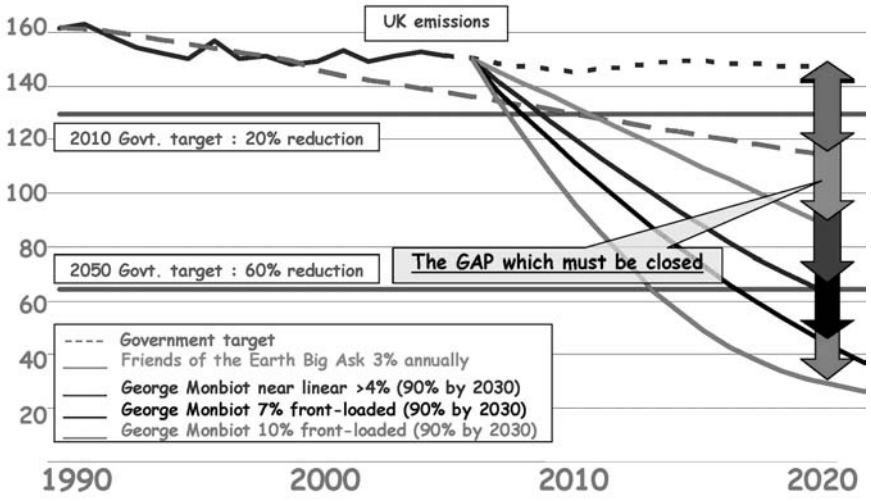
Grain has historically been one of the least volatile commodities. Price stability could be achieved by planting more crops – relatively rapidly compared to, say, mining more minerals. However, global corn stocks are now at their lowest level for 25 years, while wheat stocks are the lowest on record. Increasing demand for food crops in India and China, and global demand for biofuel feedstock, has led to structural changes to the market. *The Guardian*[18] reported on 28 October that corn and wheat prices have risen by 60% this year, fostering a new wave of speculator investment.

So there is now serious competition between food crops and biofuels. Lester Brown has noted that of the 20 millions tonnes of increased world grain use in 2006, 14 million tonnes will have been used to fuel US cars whilst only 6 million will have contributed to the world's growing food supplies[19]. "Put simply," he says, "the world is set for a head-on collision between the world's 800 million affluent automobile owners and food consumers." Countries in the global South will be tempted to devote ever-expanding areas of cash crops for vehicle fuels, displacing their local food production.

The addition of profit-hungry speculators to the game is terrifying in the unregulated global free market. Commodity speculation in vital crop resources could now decimate the livelihoods of small farmers and local people through price fluctuation, potentially causing starvation.

The 'biofuels.com' fall-out

The massive growth of the biofuels industry has been underwritten by huge investment. Rising commodity prices and the potential for poor crop yields due to climate change may hit profits badly. This is a 'biofuels.com' bubble that will burst as key issues about sustainability and social impact emerge. Biofuels will no longer be seen as an ethical, green investment in renewable energy. In fact, concerns about the sustainability and social impacts of biofuels have caused a Swiss bank, Sarasin, to warn investors in July 2006 that the limit for socially responsible use of biofuels was 5% of current petrol and diesel consumption in the EU and USA[20]. Note how this clear financial thinking differs from official policy – in addition to the EU biofuels targets mentioned earlier, the USA is aiming for 30% biofuels at the pump by 2020!



UK carbon emissions scenarios 1990-2020 (in MtC): showing Friends of the Earth scenario[26] and three Monbiot scenarios[27]

Cellulosic technology – genetically modified and too late?

Corporate gaze is already focussed on researching a new generation of biofuels from the cellulosic residues from crops or wood. Richard Branson may be investing some of his billions in this[21]. Some scientists believe such fuels have better theoretical energy and greenhouse gas balances, but the excitement around these may well be wishful thinking. Branson is putting money where most US private investors have steered clear – as Fred Pearce reported, Raymond Orbach, Under Secretary of State at the US Department of Energy, says, "It's too risky for the private sector"[15].

Although ligno-cellulosic technologies underpin the Bush/Clinton route to ending US oil addiction, there is doubt that they will ever scale up from the laboratory to commercial refineries[22], *or can do this in sufficient time.*

Time is against ligno-cellulosic ethanol. There has been a spate of recent research that provides important evidence of possible positive climate feedback effects, i.e. rapid, irreversible climate change:

- a huge increase in Arctic ice cap summer melting found in two independent studies – one reporting a 30-fold increase[23];
- rapidly increasing methane emissions from Siberian tundra melt[24];
- more data on the slowing of the Gulf Stream[25].

We need to reduce emissions rapidly to have a hope of avoiding dangerous, irreversible climate change. Urgent action should initiate 'front-loaded' cuts now. The positive feedback effects being detected now demand nothing less, and front-loading will create lower total emissions over the period until 2030, leaving a less damaging legacy beyond 2050[26, 27].

Ligno-cellulosic technologies will have little impact during this timeframe, whilst inefficient first generation technologies will continue to expand under the current policy drivers (e.g. EU Biofuels Directive).

If cellulosic technology does scale up, it is likely to be based on industrial-scale GM crops. These crops will be developed for maximum cellulosic content (i.e. energy content), possibly with genes for self-nitrogenous fertilizing, and with fermentation and processing using GM based enzymes and bacteria[28]. Such extensive use of GM within the production cycle, and with the crops to be planted on such a large scale, is cause for great concern[29].

The UK way forward

This summer's report from the House of Commons Environment, Food and Rural Affairs Committee[30] on bioenergy stated, "However, in their current state of development and with the limitations on land capacity in the UK, these [1st generation] fuels do not present the most effective or efficient way of making a significant difference to the UK's carbon emissions in the long term." However, it is argued that much greater exploitation of biomass should be made. This concurs with recommendations made elsewhere[31]. Indeed, detailed evidence given to the Committee left question marks on the value of any development of first generation fuels, and the report recognises that second generation fuels may fail to be developed.

Biomass, especially used in CHP plants as part of a decentralised energy system[32], is indeed a much preferable use of bioenergy as long as the crops are grown in a sustainable way (organically, if possible) and used locally (to minimise transport emissions in the lifecycle).

As for carbon emissions from transport, there is a desperate need to cut them, but industrial-scale biofuels are unable to contribute significantly to this. Indeed, as this article argues, biofuels create significant friendly fire in the environmental, economic and social domains. With not enough time to develop second generation biofuels, it is essential that we reduce transport demand by numerous schemes for car sharing, modal shift to walking and cycling, and massive investment in public transport, including renationalisation of the railways.

Dr Andrew Boswell's scientific career has spanned over three decades, and included work in chemistry, biochemistry, electronics and high performance computing. He is now part of the Large Scale Biofuels Action Group and a Councillor on Norfolk County Council.

Each litre of bioethanol (from corn) requires 2,200 litres of water to be used in crop irrigation

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AESR library give-away

It has been decided that the library of Architects and Engineers for Social Responsibility (AESR), containing documents on sustainability and peace themes, is to be dispersed and disposed of. Any member who thinks that it may contain a document he or she would like to acquire is invited to obtain a list of abstracts from Tony White, who will then be able to supply any document requested on a first come first served basis. The residue of the collection will then be disposed of.

Contact:
Tony White: Ty Segur, Neath, Glamorgan, SA11 1YN.
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